



(86) Date de dépôt PCT/PCT Filing Date: 2011/06/10
(87) Date publication PCT/PCT Publication Date: 2011/12/15
(45) Date de délivrance/Issue Date: 2019/10/22
(85) Entrée phase nationale/National Entry: 2012/11/27
(86) N° demande PCT/PCT Application No.: JP 2011/063396
(87) N° publication PCT/PCT Publication No.: 2011/155607
(30) Priorité/Priority: 2010/06/11 (US61/353836)

(51) Cl.Int./Int.Cl. *C07K 16/28* (2006.01),
A61K 39/395 (2006.01), *C12N 15/13* (2006.01),
C12P 21/08 (2006.01), *G01N 33/577* (2006.01)

(72) Inventeurs/Inventors:
TAKAYANAGI, SHIN-ICHIRO, JP;
TOMURA, HITOMI, JP;
TAWARA, TOMONORI, JP;
INAGAKI, YOSHIMASA, JP;
KUBOTA, TSUGUO, JP;
...

(73) Propriétaires/Owners:
KYOWA HAKKO KIRIN CO., LTD., JP; ...

(54) Titre : ANTICORPS ANTI-TIM-3
(54) Title: ANTI-TIM-3 ANTIBODY

(57) **Abrégé/Abstract:**

The present invention provides an anti-human TIM-3 antibody which binds to the amino acid sequence of the extracellular region of TIM-3 or its three-dimensional structure thereof and exhibits higher effector activity such as an antibody-dependent cellular cytotoxicity (ADCC activity) for diseases relating to a human TIM-3 expressing cell. The present invention provides a monoclonal antibody or antibody fragment thereof which binds to the amino acid sequence of the extracellular region of TIM-3 or its three-dimensional structure and exhibits ADCC activity; a hybridoma which produces the antibody; a DNA encoding the antibody; a vector comprising the DNA; a transformant which is obtainable by introducing the vector; a method for producing the antibody or the antibody fragment thereof which comprises using the hybridoma or the transformant; a therapeutic agent and a diagnostic agent comprising the antibody or the antibody fragment thereof as an active ingredient. In addition, the present invention provides an anti-human TIM-3 antibody having high ADCC activity by screening an anti-human TIM-3 antibody which competes with the monoclonal antibody or the antibody fragment thereof.

(72) Inventeurs(suite)/Inventors(continued): AKASHI, KOICHI, JP; KIKUSHIGE, YOSHIKANE, JP

(73) Propriétaires(suite)/Owners(continued):KYUSHU UNIVERSITY, NATIONAL UNIVERSITY CORPORATION, JP

(74) Agent: LAVERY, DE BILLY, LLP

Abstract

The present invention provides an anti-human TIM-3 antibody which binds to the amino acid sequence of the extracellular region of TIM-3 or its three-dimensional structure thereof and exhibits higher effector activity such as an antibody-dependent cellular cytotoxicity (ADCC activity) for diseases relating to a human TIM-3 expressing cell. The present invention provides a monoclonal antibody or antibody fragment thereof which binds to the amino acid sequence of the extracellular region of TIM-3 or its three-dimensional structure and exhibits ADCC activity; a hybridoma which produces the antibody; a DNA encoding the antibody; a vector comprising the DNA; a transformant which is obtainable by introducing the vector; a method for producing the antibody or the antibody fragment thereof which comprises using the hybridoma or the transformant; a therapeutic agent and a diagnostic agent comprising the antibody or the antibody fragment thereof as an active ingredient. In addition, the present invention provides an anti-human TIM-3 antibody having high ADCC activity by screening an anti-human TIM-3 antibody which competes with the monoclonal antibody or the antibody fragment thereof.

DESCRIPTION

Title of Invention: ANTI-TIM-3 ANTIBODY

5 Technical Field

[0001]

The present invention relates to a monoclonal antibody or an antibody
fragment thereof, which binds to the extracellular region of T-cell immunoglobulin and
mucin domain containing molecule-3 (hereinafter referred to as "TIM-3") and exhibits
10 antibody-dependent cellular cytotoxicity (hereinafter referred to as "ADCC"); a
hybridoma which produces the antibody; a DNA which encodes the antibody; a vector
which comprises the DNA; a transformant obtained by transforming the vector; a
process for producing an antibody or an antibody fragment thereof using the hybridoma
or the transformant; and a diagnostic agent or a therapeutic agent using the antibody or
15 the antibody fragment thereof.

Background Art

[0002]

TIM-3 gene family consists of eight genes in mouse and three genes in human,
20 and each of these genes are located at chromosome 11 and at chromosome 5q33
respectively (Non-patent Document 1). These gene regions are known to be related
with autoimmune diseases and allergic diseases. TIM protein is a type I
transmembrane protein having a structurally conserved immunoglobulin variable (IgV)
domain and a mucin domain.

25 [0003]

TIM protein was considered to be specifically expressed on T cells and directly
regulate the T cell activity, but there are recent reports on expression of TIM-3 protein
in antigen-presenting cells and on their functions (Non-patent Document 2).
According to the crystal structure analysis, the TIM protein has a conserved protein
30 structure and has a ligand binding site in the IgV domain.

[0004]

TIM-3 was identified as a molecule specifically expressed on mouse Th1 cells
but not on Th2 cells (Non-patent Document 3). The DNA sequence, the amino acid
sequence and the three-dimensional structure of TIM-3 is available in the public data
35 base such as the GenBank accession number NM_032782 and NM_134250. TIM-3 is
also known as HAVCR2.

[0005]

In humans, as similar to mice, TIM-3 is expressed on T-cells as well as phagocytic cells such as macrophages and dendritic cells. Binding of TIM-3 to a protein ligand (e.g., galectin-9) can inhibit the Th1 response via mechanism of apoptosis induction, and therefore lead to such as induction of peripheral tolerance.

5 [0006]

The reduction in expression of human TIM-3 with siRNA or the inhibition of human TIM-3 by blocking-antibody increased the secretion of interferon γ (IFN- γ) from CD4 positive T-cells, supporting the inhibitory role of TIM-3 in human T cells. In phagocytes, TIM-3 also functions as a receptor for recognizing the apoptosis cells.

10 [0007]

Analysis of clinical samples from autoimmune disease patients showed no expression of TIM-3 in CD4 positive cells. In particular, in T cell clones derived from the cerebrospinal fluid of patients with multiple sclerosis, the expression level of TIM-3 was lower and the secretion level of IFN- γ was higher than those of clones derived from normal healthy persons (Non-patent Document 4). There are reports on relation of TIM-3 with allergic diseases or asthma (Patent Documents 1 and 2).

15

[0008]

According to the microarray analysis of hematopoietic stem cells from acute myeloid leukemia (hereinafter referred to as "AML") patients and normal hematopoietic stem cells, TIM-3 is expressed on AML stem cells and therefore the analysis suggested involvement of TIM-3 in hematological malignancy (Non-patent Document 5 and Patent Document 3).

20

[0009]

Examples of the anti-TIM-3 monoclonal antibodies which were established up to now include anti-human TIM-3 rat monoclonal antibody (Clone 344823, manufactured by R&D Systems) and anti-human TIM-3 mouse monoclonal antibody (Clone F38-2E2, manufactured by R&D Systems).

25

Related Art

30

Patent Literature

[0010]

Patent Literature 1 WO96/27603

Patent Literature 2 WO2003/063792

Patent Literature 3 WO2009/091547

35

Non-Patent Literature

[0011]

Non-Patent Literature 1 Hafler DA *et al.*, *J Exp Med.* 205: 2699-701 (2008)

Non-Patent Literature 2 Anderson AC *et al.*, *Science* 318: 1141-3 (2007)

Non-Patent Literature 3 Monney L *et al.*, *Nature* 415: 536-41 (2002)

Non-Patent Literature 4 Koguchi K *et al.*, *J Exp Med.* 203: 1413-8 (2006)

Non-Patent Literature 5 Majeti R *et al.*, *Proc Natl Acad Sci USA* 2009 Mar 3;
5 106 (9): 3396-401.

Disclosure of Invention

Problems to Be Solved by the Invention

[0012]

10 However, there is no report on monoclonal antibody against human TIM-3
having ADCC activity. Therefore, the object of the present invention is to provide a
monoclonal antibody or an antibody fragment which binds to the amino acid sequence
or the three-dimensional structure of the extracellular region of TIM-3 and expresses
ADCC activity. In addition, the object of the present invention is to provide an anti-
15 human TIM-3 antibody having high ADCC activity by screening an anti-human TIM-3
antibody which competes with the monoclonal antibody or the antibody fragment
thereof.

[0013]

In addition, the present invention is to provide a hybridoma which produces the
20 antibody; a DNA which encodes the antibody; a vector which comprises the DNA; a
transformant obtained by transforming the vector; a process for producing an antibody
or an antibody fragment thereof using the hybridoma or the transformant; and a
diagnostic agent or a therapeutic agent using the antibody or the antibody fragment
thereof as an active ingredient.

25

Means for Solving the Problems

[0014]

The gist of the present invention relates to the followings.

(1) A monoclonal antibody or an antibody fragment thereof, which binds to an
30 extracellular region of human TIM-3 while competing with one antibody selected from
the following (i) to (iii):

(i) an antibody which comprises a heavy chain (hereinafter referred to as “H
chain”) of an antibody which comprises complementary determining regions
(hereinafter referred to as “CDR”) 1 to 3 comprising the amino acid sequences
represented by SEQ ID NOs: 1 to 3, respectively, and comprises a light chain
35 (hereinafter referred to as “L chain”) of an antibody which comprises CDRs 1 to 3
comprising the amino acid sequences represented by SEQ ID NOs: 4 to 6, respectively,

(ii) an antibody which comprises an H chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 11 to 13, respectively, and comprises an L chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 14 to 16, respectively,

(iii) an antibody which comprises an H chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 21 to 23, respectively, and comprises an L chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 24 to 26, respectively.

(1a) A monoclonal antibody or an antigen-binding fragment thereof, which binds to the amino acid sequences at positions 67 to 105, positions 67 to 96 or positions 67 to 87 in the amino acid sequence of IgV domain of human TIM-3 represented by SEQ ID NO: 53, wherein said monoclonal antibody or antigen-binding fragment thereof competes with one or more of the following antibodies:

(i) an antibody which comprises a heavy (H) chain of an antibody which comprises complementary determining regions (CDRs) 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 1 to 3, respectively, and comprises a light (L) chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 4 to 6, respectively,

(ii) an antibody which comprises an H chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 11 to 13, respectively, and comprises an L chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 14 to 16, respectively,

(iii) an antibody which comprises an H chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 21 to 23, respectively, and comprises an L chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 24 to 26, respectively;

(iv) an antibody which comprises a variable heavy chain (VH) of an antibody comprising the amino acid sequence represented by SEQ ID NO: 116 and comprises a variable light chain (VL) of an antibody comprising the amino acid sequence represented by SEQ ID NO: 117; and

(v) an antibody which comprises a VH of an antibody comprising the amino acid sequence represented by SEQ ID NO: 118 and comprises a VL of an antibody comprising the amino acid sequence represented by SEQ ID NO: 119.

(1b) A monoclonal antibody or an antigen-binding fragment thereof, which binds to the amino acid sequences at positions 67 to 105, positions 67 to 96 or positions 67 to 87 in the amino acid sequence of IgV domain of human TIM-3 represented by SEQ ID NO: 53, wherein said monoclonal antibody or antigen-binding fragment thereof comprises:

5 (i) heavy (H) chain complementarity determining regions (CDRs) 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 1 to 3, respectively, and light (L) chain CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 4 to 6, respectively, or

(ii) a variable heavy chain (VH) comprising the amino acid sequence represented by SEQ ID NO: 116 and a variable light chain (VL) comprising the amino acid sequence represented by SEQ ID NO: 117.

(2) The monoclonal antibody or the antibody fragment thereof described in the above (1), wherein the monoclonal antibody binds to the same epitope to which one antibody selected from the above (i) to (iii) binds.

15 (3) A monoclonal antibody or an antibody fragment thereof, which binds to an extracellular region of human TIM-3 while competing with one antibody selected from the following (a) and (b):

(a) an antibody which comprises VH of an antibody comprising the amino acid sequence represented by SEQ ID NO: 8 and comprises VL of an antibody comprising the amino acid sequence represented by SEQ ID NO: 10,

(b) an antibody which comprises VH of an antibody comprising the amino acid sequence represented by SEQ ID NO: 18 and comprises VL of an antibody comprising the amino acid sequence represented by SEQ ID NO: 20.

(4) The monoclonal antibody or the antibody fragment thereof described in the above (3), which binds to the same epitope to which one antibody selected from the above (a) or (b) binds.

(5) The monoclonal antibody or the antibody fragment thereof described in any one of the above (1) to (4), which is a recombinant antibody.

30 (6) The monoclonal antibody or the antibody fragment thereof described in the above (5), which is a recombinant antibody selected from a human chimeric antibody, a humanized antibody and a human antibody.

(7) A monoclonal antibody or an antibody fragment thereof, which is one selected from the following (i) to (iii):

35 (i) a monoclonal antibody and an antibody fragment thereof which comprises an H chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 1 to 3, respectively, and comprises an L chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 4 to 6, respectively,

(ii) a monoclonal antibody and an antibody fragment thereof which comprises an H chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 11 to 13, respectively, and comprises an L chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 14 to 16, respectively,

(iii) a monoclonal antibody and an antibody fragment thereof which comprises an H chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 21 to 23, respectively, and comprises an L chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 24 to 26, respectively.

(8) A monoclonal antibody and an antibody fragment thereof, which is one selected from the following (a) and (b):

(a) a monoclonal antibody and an antibody fragment thereof which comprises VH of an antibody comprising the amino acid sequence represented by SEQ ID NO: 8 and comprises VL of an antibody comprising the amino acid sequence represented by SEQ ID NO: 10,

(b) a monoclonal antibody and an antibody fragment thereof which comprises VH of an antibody comprising the amino acid sequence represented by SEQ ID NO: 18 and comprises VL of an antibody comprising the amino acid sequence represented by SEQ ID NO: 20.

(8a) A monoclonal antibody and an antibody fragment thereof, which is one selected from the following (a) and (b):

(a) a monoclonal antibody and an antibody fragment thereof which comprises VH of an antibody comprising the amino acid sequence represented by SEQ ID NO: 116 and comprises VL of an antibody comprising the amino acid sequence represented by SEQ ID NO: 117,

(b) a monoclonal antibody and an antibody fragment thereof which comprises VH of an antibody comprising the amino acid sequence represented by SEQ ID NO: 118 and comprises VL of an antibody comprising the amino acid sequence represented by SEQ ID NO: 119.

(9) A monoclonal antibody and an antibody fragment thereof which binds to the amino acid sequences at positions 67 to 105, the amino acid sequences at positions 67 to 96 or the amino acid sequences at positions 67 to 87 in the amino acid sequence of IgV domain of human TIM-3 represented by SEQ ID NO: 53.

(10) The antibody fragment described in any one of the above (1) to (9), wherein the antibody fragment is an antibody fragment selected from Fab, Fab', F(ab')₂, a single chain antibody (scFv), a dimerized V region (diabody), a disulfide stabilized V region (dsFv) and a peptide comprising CDR.

5 (11) A DNA which encodes the monoclonal antibody or the antibody fragment thereof described in any one of the above (1) to (10).

(12) A recombinant vector which comprises the DNA described in the above (11).

10 (13) A transformant obtainable by introducing the recombinant vector described in the above (12) into a host cell.

(14) A process for producing the monoclonal antibody or the antibody fragment thereof described in any one of the above (1) to (10), which comprises culturing the transformant described in the above (13) in culture to form and accumulate the

monoclonal antibody or the antibody fragment thereof described in any one of the above (1) to (10), and recovering the monoclonal antibody or the antibody fragment thereof from the culture.

5 (15) A method for immunologically detecting or measuring a human TIM-3 which comprises using the monoclonal antibody or the antibody fragment thereof described in any one of the above (1) to (10).

(15a) A method for immunologically detecting or measuring a human TIM-3 in a sample, the method comprising:

- 10 - contacting the sample with the monoclonal antibody or the antigen-binding fragment thereof according to any one of the above (1) to (10); and
- detecting or measuring the human TIM-3 on the basis of the reactivity of the monoclonal antibody or the antigen-binding fragment thereof with the sample.

(16) A reagent for detecting or measuring a human TIM-3 which comprises the monoclonal antibody or the antibody fragment thereof described in any one of the above
15 (1) to (10).

(16a) A detection agent for detecting or measuring a human TIM-3 which comprises the monoclonal antibody or the antigen-binding fragment thereof according to any one of the above (1) to (10), and a detection compatible reagent.

20 (17) A diagnostic agent for a disease relating to a human TIM-3 positive cell which comprises the monoclonal antibody or the antibody fragment thereof described in any one of the above (1) to (10).

(17a) A diagnostic agent for a disease relating to a human TIM-3 positive cell which comprises the monoclonal antibody or the antigen-binding fragment thereof described in any one of the above (1) to (10), and a diagnostic compatible reagent.

25 (18) A method for diagnosing a disease relating to a human TIM-3 positive cell which comprises detect or measure a human TIM-3 positive cell using the monoclonal antibody or the antibody fragment thereof described in any one of the above (1) to (10).

30 (18a) An *in vitro* method for diagnosing a disease relating to a human TIM-3 positive cell, which comprises detecting or measuring a human TIM-3 positive cell using (i) the monoclonal antibody or the antigen-binding fragment thereof described in any one of the above (1) to (10), or (ii) the diagnostic agent according to the above (17).

(19) A method for diagnosing a disease relating to a human TIM-3 positive cell, which comprises detecting or measuring a human TIM-3 using the monoclonal antibody or the antibody fragment thereof described in any one of the above (1) to (10).

35 (20) Use of the monoclonal antibody or the antibody fragment thereof described in any one of the above (1) to (10) for the manufacture of a diagnostic agent for a disease relating to a human TIM-3 positive cell.

(21a) Use of the monoclonal antibody or the antigen-binding fragment thereof described in any one of the above (1) to (10) for diagnosis of a disease relating to a human TIM-3 positive cell.

5 (21) A therapeutic agent for a disease relating to a human TIM-3 positive cell, which comprises the monoclonal antibody or the antibody fragment thereof described in any one of the above (1) to (10).

(21a) A pharmaceutical composition for treating a disease relating to a human TIM-3 positive cell, which comprises the monoclonal antibody or the antigen-binding fragment thereof described in any one of the above (1) to (10), and one or more
10 pharmaceutically acceptable carriers.

(22) A therapeutic method for a disease relating to a human TIM-3 positive cell, which comprises inducing cell death of a human TIM-3 positive cell using the monoclonal antibody or the antibody fragment thereof described in any one of the above (1) to (10).

15 (23) Use of the monoclonal antibody or the antibody fragment thereof described in any one of the above (1) to (10) for the manufacture of a therapeutic agent for a disease relating to a human TIM-3 positive cell.

Effects of the Invention

20 [0015]

The monoclonal antibody or the antibody fragment of the present invention specifically recognizes the amino acid sequence or the three-dimensional structure of the extracellular region of human TIM-3, and binds to the extracellular region. The

amino acid sequence or the three-dimensional structure of the extracellular region of human TIM-3 which is recognized by the monoclonal antibody or the antibody fragment of the present invention is different from those recognized by known anti-TIM-3 monoclonal antibodies. Therefore, the monoclonal antibody or the antibody fragment of the present invention has higher ADCC activity. The monoclonal antibody or the antibody fragment of the present invention which specifically binds to the extracellular region of human TIM-3 and has higher ADCC activity is useful as a therapeutic agent and a diagnostic agent for a disease relating to a human TIM-3 positive cell.

10 [0016]

The present invention may provide a hybridoma which produces the antibody; a DNA which encodes the antibody; a vector which comprises the DNA; a transformant obtained by transforming the vector; a process for producing an antibody or an antibody fragment thereof using the hybridoma or the transformant; and a diagnostic agent or a therapeutic agent using the antibody or the antibody fragment thereof.

Brief Description of the Drawings

[0017]

[Fig. 1] Fig. 1 is the amino acid sequences which represent HV0, HV3, HV4, HV5, HV6, HV7, HV8, HV10, and HV12 of the designed H chain variable regions of antibody 8213, respectively.

[Fig. 2] Fig. 2 is the amino acid sequences which represent LV0, LV2, LV4, LV5, LV6, LV7, and LV9 of the designed L chain variable regions of antibody 8213.

25 Embodiments for Carrying Out the Invention

[0018]

The human TIM-3 of the present invention include a polypeptide comprising the amino acid sequence represented by SEQ ID NO: 53 or NCBI Accession No. NM_032782, and having a function of TIM-3; a polypeptide comprising an amino acid sequence having at least 60% homology, preferably at least 80% homology, more preferably at least 90% homology, and most preferably at least 95% homology, with the amino acid sequence represented by SEQ ID NO: 53 or NCBI Accession No. NM_032782, and having a function of TIM-3; and the like.

[0019]

35 The polypeptide comprising an amino acid sequence wherein one or more amino acid residue(s) is/are deleted, substituted and/or added in the amino acid

sequence represented by SEQ ID NO: 53 or NCBI Accession No. NM_032782 can be obtained, for example, by introducing a site-directed mutation into DNA encoding the polypeptide comprising the amino acid sequence represented by SEQ ID NO: 53 by site-directed mutagenesis described in *Molecular Cloning, A Laboratory Manual*,
 5 Second Edition (Cold Spring Harbor Laboratory Press, 1989), *Current Protocols in Molecular Biology* (John Wiley & Sons, 1987-1997), *Nucleic Acids Research*, 10, 6487 (1982), *Proc. Natl. Acad. Sci. USA*, 79, 6409 (1982), *Gene*, 34, 315 (1985), *Proc. Natl. Acad. Sci. USA*, 82, 488 (1985), or the like.

[0020]

10 The number of amino acid residues which are deleted, substituted or added is not particularly limited, and the number is preferably, 1 to dozens, such as 1 to 20, and more preferably 1 to several, such as 1 to 5.

[0021]

As a gene which encodes human TIM-3, examples include the nucleotide
 15 sequence represented by SEQ ID NO: 52 or NCBI Accession No. NM_032782. Examples also include a gene comprising a nucleotide sequence in which at least one nucleotide is deleted, substituted or added in the nucleotide sequence represented by SEQ ID NO: 52 or NCBI Accession No. NM_032782 and comprising a DNA encoding a polypeptide having a function of TIM-3; a gene comprising an nucleotide sequence
 20 having at least 60% homology, preferably at least 80% homology, and more preferably at least 95% homology, with the nucleotide sequence represented by SEQ ID NO: 52 or NCBI Accession No. NM_032782 and comprising a DNA encoding a polypeptide having a function of TIM-3; a gene which hybridizes with the DNA consisting of the nucleotide sequence represented by SEQ ID NO: 52 or NCBI Accession No.
 25 NM_032782 under stringent conditions and encodes a polypeptide having a function of TIM-3; and the like.

[0022]

In the present invention, the DNA which hybridizes under stringent conditions refers to a DNA which is obtained by colony hybridization, plaque hybridization,
 30 Southern blot hybridization, DNA microarray analysis, or the like using a DNA consisting of the nucleotide sequence represented by SEQ ID NO: 52 or NCBI Accession No. NM_032782 as a probe.

[0023]

A specific example of such DNA is a DNA which can be identified by
 35 performing hybridization at 65°C in the presence of 0.7 to 1.0 mol/L sodium chloride using a filter or a slide glass with colony- or plaque-derived DNA, PCR products or oligo DNA encoding the DNA sequence immobilized thereon, and then washing the

filter or a slide glass at 65°C with a 0.1 to 2-fold concentration SSC solution (1-fold concentration SSC solution: 150 mmol/L sodium chloride and 15 mmol/L sodium citrate). Hybridization can be carried out according to the methods described in *Molecular Cloning, A Laboratory Manual*, Second Edition, Cold Spring Harbor Laboratory Press (1989), *Current Protocols in Molecular Biology*, John Wiley & Sons (1987-1997); *DNA Cloning 1: Core Techniques, A Practical Approach*, Second Edition, Oxford University (1995); and the like.

[0024]

Specifically, the DNA capable of hybridization includes DNA having at least 60% or more homology, preferably 80% or more homology, and more preferably 95% or more homology to the nucleotide sequence represented by SEQ ID NO: 52 or NCBI Accession No. NM_032782.

[0025]

In the nucleotide sequence of the gene encoding a protein of a eukaryote, genetic polymorphism is often recognized. The TIM-3 gene used in the present invention also includes a gene in which small modification is generated in the nucleotide sequence by such polymorphism.

[0026]

The number of the homology described in the present invention may be a number calculated by using a homology search program known by the skilled person, unless otherwise indicated. Regarding the nucleotide sequence, the number may be calculated by using a default parameter in BLAST [*J. Mol. Biol.*, 215, 403 (1990)] or the like, and regarding the amino acid sequence, the number may be calculated by using a default parameter in BLAST2 [*Nucleic Acids Res.*, 25, 3389 (1997); *Genome Res.*, 7, 649 (1997); <http://www.ncbi.nlm.nih.gov/Education/BLASTinfo/information3.html>] or the like.

[0027]

As the default parameter, G (cost to open gap) is 5 for the nucleotide sequence and 11 for the amino acid sequence; -E (cost to extend gap) is 2 for the nucleotide sequence and 1 for the amino acid sequence; -q (penalty for nucleotide mismatch) is -3; -r (reward for nucleotide match) is 1; -e (expect value) is 10; -W (wordsize) is 11 residues for the nucleotide sequence and 3 residues for the amino acid sequence; -y (Dropoff (X) for blast extensions in bits) is 20 for blastn and 7 for a program other than blastn; -X (X dropoff value for gapped alignment in bits) is 15; and Z (final X dropoff value for gapped alignment in bits) is 50 for blastn and 25 for a program other than blastn (<http://www.ncbi.nlm.nih.gov/blast/html/blastcgihelp.html>).

[0028]

The polypeptide comprising a partial sequence of the amino acid sequence represented by SEQ ID NO: 53 or NCBI Accession No. NM_032782 can be prepared according to a method known by the skilled person. For example, it can be prepared by deleting a part of DNA encoding the amino acid sequence represented by SEQ ID
5 NO: 52 and culturing a transformant into which an expression vector containing the DNA is introduced.
[0029]

Also, based on the thus prepared polypeptide or DNA, a polypeptide comprising an amino acid sequence in which one or more amino acid(s) is/are deleted,
10 substituted or added in a partial sequence of the amino acid sequence represented by SEQ ID NO: 53 or NCBI Accession No. NM_032782 can be prepared in the same manner as described above.
[0030]

The polypeptide comprising a partial sequence of the amino acid sequence represented by SEQ ID NO: 53 or NCBI Accession No. NM_032782; or the polypeptide
15 comprising an amino acid sequence in which at least one amino acid is deleted, substituted or added in a partial sequence of the amino acid sequence represented by SEQ ID NO: 53 or NCBI Accession No. NM_032782 can also be produced by a chemical synthesis method such as fluorenylmethoxycarbonyl (Fmoc) method or
20 t-butyloxycarbonyl (tBoc) method.
[0031]

The extracellular region of human TIM-3 of the present invention includes, for example, regions predicted by using the amino acid sequence of the polypeptide represented by SEQ ID NO: 53 with conventionally known transmembrane region
25 prediction program SOSUI .
[0032]

In the present invention, the amino acid sequence of extracellular region of human TIM-3 includes the amino acid sequence at positions 1 to 201 in the amino acid sequence represented by SEQ ID NO: 53, which is the region of the extracellular region
30 predicted by SMART.
[0033]

In the present invention, the three-dimensional structure of the extracellular region of human TIM-3 is not limited, so long as the extracellular region of human TIM-3 comprising the amino acid sequence represented by SEQ ID NO: 53 or GenBank
35 accession number NM_032782 has the same structure as in the natural state. The

three-dimensional structure of the extracellular region of human TIM-3 in the natural state is a natural type of the three-dimensional structure of human TIM-3 expressed on the surface of the cell membrane.

[0034]

5 Regarding the function of human TIM-3, binding of TIM-3 with a protein ligand (e.g., galectin 9) can inhibit the Th1 response thorough mechanism such as apoptosis induction in Th1 cells, therefore leading to induction of peripheral tolerance. In phagocytes, human TIM-3 functions as a receptor for recognizing the apoptosis cells.

[0035]

10 Binding of the antibody or antibody fragment thereof in the present invention to an amino acid sequence of an extracellular region of human TIM-3 or a three-dimensional structure thereof can be confirmed by a conventionally known immunological immunological detection method using human TIM-3 expressing cells such as a radioimmuno assay with a solid phase sandwich method or enzyme-linked
15 immunosorbent assay (ELISA), and preferably a fluorescent cell staining method in which the binding ability of a cell expressing a specified antigen and an antibody for the specific antigen is confirmed.

[0036]

 Specific examples include a fluorescent antibody staining method using an
20 FMAT8100HTS System (manufactured by Applied Biosystems) [*Cancer Immunol. Immunother.*, 36, 373 (1993)] or the like, a fluorescent cell staining method using flow cytometry, surface plasmon resonance using a Biacore™ System (manufactured by GE Healthcare) or the like, and the like.

[0037]

25 Furthermore, a known immunological detection methods [*Monoclonal Antibodies - Principles and practice*, Third edition, Academic Press (1996), *Antibodies - A Laboratory Manual*, Cold Spring Harbor Laboratory (1988), *Monoclonal Antibody Experimental Manual*, Kodan-sha Scientific (1987)] and the like can be combined to confirm the binding.

30 [0038]

 In the present invention, the cell expressing human TIM-3 may be any cell, so long as it expresses human TIM-3, and examples include a cell which is naturally present in the human body, a cell line established from the cell which is naturally present in the human body, a cell obtained by a recombinant technique and the like.

35 [0039]

 Example of the cell which is naturally present in the human body includes a cell expressing the TIM-3 in the body of a patient suffering from cancer, autoimmune

disease or allergic disease, concretely, the cells are Th1 cells, macrophages, dendritic cells, and the like.

[0040]

Example of a cell line established from the cell which is naturally present in the human body include a cell line expressing human TIM-3, among cell lines prepared by establishing the human TIM-3-expressing cells obtained from the above cancer patients, and examples include human acute myeloid leukemia cell line KG-1 (ATCC Accession No: CCL-246), human Burkitt's lymphoma cell line Daudi (ATCC Accession No: CCL-213) which are established from a human cell and the like.

10 [0041]

Specific examples of the cell obtained by a recombinant technique may include a human TIM-3-expressing cell obtained by introducing an expression vector comprising a human TIM-3-encoding cDNA into an insect cell, an animal cell or the like, and others.

15 [0042]

In addition, the present invention relates to a monoclonal antibody which recognizes an amino acid sequence or a three-dimensional structure of an extracellular region of human TIM-3 and exhibits ADCC activity.

[0043]

20 The ADCC activity of the present invention is a reaction in which an antibody which is bound to human TIM-3 on the cell surface is bound to FcγRIIIa on the surface of mainly a natural killer cell (hereinafter referred to as NK cell) through Fc region and therefore a cytotoxic molecule such as molecules perforin, and granzyme released from an NK cell leads to cell lysis [Clark M, Chemical Immunology, 65, 88 (1997); Gorter A *et al.*, Immunol. Today, 20, 576 (1999)].

25

[0044]

The antibody of the present invention may be any antibodies as long as it is an antibody or antibody fragment thereof which recognizes an amino acid sequence of an extracellular region of human TIM-3 or a three-dimensional structure thereof and binds to the extracellular region; or an antibody or antibody fragment thereof which binds an extracellular region of human TIM-3 or a three-dimensional structure thereof and have ADCC activity.

30

[0045]

Specific example of the antibody of the present invention may include an antibody which binds to the amino acid sequence selected from sequences preferably at positions 67 to 105, more preferably at positions 67 to 96, and most preferably at positions 67 to 87 among the amino acid sequence of extracellular region of human

35

TIM-3 comprising of the sequence at positions 1 to 201 in the sequence represented by SEQ ID NO: 53, or the three-dimensional structure thereof.

[0046]

5 The example of the antibody includes the monoclonal antibody and the antibody fragment thereof as described in the following (i) to (iii):

(i) a monoclonal antibody or an antibody fragment thereof which comprises a heavy chain (hereinafter referred to as "H chain") of an antibody which comprises complementary determining regions (hereinafter referred to as "CDR") 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 1 to 3, respectively, and comprises a light chain (hereinafter referred to as "L chain") of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 4 to 6, respectively.

(ii) a monoclonal antibody or an antibody fragment thereof which comprises an H chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 11 to 13, respectively, and comprises an L chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 14 to 16, respectively.

(iii) a monoclonal antibody or an antibody fragment thereof which comprises an H chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 21 to 23, respectively, and comprises an L chain of an antibody which comprises CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 24 to 26, respectively.

[0047]

25 The example of the monoclonal antibody includes a monoclonal antibody and an antibody fragment thereof as described in the following (a) and (b):

(a) a monoclonal antibody and an antibody fragment thereof which comprises VH of an antibody comprising the amino acid sequence represented by SEQ ID NO: 8 and comprises VL of an antibody comprising the amino acid sequence represented by SEQ ID NO: 10,

30 (b) a monoclonal antibody and an antibody fragment thereof which comprises VH of an antibody comprising the amino acid sequence represented by SEQ ID NO: 18 and comprises VL of an antibody comprising the amino acid sequence represented by SEQ ID NO: 20.

[0048]

35 In addition, the antibody of the present invention include a monoclonal antibody or an antibody fragment thereof which competes with the above monoclonal antibody in the binding of an amino acid sequence of an extracellular region of human

TIM-3 or a three-dimensional structure thereof; and a monoclonal antibody or an antibody fragment thereof which binds to the same epitope existing on the extracellular region of human TIM-3 to which the above monoclonal antibody binds.

[0049]

5 In the present invention, an antibody which compete with a monoclonal antibody means an antibody which recognizes the same or a part of the same epitope (also referred to as antigen determinant) on the extracellular region of human TIM-3 as the monoclonal antibody of the present invention, and binds to the epitope. The antibody which binds to the same epitope as the monoclonal antibody of the present
10 invention means an antibody which recognizes and binds to an amino acid sequence of human TIM-3 which the monoclonal antibody of the present invention recognizes.

[0050]

The monoclonal antibody of the present invention includes an antibody produced by a hybridoma and a recombinant antibody produced by a transformant
15 transformed with an expression vector containing a gene encoding an antibody.

[0051]

The monoclonal antibody is an antibody secreted by a single clone antibody-producing cell, and recognizes only one epitope (also called antigen determinant) and has uniform amino acid sequence (primary structure).

20 [0052]

Examples of the epitope include a single amino acid sequence, a three-dimensional structure comprising the amino acid sequence, a sugar chain-bound amino acid sequence, a three-dimensional structure comprising a sugar chain-bound amino acid sequence, and the like, recognized and bound by a monoclonal antibody.

25 [0053]

The monoclonal antibody of the present invention binds preferably to the amino acid sequence at positions 22 to 131 of the IgV domain of human TIM-3 in the extracellular regions of human TIM-3 represented by SEQ ID NO: 53. Specifically, the amino acid sequence to which the monoclonal antibody of the present invention
30 binds is preferably the amino acid sequence at positions 67 to 105, more preferably the amino acid sequence at positions 67 to 96, and most preferably the amino acid sequence at positions 67 to 87 in the amino acid sequence represented by SEQ ID NO: 53.

[0054]

The epitope to which the monoclonal antibody of the present invention binds
35 may preferably be included in the IgV domain of human TIM-3 represented by the amino acid sequence at positions 22 to 131 in the extracellular region of human TIM-3 represented by SEQ ID NO: 53. Specifically, the epitope to which the monoclonal

antibody of the present invention binds is preferably included in the amino acid sequence at positions 67 to 105, more preferably included in the amino acid sequence at positions 67 to 96, and most preferably included in the amino acid sequence at positions 67 to 87 in the amino acid sequence represented by SEQ ID NO: 53.

5 [0055]

The amino acid sequence of the epitope to which the monoclonal antibody of the present invention binds may preferably include at least one amino acid selected from the amino acid sequence at positions 67 to 87 in the amino acid sequence represented by SEQ ID NO: 53 in the IgV domain of human TIM-3, and more preferably include at least one amino acid selected from the amino acids at position 67, position 74, position 76, position 78, position 79, position 81, position 83 and position 85.

[0056]

The amino acid sequence of the epitope to which the monoclonal antibody of the present invention binds may preferably include at least two or more continuous amino acids selected from positions 67 to 87 of the human TIM-3 IgV domain; and more preferably may include at least one amino acid selected from the amino acids at position 67, position 74, position 76, position 78, position 79, position 81, position 83 and position 85 and include at least two or more continuous amino acids selected from the amino acid sequence at positions 67 to 87 in the amino acid sequence represented by SEQ ID NO: 53.

[0057]

Specifically, examples of the amino acid sequence of the epitope to which the monoclonal antibody of the present invention binds include the amino acid sequence comprising the amino acids at positions 67 to 74, the amino acid sequence comprising the amino acids at positions 67 to 76, the amino acid sequence comprising the amino acids at positions 67 to 78, the amino acid sequence comprising the amino acids at positions 67 to 79, the amino acid sequence comprising the amino acids at positions 67 to 81, the amino acid sequence comprising the amino acids at positions 67 to 83, the amino acid sequence comprising the amino acids at positions 67 to 85,

the amino acid sequence comprising the amino acids at positions 74 to 76, the amino acid sequence comprising the amino acids at positions 74 to 78, the amino acid sequence comprising the amino acids at positions 74 to 79, the amino acid sequence comprising the amino acids at positions 74 to 81, the amino acid sequence comprising the amino acids at positions 74 to 83, the amino acid sequence comprising the amino acids at positions 74 to 85,

the amino acid sequence comprising the amino acids at positions 76 to 78, the amino acid sequence comprising the amino acids at positions 76 to 79, the amino acid

sequence comprising the amino acids at positions 76 to 81, the amino acid sequence comprising the amino acids at positions 76 to 83, the amino acid sequence comprising the amino acids at positions 76 to 85, the amino acid sequence comprising the amino acids at positions 78 to 79, the amino acid sequence comprising the amino acids at positions 78 to 81, the amino acid sequence comprising the amino acids at positions 78 to 83, the amino acid sequence comprising the amino acids at positions 78 to 85,

the amino acid sequence comprising the amino acids at positions 79 to 81, the amino acid sequence comprising the amino acids at positions 79 to 83, the amino acid sequence comprising the amino acids at positions 79 to 85,

the amino acid sequence comprising the amino acids at position 81 to 83, the amino acid sequence comprising the amino acids at positions 81 to 85,

the amino acid sequence comprising the amino acids at positions 83 to 85, and the like,

in the amino acid sequence represented by SEQ ID NO: 53.

[0058]

The hybridoma can be prepared, for example, by preparing the above cell expressing TIM-3 as an antigen, inducing an antibody-producing cell having antigen specificity from an animal immunized with the antigen, and fusing the antibody-producing cell with a myeloma cell. The anti-TIM-3 antibody can be obtained by culturing the hybridoma or administering the hybridoma cell into an animal to cause ascites tumor in the animal and separating and purifying the culture or the ascites.

[0059]

The animal immunized with an antigen may be any animal, so long as a hybridoma can be prepared, and mouse, rat, hamster, chicken, rabbit or the like is suitably used. Also, the cell having antibody-producing activity can be obtained from such an animal, and the antibody of the present invention includes an antibody produced by a hybridoma obtained by fusion of the cell after *in vitro* immunization with a myeloma cell.

[0060]

In the present invention, the recombinant antibody includes an antibody produced by gene recombination, such as a human chimeric antibody, a human CDR grafted antibody, a human antibody and an antibody fragment thereof. Among the recombinant antibodies, one having character of a common monoclonal antibody, low immunogenicity and prolonged half-life in blood is preferable as a therapeutic agent. Examples of the recombinant antibody include an antibody which is prepared by modifying the above monoclonal antibody of the present invention using a recombinant technique.

[0061]

The human chimeric antibody is an antibody comprising VH and VL of an antibody of a non-human animal, and a heavy chain constant region (hereinafter referred to as CH) and a light chain constant region (hereinafter referred to as CL) of a human antibody. Specifically, the human chimeric antibody of the present invention can be produced by obtaining cDNAs encoding VH and VL from a hybridoma which produces a monoclonal antibody which specifically recognizes human TIM-3 and binds to an amino acid sequence of extracellular region or a three-dimensional structure thereof, inserting each of them into an expression vector for animal cell comprising DNAs encoding CH and CL of human antibody to thereby construct a vector for expression of human chimeric antibody, and then introducing the vector into an animal cell to express the antibody.

[0062]

As the CH of the human chimeric antibody, any CH can be used, so long as it belongs to human immunoglobulin (hereinafter referred to as "hIg"), and those belonging to the hIgG class are preferred, and any one of the subclasses belonging to the hIgG class, such as hIgG1, hIgG2, hIgG3 and hIgG4, can be used. As the CL of the human chimeric antibody, any CL can be used, so long as it belongs to the hIg class, and those belonging to κ class or λ class can be used.

[0063]

Specific examples of the human chimeric antibody of the present invention includes a chimeric antibody which comprises VH of the antibody comprising the amino acid sequence represented by SEQ ID NO: 28 and comprises VL of the antibody comprising the amino acid sequence represented by SEQ ID NO: 30.

[0064]

In addition, the chimeric antibody of the present invention include a chimeric antibody which competes with the above monoclonal antibody in the binding of an extracellular region of human TIM-3 or a three-dimensional structure thereof; and a chimeric antibody which binds to the same epitope existing on the extracellular region of human TIM-3 to which the above chimeric antibody binds.

[0065]

The human CDR grafted antibody is also called as a humanized antibody and is an antibody in which CDR of VH and VL of a non-human animal antibody were grafted into the appropriate site of VH and VL of a human antibody. The human CDR grafted antibody of the present invention can be produced by constructing cDNAs encoding an antibody V region in which the amino acid sequences of CDRs of VH and VL of an antibody derived from a non-human animal produced by a hybridoma which produces a

monoclonal antibody which specifically recognizes three-dimensional structure of TIM-3 and binds to an amino acid sequence of the extracellular region or three-dimensional structure thereof are grafted into frameworks (hereinafter referred to as "FR") of VH and VL of a suitable human antibody, inserting each of them into an expression vector for animal cell comprising genes encoding CH and CL of a human antibody to thereby construct a vector for expression of humanized antibody, and introducing it into an animal cell to thereby express and produce the humanized antibody.

[0066]

As the CH of the human CDR grafted antibody, any CH can be used, so long as it belongs to human immunoglobulin (hereinafter referred to as "hIg"), and those belonging to the hIgG class are preferred, and any one of the subclasses belonging to the hIgG class, such as hIgG1, hIgG2, hIgG3 and hIgG4, can be used. As the CL of the human CDR grafted antibody, any CL can be used, so long as it belongs to the hIg class, and those belonging to κ class or λ class can be used.

[0067]

Examples of the CDR grafted antibody of the present invention include a humanized antibody in which CDRs 1 to 3 of VH of the antibody comprises the amino acid sequences represented by SEQ ID NO: 21, 22, and 23, respectively, and CDRs 1 to 3 of VL of the antibody comprises the amino acid sequences represented by SEQ ID NO: 24, 25, and 26, respectively.

[0068]

Specific examples of the humanized antibody include a humanized antibody comprising at least one of the following (a) VH and (b) VL:

(a) VH of the antibody comprising the amino acid sequence represented by SEQ ID NO: 67, or an amino acid sequence in which at least one amino acid residue selected from Lys at position 12, Val at position 20, Arg at position 38, Ala at position 40, Met at position 48, Arg at position 67, Val at position 68, Ile at position 70, Ala at position 72, Thr at position 74, Arg at position 98 and Val at position 113 in the amino acid sequence represented by SEQ ID NO: 67 is substituted with other amino acid residue(s),

(b) VL of the antibody comprising the amino acid sequence represented by SEQ ID NO: 69, or an amino acid sequence in which at least one amino acid residue selected from Leu at position 11, Ala at position 13, Val at position 15, Tyr at position 36, Ala at position 43, Pro at position 44, Leu at position 46, Phe at position 71 and Thr at position 85 in the amino acid sequence represented by SEQ ID NO: 69 is substituted with other amino acid residue(s).

[0069]

As the VH comprised in the humanized antibody, the following (1) to (8) are preferable:

(1) VH comprising an amino acid sequence in which Lys at position 12, Val at position 20, Arg at position 38, Ala at position 40, Met at position 48, Arg at position 67, Val at position 68, Ile at position 70, Ala at position 72, Thr at position 74, Arg at position 98 and Val at position 113 in the amino acid sequence represented by SEQ ID NO: 67 are substituted with other amino acid residues;

(2) VH comprising an amino acid sequence in which Lys at position 12, Arg at position 38, Ala at position 40, Met at position 48, Arg at position 67, Val at position 68, Ile at position 70, Ala at position 72, Thr at position 74 and Arg at position 98 in the amino acid sequence represented by SEQ ID NO: 67 are substituted with other amino acid residues;

(3) VH comprising an amino acid sequence in which Val at position 20, Arg at position 38, Met at position 48, Val at position 68, Ile at position 70, Ala at position 72, Arg at position 98 and Val at position 113 in the amino acid sequence represented by SEQ ID NO: 67 are substituted with other amino acid residues;

(4) VH comprising an amino acid sequence in which Arg at position 38, Ala at position 40, Met at position 48, Arg at position 67, Ala at position 72, Thr at position 74 and Arg at position 98 in the amino acid sequence represented by SEQ ID NO: 67 are substituted with other amino acid residues;

(5) VH comprising an amino acid sequence in which Lys at position 12, Arg at position 67, Val at position 68, Ala at position 72, Thr at position 74 and Arg at position 98 in the amino acid sequence represented by SEQ ID NO: 67 are substituted with other amino acid residues;

(6) VH comprising an amino acid sequence in which Arg at position 38, Ala at position 40, Met at position 48, Arg at position 67 and Arg at position 98 in the amino acid sequence represented by SEQ ID NO: 67 are substituted with other amino acid residues,

(7) VH comprising an amino acid sequence in which Arg at position 38, Met at position 48, Arg at position 67 and Thr at position 74 in the amino acid sequence represented by SEQ ID NO: 67 are substituted with other amino acid residues; and

(8) VH comprising an amino acid sequence in which Arg at position 38, Met at position 48 and Arg at position 98 in the amino acid sequence represented by SEQ ID NO: 67 are substituted with other amino acid residues.

[0070]

The amino acid sequence of the above VH obtained by the amino acid modifications includes an amino acid sequence in which at least one modification

among amino acid modifications for substituting Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys, Arg at position 98 with Gly or Val at position 113 with Leu is introduced in the amino acid sequence represented by SEQ ID NO: 67.
[0071]

Specific examples of the amino acid sequence of VH in which twelve modifications are introduced include an amino acid sequence in which substitutions of Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67.
[0072]

Examples of the amino acid sequence of VH in which eleven modifications are introduced include the following amino acid sequence (1) to (12):

(1) an amino acid sequence in which substitutions of Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(2) an amino acid sequence in which substitutions of Lys at position 12 with Val, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(3) an amino acid sequence in which substitutions of Lys at position 12 with Val, Val at position 20 with Leu, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(4) an amino acid sequence in which substitutions of Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Met at position 48 with

Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

5 (5) an amino acid sequence in which substitutions of Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence
10 represented by SEQ ID NO: 67;

(6) an amino acid sequence in which substitutions of Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys, Arg at position 98 with Gly and
15 Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(7) an amino acid sequence in which substitutions of Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys, Arg at position 98 with Gly and
20 Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(8) an amino acid sequence in which substitutions of Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ala at position 72 with Val, Thr at position 74 with Lys, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence represented
25 by SEQ ID NO: 67;

(9) an amino acid sequence in which substitutions of Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Thr at position 74 with Lys, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence represented
30 by SEQ ID NO: 67;

(10) an amino acid sequence in which substitutions of Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with
35

Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(11) an amino acid sequence in which substitutions of Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys and Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67; and

(12) an amino acid sequence in which substitutions of Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67.

[0073]

Specific examples of the amino acid sequence of VH in which ten modifications are introduced include the following amino acid sequence (1) to (8):

(1) an amino acid sequence in which substitutions of Lys at position 12 with Val, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(2) an amino acid sequence in which substitutions of Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(3) an amino acid sequence in which substitutions of Val at position 20 with Leu, Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(4) an amino acid sequence in which substitutions of Lys at position 12 with Val, Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys, Arg at position 98 with Gly and Val at position 113 with

Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(5) an amino acid sequence in which substitutions of Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(6) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(7) an amino acid sequence in which substitutions of Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67; and

(8) an amino acid sequence in which substitutions of Lys at position 12 with Val, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67.

[0074]

Examples of the amino acid sequence of VH in which eight modifications are introduced include the following amino acid sequence (1) to (13):

(1) an amino acid sequence in which substitutions of Val at position 20 with Leu, Arg at position 38 with Lys, Met at position 48 with Ile, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(2) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(3) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Arg at position 98 with Gly and

Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(4) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(5) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(6) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(7) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(8) an amino acid sequence in which substitutions of Val at position 20 with Leu, Arg at position 38 with Lys, Met at position 48 with Ile, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(9) an amino acid sequence in which substitutions of Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(10) an amino acid sequence in which substitutions of Val at position 20 with Leu, Arg at position 38 with Lys, Met at position 48 with Ile, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Arg at position 98 with Gly and Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(11) an amino acid sequence in which substitutions of Lys at position 12 with Val, Arg at position 38 with Lys, Met at position 48 with Ile, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by
5 SEQ ID NO: 67;

(12) an amino acid sequence in which substitutions of Lys at position 12 with Val, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val and Arg at position 98 with Gly are introduced in the amino acid sequence represented
10 by SEQ ID NO: 67; and

(13) an amino acid sequence in which substitutions of Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Met at position 48 with Ile, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val and Arg at position 98 with Gly are introduced in the amino acid sequence represented
15 by SEQ ID NO: 67.

[0075]

Specific examples of the amino acid sequence of VH in which seven modifications are introduced include the following amino acid sequence (1) to (11):

(1) an amino acid sequence in which substitutions of Arg at position 38 with
20 Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(2) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Val at position 68 with Ala, Ile at position 70 with Leu,
25 Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(3) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly
30 are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(4) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly
are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(5) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val and Arg at position 98 with Gly
35

are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(6) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(7) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Val at position 68 with Ala, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(8) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(9) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(10) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Ile at position 70 with Leu, Ala at position 72 with Val and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67; and

(11) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ala at position 72 with Val and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67.

[0076]

Specific Examples of the amino acid sequence of VH in which six modifications are introduced include the following amino acid sequence (1) to (16):

(1) an amino acid sequence in which substitutions of Lys at position 12 with Val, Arg at position 67 with Lys, Val at position 68 with Ala, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(2) an amino acid sequence in which substitutions of Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(3) an amino acid sequence in which substitutions of Lys at position 12 with

Val, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(4) an amino acid sequence in which substitutions of Lys at position 12 with Val, Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(5) an amino acid sequence in which substitutions of Lys at position 12 with Val, Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Ala at position 72 with Val and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(6) an amino acid sequence in which substitutions of Lys at position 12 with Val, Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(7) an amino acid sequence in which substitutions of Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(8) an amino acid sequence in which substitutions of Val at position 20 with Leu, Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(9) an amino acid sequence in which substitutions of Val at position 20 with Leu, Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Ala at position 72 with Val and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(10) an amino acid sequence in which substitutions of Val at position 20 with Leu, Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(11) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(12) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with

Lys, Ala at position 72 with Val and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(13) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(14) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ala at position 72 with Val and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(15) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67; and

(16) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Ala at position 72 with Val, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67.

[0077]

Specific examples of the amino acid sequence of VH in which five modifications are introduced include the following amino acid sequence (1) to (7):

(1) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(2) an amino acid sequence in which substitutions of Lys at position 12 with Val, Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(3) an amino acid sequence in which substitutions of Val at position 20 with Leu, Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(4) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(5) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Ile at position 70 with Leu and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

5 (6) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Ala at position 72 with Val and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67; and

10 (7) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys, Thr at position 74 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67.

[0078]

15 Specific examples of the amino acid sequence of VH in which four modifications are introduced include the following amino acid sequence (1) to (8):

(1) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys and Thr at position 74 with Lys are introduced in the amino acid sequence represented by SEQ ID NO: 67;

20 (2) an amino acid sequence in which substitutions of Lys at position 12 with Val, Arg at position 38 with Lys, Met at position 48 with Ile and Arg at position 67 with Lys are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(3) an amino acid sequence in which substitutions of Val at position 20 with Leu, Arg at position 38 with Lys, Met at position 48 with Ile and Arg at position 67 with Lys are introduced in the amino acid sequence represented by SEQ ID NO: 67;

25 (4) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile and Arg at position 67 with Lys are introduced in the amino acid sequence represented by SEQ ID NO: 67;

30 (5) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys and Val at position 68 with Ala are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(6) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys and Ile at position 70 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

35 (7) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile, Arg at position 67 with Lys and Ala at position 72 with Val are introduced in the amino acid sequence represented by SEQ ID NO: 67; and

(8) an amino acid sequence in which substitutions of Arg at position 38 with

Lys, Met at position 48 with Ile, Arg at position 67 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67.

[0079]

Specific examples of the amino acid sequence of VH in which three
5 modifications are introduced include the following amino acid sequence (1) to (9):

(1) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(2) an amino acid sequence in which substitutions of Lys at position 12 with
10 Val, Arg at position 38 with Lys and Met at position 48 with Ile are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(3) an amino acid sequence in which substitutions of Val at position 20 with Leu, Arg at position 38 with Lys and Met at position 48 with Ile are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(4) an amino acid sequence in which substitutions of Arg at position 38 with
15 Lys, Ala at position 40 with Arg and Met at position 48 with Ile are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(5) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile and Arg at position 67 with Lys are introduced in the
20 amino acid sequence represented by SEQ ID NO: 67;

(6) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile and Val at position 68 with Ala are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(7) an amino acid sequence in which substitutions of Arg at position 38 with
25 Lys, Met at position 48 with Ile and Ile at position 70 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(8) an amino acid sequence in which substitutions of Arg at position 38 with Lys, Met at position 48 with Ile and Ala at position 72 with Val are introduced in the amino acid sequence represented by SEQ ID NO: 67; and

(9) an amino acid sequence in which substitutions of Arg at position 38 with
30 Lys, Met at position 48 with Ile and Thr at position 74 with Lys are introduced in the amino acid sequence represented by SEQ ID NO: 67;

[0080]

Specific examples of the amino acid sequence of VH in which two
35 modifications are introduced include the following amino acid sequence (1) to (21):

(1) an amino acid sequence in which substitutions of Lys at position 12 with Val and Arg at position 38 with Lys are introduced in the amino acid sequence

represented by SEQ ID NO: 67;

(2) an amino acid sequence in which substitutions of Val at position 20 with Leu and Arg at position 38 with Lys are introduced in the amino acid sequence represented by SEQ ID NO: 67;

5 (3) an amino acid sequence in which substitutions of Arg at position 38 with Lys and Ala at position 40 with Arg are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(4) an amino acid sequence in which substitutions of Arg at position 38 with Lys and Met at position 48 with Ile are introduced in the amino acid sequence
10 represented by SEQ ID NO: 67;

(5) an amino acid sequence in which substitutions of Arg at position 38 with Lys and Arg at position 67 with Lys are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(6) an amino acid sequence in which substitutions of Arg at position 38 with Lys and Val at position 68 with Ala are introduced in the amino acid sequence
15 represented by SEQ ID NO: 67;

(7) an amino acid sequence in which substitutions of Arg at position 38 with Lys and Ile at position 70 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

20 (8) an amino acid sequence in which substitutions of Arg at position 38 with Lys and Ala at position 72 with Val are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(9) an amino acid sequence in which substitutions of Arg at position 38 with Lys and Thr at position 74 with Lys are introduced in the amino acid sequence
25 represented by SEQ ID NO: 67;

(10) an amino acid sequence in which substitutions of Arg at position 38 with Lys and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(11) an amino acid sequence in which substitutions of Arg at position 38 with Lys and Val at position 113 with Leu are introduced in the amino acid sequence
30 represented by SEQ ID NO: 67;

(12) an amino acid sequence in which substitutions of Lys at position 12 with Val and Met at position 48 with Ile are introduced in the amino acid sequence represented by SEQ ID NO: 67;

35 (13) an amino acid sequence in which substitutions of Val at position 20 with Leu and Met at position 48 with Ile are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(14) an amino acid sequence in which substitutions of Ala at position 40 with Arg and Met at position 48 with Ile are introduced in the amino acid sequence represented by SEQ ID NO: 67;

5 (15) an amino acid sequence in which substitutions of Met at position 48 with Ile and Arg at position 67 with Lys are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(16) an amino acid sequence in which substitutions of Met at position 48 with Ile and Val at position 68 with Ala are introduced in the amino acid sequence represented by SEQ ID NO: 67;

10 (17) an amino acid sequence in which substitutions of Met at position 48 with Ile and Ile at position 70 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(18) an amino acid sequence in which substitutions of Met at position 48 with Ile and Ala at position 72 with Val are introduced in the amino acid sequence represented by SEQ ID NO: 67;

(19) an amino acid sequence in which substitutions of Met at position 48 with Ile and Thr at position 74 with Lys are introduced in the amino acid sequence represented by SEQ ID NO: 67;

20 (20) an amino acid sequence in which substitutions of Met at position 48 with Ile and Arg at position 98 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 67; and

(21) an amino acid sequence in which substitutions of Met at position 48 with Ile and Val at position 113 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 67.

25 [0081]

Specific examples of the amino acid sequence of VH in which one modification is introduced include the following amino acid sequence (1) to (12):

(1) an amino acid sequence in which substitution of Lys at position 12 with Val is introduced in the amino acid sequence represented by SEQ ID NO: 67;

30 (2) an amino acid sequence in which substitution of Val at position 20 with Leu is introduced in the amino acid sequence represented by SEQ ID NO: 67;

(3) an amino acid sequence in which substitution of Arg at position 38 with Lys is introduced in the amino acid sequence represented by SEQ ID NO: 67;

35 (4) an amino acid sequence in which substitution of Ala at position 40 with Arg is introduced in the amino acid sequence represented by SEQ ID NO: 67;

(5) an amino acid sequence in which substitution of Met at position 48 with Ile is introduced in the amino acid sequence represented by SEQ ID NO: 67;

(6) an amino acid sequence in which substitution of Arg at position 67 with Lys is introduced in the amino acid sequence represented by SEQ ID NO: 67;

(7) an amino acid sequence in which substitution of Val at position 68 with Ala is introduced in the amino acid sequence represented by SEQ ID NO: 67;

5 (8) an amino acid sequence in which substitution of Ile at position 70 with Leu is introduced in the amino acid sequence represented by SEQ ID NO: 67;

(9) an amino acid sequence in which substitution of Ala at position 72 with Val is introduced in the amino acid sequence represented by SEQ ID NO: 67;

10 (10) an amino acid sequence in which substitution of Thr at position 74 with Lys is introduced in the amino acid sequence represented by SEQ ID NO: 67;

(11) an amino acid sequence in which substitution of Arg at position 98 with Gly is introduced in the amino acid sequence represented by SEQ ID NO: 67; and

(12) an amino acid sequence in which substitution of Val at position 113 with Leu is introduced in the amino acid sequence represented by SEQ ID NO: 67.

15 [0082]

As the VL comprised in the humanized antibody, the following (1) to (6) are preferable:

20 (1) VL comprising an amino acid sequence in which Leu at position 11, Ala at position 13, Val at position 15, Tyr at position 36, Ala at position 43, Pro at position 44, Leu at position 46, Phe at position 71 and Thr at position 85 in the amino acid sequence represented by SEQ ID NO: 69 are substituted with other amino acid residues.

25 (2) VL comprising an amino acid sequence in which Leu at position 11, Val at position 15, Tyr at position 36, Pro at position 44, Leu at position 46, Phe at position 71 and Thr at position 85 in the amino acid sequence represented by SEQ ID NO: 69 are substituted with other amino acid residues.

(3) VL comprising an amino acid sequence in which Val at position 15, Tyr at position 36, Pro at position 44, Leu at position 46, Phe at position 71 and Thr at position 85 in the amino acid sequence represented by SEQ ID NO: 69 are substituted with other amino acid residues.

30 (4) VL comprising an amino acid sequence in which Tyr at position 36, Ala at position 43, Pro at position 44, Leu at position 46 and Thr at position 85 in the amino acid sequence represented by SEQ ID NO: 69 are substituted with other amino acid residues.

35 (5) VL comprising an amino acid sequence in which Val at position 15, Tyr at position 36, Leu at position 46 and Phe at position 71 in the amino acid sequence represented by SEQ ID NO: 69 are substituted with other amino acid residues.

(6) VL comprising an amino acid sequence in which Tyr at position 36 and Pro

at position 44 in the amino acid sequence represented by SEQ ID NO: 69 are substituted with other amino acid residues.

[0083]

The amino acid sequence of the above VL obtained by the amino acid modifications includes an amino acid sequence in which at least one modification among amino acid modifications for substituting Leu at position 11 with Met, Ala at position 13 with Val, Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr, and Thr at position 85 with Asp is introduced in the amino acid sequence represented by SEQ ID NO: 69.

[0084]

Examples of the amino acid sequence of VL in which nine modifications are introduced include an amino acid sequence in which substitutions of Leu at position 11 with Met, Ala at position 13 with Val, Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr, and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69.

[0085]

Specific examples of the amino acid sequence of VL in which eight modifications are introduced include the following amino acid sequence (1) to (9):

(1) an amino acid sequence in which substitutions of Ala at position 13 with Val, Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(2) an amino acid sequence in which substitutions of Leu at position 11 with Met, Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(3) an amino acid sequence in which substitutions of Leu at position 11 with Met, Ala at position 13 with Val, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(4) an amino acid sequence in which substitutions of Leu at position 11 with Met, Ala at position 13 with Val, Val at position 15 with Leu, Ala at position 43 with

Ser, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(5) an amino acid sequence in which substitutions of Leu at position 11 with Met, Ala at position 13 with Val, Val at position 15 with Leu, Tyr at position 36 with Leu, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(6) an amino acid sequence in which substitutions of Leu at position 11 with Met, Ala at position 13 with Val, Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(7) an amino acid sequence in which substitutions of Leu at position 11 with Met, Ala at position 13 with Val, Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(8) an amino acid sequence in which substitutions of Leu at position 11 with Met, Ala at position 13 with Val, Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69; and

(9) an amino acid sequence in which substitutions of Leu at position 11 with Met, Ala at position 13 with Val, Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly and Phe at position 71 with Tyr are introduced in the amino acid sequence represented by SEQ ID NO: 69.

[0086]

Specific example of the amino acid sequence of VL in which seven modifications are introduced include the following amino acid sequence (1) to (9):

(1) an amino acid sequence in which substitutions of Leu at position 11 with Met, Val at position 15 with Leu, Tyr at position 36 with Leu, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(2) an amino acid sequence in which substitutions of Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with

Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(3) an amino acid sequence in which substitutions of Leu at position 11 with Met, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(4) an amino acid sequence in which substitutions of Leu at position 11 with Met, Val at position 15 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(5) an amino acid sequence in which substitutions of Leu at position 11 with Met, Val at position 15 with Leu, Tyr at position 36 with Leu, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(6) an amino acid sequence in which substitutions of Leu at position 11 with Met, Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(7) an amino acid sequence in which substitutions of Leu at position 11 with Met, Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(8) an amino acid sequence in which substitutions of Leu at position 11 with Met, Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69; and

(9) an amino acid sequence in which substitutions of Leu at position 11 with Met, Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly and Phe at position 71 with Tyr are introduced in the amino acid sequence represented by SEQ ID NO: 69.

[0087]

Specific example of the amino acid sequence of VL in which six modifications are introduced include the following amino acid sequence (1) to (6):

(1) an amino acid sequence in which substitutions of Val at position 15 with Leu, Tyr at position 36 with Leu, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(2) an amino acid sequence in which substitutions of Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

5 (3) an amino acid sequence in which substitutions of Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

10 (4) an amino acid sequence in which substitutions of Leu at position 11 with Met, Tyr at position 36 with Leu, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

15 (5) an amino acid sequence in which substitutions of Leu at position 11 with Met, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69; and

20 (6) an amino acid sequence in which substitutions of Leu at position 11 with Met, Ala at position 13 with Val, Tyr at position 36 with Leu, Pro at position 44 with Phe, Leu at position 46 with Gly and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69.

[0088]

Specific example of the amino acid sequence of VL in which five modifications are introduced include the following amino acid sequence (1) to (7):

25 (1) an amino acid sequence in which substitutions of Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

30 (2) an amino acid sequence in which substitutions of Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe and Leu at position 46 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 69;

35 (3) an amino acid sequence in which substitutions of Val at position 15 with Leu, Tyr at position 36 with Leu, Pro at position 44 with Phe, Leu at position 46 with Gly and Phe at position 71 with Tyr are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(4) an amino acid sequence in which substitutions of Val at position 15 with Leu, Tyr at position 36 with Leu, Pro at position 44 with Phe, Leu at position 46 with

Gly and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(5) an amino acid sequence in which substitutions of Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly and Phe at position 71 with Tyr are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(6) an amino acid sequence in which substitutions of Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69; and

(7) an amino acid sequence in which substitutions of Tyr at position 36 with Leu, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69.

[0089]

Specific example of the amino acid sequence of VL in which four modifications are introduced include the following amino acid sequence (1) to (10):

(1) an amino acid sequence in which substitutions of Val at position 15 with Leu, Tyr at position 36 with Leu, Leu at position 46 with Gly and Phe at position 71 with Tyr are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(2) an amino acid sequence in which substitutions of Val at position 15 with Leu, Tyr at position 36 with Leu, Pro at position 44 with Phe and Leu at position 46 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(3) an amino acid sequence in which substitutions of Val at position 15 with Leu, Tyr at position 36 with Leu, Pro at position 44 with Phe and Phe at position 71 with Tyr are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(4) an amino acid sequence in which substitutions of Val at position 15 with Leu, Tyr at position 36 with Leu, Pro at position 44 with Phe and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(5) an amino acid sequence in which substitutions of Val at position 15 with Leu, Tyr at position 36 with Leu, Leu at position 46 with Gly and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(6) an amino acid sequence in which substitutions of Val at position 15 with Leu, Tyr at position 36 with Leu, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(7) an amino acid sequence in which substitutions of Tyr at position 36 with Leu, Pro at position 44 with Phe, Leu at position 46 with Gly and Phe at position 71

with Tyr are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(8) an amino acid sequence in which substitutions of Tyr at position 36 with Leu, Pro at position 44 with Phe, Leu at position 46 with Gly and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;

5 (9) an amino acid sequence in which substitutions of Tyr at position 36 with Leu, Pro at position 44 with Phe, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69; and

(10) an amino acid sequence in which substitutions of Tyr at position 36 with Leu, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69.
[0090]

Specific example of the amino acid sequence of VL in which three modifications are introduced include the following amino acid sequence (1) to (7):

15 (1) an amino acid sequence in which substitutions of Leu at position 11 with Met, Tyr at position 36 with Leu and Pro at position 44 with Phe are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(2) an amino acid sequence in which substitutions of Ala at position 13 with Val, Tyr at position 36 with Leu and Pro at position 44 with Phe are introduced in the amino acid sequence represented by SEQ ID NO: 69;

20 (3) an amino acid sequence in which substitutions of Val at position 15 with Leu, Tyr at position 36 with Leu and Pro at position 44 with Phe are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(4) an amino acid sequence in which substitutions of Tyr at position 36 with Leu, Ala at position 43 with Ser and Pro at position 44 with Phe are introduced in the
25 amino acid sequence represented by SEQ ID NO: 69;

(5) an amino acid sequence in which substitutions of Tyr at position 36 with Leu, Pro at position 44 with Phe and Leu at position 46 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 69;

30 (6) an amino acid sequence in which substitutions of Tyr at position 36 with Leu, Pro at position 44 with Phe and Phe at position 71 with Tyr are introduced in the amino acid sequence represented by SEQ ID NO: 69; and

(7) an amino acid sequence in which substitutions of Tyr at position 36 with Leu, Pro at position 44 with Phe and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69.

35 [0091]

Specific example of the amino acid sequence of VL in which two modifications are introduced include the following amino acid sequence (1) to (15):

- (1) an amino acid sequence in which substitutions of Tyr at position 36 with Leu and Pro at position 44 with Phe are introduced in the amino acid sequence represented by SEQ ID NO: 69;
- (2) an amino acid sequence in which substitutions of Leu at position 11 with Met and Tyr at position 36 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 69;
- (3) an amino acid sequence in which substitutions of Ala at position 13 with Val and Tyr at position 36 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 69;
- (4) an amino acid sequence in which substitutions of Val at position 15 with Leu and Tyr at position 36 with Leu are introduced in the amino acid sequence represented by SEQ ID NO: 69;
- (5) an amino acid sequence in which substitutions of Tyr at position 36 with Leu and Ala at position 43 with Ser are introduced in the amino acid sequence represented by SEQ ID NO: 69;
- (6) an amino acid sequence in which substitutions of Tyr at position 36 with Leu and Leu at position 46 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 69;
- (7) an amino acid sequence in which substitutions of Tyr at position 36 with Leu and Phe at position 71 with Tyr are introduced in the amino acid sequence represented by SEQ ID NO: 69;
- (8) an amino acid sequence in which substitutions of Tyr at position 36 with Leu and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69;
- (9) an amino acid sequence in which substitutions of Leu at position 11 with Met and Pro at position 44 with Phe are introduced in the amino acid sequence represented by SEQ ID NO: 69;
- (10) an amino acid sequence in which substitutions of Ala at position 13 with Val and Pro at position 44 with Phe are introduced in the amino acid sequence represented by SEQ ID NO: 69;
- (11) an amino acid sequence in which substitutions of Val at position 15 with Leu and Pro at position 44 with Phe are introduced in the amino acid sequence represented by SEQ ID NO: 69;
- (12) an amino acid sequence in which substitutions of Ala at position 43 with Ser and Pro at position 44 with Phe are introduced in the amino acid sequence represented by SEQ ID NO: 69;
- (13) an amino acid sequence in which substitutions of Pro at position 44 with

Phe and Leu at position 46 with Gly are introduced in the amino acid sequence represented by SEQ ID NO: 69;

(14) an amino acid sequence in which substitutions of Pro at position 44 with Phe and Phe at position 71 with Tyr are introduced in the amino acid sequence

5 represented by SEQ ID NO: 69; and

(15) an amino acid sequence in which substitutions of Pro at position 44 with Phe and Thr at position 85 with Asp are introduced in the amino acid sequence represented by SEQ ID NO: 69.

[0092]

10 Specific example of the amino acid sequence of VH in which one modification is introduced include the following amino acid sequence (1) to (9):

(1) an amino acid sequence in which substitution of Leu at position 11 with Met is introduced in the amino acid sequence represented by SEQ ID NO: 69;

(2) an amino acid sequence in which substitution of Ala at position 13 with Val is introduced in the amino acid sequence represented by SEQ ID NO: 69;

(3) an amino acid sequence in which substitution of Val at position 15 with Leu is introduced in the amino acid sequence represented by SEQ ID NO: 69;

(4) an amino acid sequence in which substitution of Tyr at position 36 with Leu is introduced in the amino acid sequence represented by SEQ ID NO: 69;

(5) an amino acid sequence in which substitution of Ala at position 43 with Ser is introduced in the amino acid sequence represented by SEQ ID NO: 69;

(6) an amino acid sequence in which substitution of Pro at position 44 with Phe is introduced in the amino acid sequence represented by SEQ ID NO: 69;

(7) an amino acid sequence in which substitution of Leu at position 46 with Gly is introduced in the amino acid sequence represented by SEQ ID NO: 69;

(8) an amino acid sequence in which substitution of Phe at position 71 with Tyr is introduced in the amino acid sequence represented by SEQ ID NO: 69; and

(9) an amino acid sequence in which substitution of Thr at position 85 with Asp is introduced in the amino acid sequence represented by SEQ ID NO: 69.

30 [0093]

In addition, examples of the humanized antibody of the present invention include a humanized antibody in which VH of the antibody comprises the amino acid sequence represented by SEQ ID NO: 67 and/or VL of the antibody comprises the amino acid sequence represented by SEQ ID: 69, a humanized antibody in which VH of the antibody comprises the amino acid sequence represented by SEQ ID NO: 67 and/or VL of the antibody comprises any one of the amino acid sequences shown in Fig. 2, or a humanized antibody in which VH of the antibody comprises any one of the amino acid

sequences shown in Fig. 1 and/or VL of the antibody comprises the amino acid sequence represented by SEQ ID: 69.

[0094]

Furthermore, examples of the humanized antibody of the present invention
5 include a humanized antibody which competes with the monoclonal antibody of the present invention in the binding of an amino acid sequence of an extracellular region of human TIM-3 or a three-dimensional structure thereof; and a humanized antibody which binds to the same epitope existing on the extracellular region of human TIM-3 to which the above humanized antibody binds.

10 [0095]

A human antibody is originally an antibody naturally existing in the human body, and it also includes an antibody obtained from a human antibody phage library or a human antibody-producing transgenic animal, which is prepared based on the recent advanced techniques in genetic engineering, cell engineering and developmental
15 engineering.

[0096]

The antibody existing in the human body can be prepared, for example, by isolating a human peripheral blood lymphocyte, immortalizing it by infecting with EB virus or the like, and then cloning it to thereby obtain lymphocytes capable of producing
20 the antibody, culturing the lymphocytes thus obtained, and purifying the antibody from the supernatant of the culture.

[0097]

The human antibody phage library is a library in which antibody fragments such as Fab and scFv are expressed on the phage surface by inserting a gene encoding
25 an antibody prepared from a human B cell into a phage gene. A phage expressing an antibody fragment having the desired antigen binding activity can be recovered from the library, using its activity to bind to an antigen-immobilized substrate as the index. The antibody fragment can be converted further into a human antibody molecule comprising two full H chains and two full L chains by genetic engineering techniques.

30 [0098]

A human antibody-producing transgenic animal is an animal in which a human antibody gene is integrated into cells. Specifically, a human antibody-producing transgenic animal can be prepared by introducing a gene encoding a human antibody into a mouse ES cell, grafting the ES cell into an early embryo of mouse and then
35 developing it. A human antibody is prepared from the human antibody-producing transgenic non-human animal by obtaining a human antibody-producing hybridoma by

a hybridoma preparation method usually carried out in non-human mammals, culturing the obtained hybridoma and forming and accumulating the human antibody in the supernatant of the culture.

[0099]

5 In the amino acid sequence constituting the above antibody or antibody fragment thereof, an antibody or antibody fragment thereof in which one or more amino acids are deleted, substituted, inserted or added, having activity similar to the above antibody or antibody fragment thereof is also included in the antibody or antibody fragment of the present invention.

10 [0100]

The number of amino acids which are deleted, substituted, inserted and/or added is one or more, and is not specifically limited, but it is within the range where deletion, substitution or addition is possible by known methods such as the site-directed mutagenesis described in *Molecular Cloning*, Second Edition, Cold Spring Harbor Laboratory Press (1989); *Current Protocols in Molecular Biology*, John Wiley & Sons (1987-1997); *Nucleic Acids Research*, 10, 6487 (1982), *Proc. Natl. Acad. Sci. USA*, 79, 6409 (1982); *Gene*, 34, 315 (1985), *Nucleic Acids Research*, 13, 4431 (1985); *Proc. Natl. Acad. Sci. USA*, 82, 488 (1985) or the like. For example, the number is preferably 1 to dozens, more preferably 1 to 20, furthermore preferably 1 to 10, and most preferably 1 to 5.

20 [0101]

The expression "one or more amino acid residue(s) is/are deleted, substituted, inserted and/or added" in the amino acid sequence of the above antibody means the followings. That is, it means there is deletion, substitution, insertion or addition of one or plural amino acids at optional positions in the same sequence and in one or plural amino acid sequences. Also, the deletion, substitution, insertion or addition may occur at the same time and the amino acid which is substituted, inserted or added may be either a natural type or a non-natural type.

25 [0102]

30 The natural type amino acid includes L-alanine, L-asparagine, L-aspartic acid, L-glutamine, L-glutamic acid, glycine, L-histidine, L-isoleucine, L-leucine, L-lysine, L-methionine, L-phenylalanine, L-proline, L-serine, L-threonine, L-tryptophan, L-tyrosine, L-valine, L-cysteine and the like.

[0103]

35 Preferable examples of mutually substitutable amino acids are shown below. The amino acids in the same group are mutually substitutable.

Group A: leucine, isoleucine, norleucine, valine, norvaline, alanine, 2-aminobutanoic acid, methionine, O-methylserine, t-butylglycine, t-butylalanine, cyclohexylalanine

Group B: aspartic acid, glutamic acid, isoaspartic acid, isoglutamic acid, 2-aminoadipic acid, 2-aminosuberic acid

Group C: asparagine, glutamine

Group D: lysine, arginine, ornithine, 2,4-diaminobutanoic acid, 2,3-diaminopropionic acid

Group E: proline, 3-hydroxyproline, 4-hydroxyproline

Group F: serine, threonine, homoserine

Group G: phenylalanine, tyrosine
[0104]

The antibody fragment of the present invention includes Fab, F(ab')₂, Fab', a single chain antibody (scFv), a dimerized V region (diabody), a disulfide stabilized V region (dsFv), a peptide comprising CDR and the like.

[0105]

An Fab is an antibody fragment among fragments obtained by treating an IgG antibody molecule with a protease, papain (cleaved at an amino acid residue at position 224 of the H chain), having a molecular weight of about 50,000 and having antigen binding activity, in which about a half of the N-terminal side of H chain and the entire L chain are bound together through a disulfide bond.

[0106]

The Fab of the present invention can be produced by treating the monoclonal antibody of the present invention which specifically recognizes human TIM-3 and binds to an amino acid sequence of the extracellular region or three-dimensional structure thereof with papain. Also, the Fab can be produced by inserting DNA encoding Fab of the antibody into an expression vector for prokaryote or an expression vector for eukaryote, and introducing the vector into a prokaryote or eukaryote to express the Fab.

[0107]

An F(ab')₂ is an antibody fragment having a molecular weight of about 100,000 and having antigen binding activity and comprising two Fab regions which are bound in the hinge position obtained by digesting the lower part of two disulfide bonds in the hinge region of IgG with an enzyme, pepsin.

[0108]

The $F(ab')_2$ of the present invention can be produced by treating the monoclonal antibody of the present invention which specifically recognizes human TIM-3 and binds to an amino acid sequence of the extracellular region or three-dimensional structure thereof with pepsin. Also, the $F(ab')_2$ can be produced by binding Fab' described below via a thioether bond or a disulfide bond.

[0109]

An Fab' is an antibody fragment having a molecular weight of about 50,000 and antigen binding activity, which is obtained by cleaving a disulfide bond at the hinge region of the above $F(ab')_2$. The Fab' of the present invention can be produced by treating the $F(ab')_2$ of the present invention which specifically recognizes TIM-3 and binds to an amino acid sequence of the extracellular region or three-dimensional structure thereof with a reducing agent, such as dithiothreitol. Also, the Fab' can be produced by inserting DNA encoding Fab' fragment of the antibody into an expression vector for prokaryote or an expression vector for eukaryote, and introducing the vector into a prokaryote or eukaryote to express the Fab'.

[0110]

An scFv is a VH-P-VL or VL-P-VH polypeptide in which one chain VH and one chain VL are linked using an appropriate peptide linker (hereinafter referred to as "P") and is an antibody fragment having antigen binding activity.

[0111]

The scFv of the present invention can be produced by obtaining cDNAs encoding VH and VL of the monoclonal antibody of the present invention which specifically recognizes human TIM-3 and binds to an amino acid sequence of the extracellular region or three-dimensional structure thereof, constructing DNA encoding scFv, inserting the DNA into an expression vector for prokaryote or an expression vector for eukaryote, and then introducing the expression vector into a prokaryote or eukaryote to express the scFv.

[0112]

A diabody is an antibody fragment wherein scFv is dimerized, is an antibody fragment having divalent antigen binding activity. In the divalent antigen binding activity, two antigens may be the same or different.

[0113]

The diabody of the present invention can be produced by obtaining cDNAs encoding VH and VL of the monoclonal antibody of the present invention which specifically recognizes human TIM-3 and binds to an amino acid sequence of the extracellular region or three-dimensional structure thereof, constructing DNA encoding scFv so that the length of the amino acid sequence of the peptide linker is 8 or less

residues, inserting the DNA into an expression vector for prokaryote or an expression vector for eukaryote, and then introducing the expression vector into a prokaryote or eukaryote to express the diabody.

[0114]

5 A dsFv is obtained by binding polypeptides in which one amino acid residue of each of VH and VL is substituted with a cysteine residue via a disulfide bond between the cysteine residues. The amino acid residue to be substituted with a cysteine residue can be selected based on a three-dimensional structure estimation of the antibody in accordance with a known methods [*Protein Engineering*, 7, 697 (1994)].

10 [0115]

The dsFv of the present invention can be produced by obtaining cDNAs encoding VH and VL of the monoclonal antibody of the present invention which specifically recognizes human TIM-3 and binds to an amino acid sequence of the extracellular region or three-dimensional structure thereof, constructing DNA encoding dsFv, inserting the DNA into an expression vector for prokaryote or an expression vector for eukaryote, and then introducing the expression vector into a prokaryote or eukaryote to express the dsFv.

[0116]

20 A peptide comprising CDR is constituted by including one or more regions of CDRs of VH or VL. Peptide comprising plural CDRs can be bound directly or via an appropriate peptide linker.

[0117]

25 The peptide comprising CDR of the present invention can be produced by constructing DNA encoding CDRs of VH and VL of the monoclonal antibody of the present invention which specifically recognizes human TIM-3 and binds to an amino acid sequence of the extracellular region or three-dimensional structure thereof, inserting the DNA into an expression vector for prokaryote or an expression vector for eukaryote, and then introducing the expression vector into a prokaryote or eukaryote to express the peptide. The peptide comprising CDR can also be produced by a chemical synthesis method such as Fmoc method or tBoc method.

30

[0118]

35 The monoclonal antibody of the present invention includes an antibody conjugate in which the monoclonal antibody or the antibody fragment of the present invention which specifically recognizes human TIM-3 and binds to an amino acid sequence of the extracellular region or three-dimensional structure thereof is chemically or genetically bound to a radioisotope, an agent having a low molecular weight, an agent having a high molecular weight, a protein, a therapeutic antibody or the like.

[0119]

The antibody conjugate of the present invention can be produced by chemically conjugating a radioisotope, an agent having a low molecular weight, an agent having a high molecular weight, an adjuvant, a protein, a therapeutic antibody or the like to the N-terminal side or C-terminal side of an H chain or an L chain, adequate substituent or sidechain, sugarchain, and the like of the monoclonal antibody or the antibody fragment of the present invention which specifically recognizes human TIM-3 and binds to an amino acid sequence of the extracellular region or three-dimensional structure thereof [*Kotai Kogaku Nyumon*, published by Chijin Shokan (1994)].

[0120]

Also, the antibody conjugate can be genetically produced by linking a DNA encoding the monoclonal antibody or the antibody fragment of the present invention which specifically recognizes human TIM-3 and binds to an amino acid sequence of the extracellular region or three-dimensional structure thereof to other DNA encoding a protein or a therapeutic antibody to be conjugated, inserting the DNA into a vector for expression, and introducing the expression vector into an appropriate host cell.

[0121]

The radioisotope includes ^{131}I , ^{125}I , ^{90}Y , ^{64}Cu , ^{199}Tc , ^{77}Lu , ^{211}At and the like. The radioisotope can directly be conjugated with the antibody by Chloramine-T method or the like. Also, a substance chelating the radioisotope can be conjugated with the antibody. The chelating agent includes 1-isothiocyanatobenzyl-3-methyldiethylene-triaminepentaacetic acid (MX-DTPA) and the like.

[0122]

The agent having a low molecular weight includes an anti-tumor agent such as an alkylating agent, a nitrosourea agent, a metabolism antagonist, an antibiotic substance, an alkaloid derived from a plant, a topoisomerase inhibitor, an agent for hormonotherapy, a hormone antagonist, an aromatase inhibitor, a P glycoprotein inhibitor, a platinum complex derivative, an M-phase inhibitor and a kinase inhibitor [*Rinsho Syuyo-gaku* (Clinical Oncology), Gan to Kagakuryoho-Sha (1996)], a steroid agent such as hydrocortisone and prednisone, a nonsteroidal agent such as aspirin and indomethacin, immunomodulatory agent such as aurothiomalate, penicillamine, immuno-suppressing agent such as cyclophosphamide and azathioprine, anti-inflammatory agent such as anti-histamine agent, for example, chlorpheniramine maleate and clemastine [*Ensho to Kouensho-Ryoho* (Inflammation and Anti-inflammation Therapy), Ishiyaku Shuppan (1982)] and the like.

[0123]

Examples of the antitumor agent include amifostine (Ethyol), cisplatin,

dacarbazine (DTIC), dactinomycin, mecloretamin (nitrogen mustard), streptozocin, cyclophosphamide, iphosphamide, carmustine (BCNU), lomustine (CCNU), doxorubicin (adriamycin), epirubicin, gemcitabine (Gemsal), daunorubicin, procarbazine, mitomycin, cytarabine, etoposide, methotrexate, 5-fluorouracil, fluorouracil, vinblastine, vincristine, bleomycin, daunomycin, peplomycin, estramustine, paclitaxel (Taxol), docetaxel (Taxotea), aldesleukin, asparaginase, busulfan, carboplatin, oxaliplatin, nedaplatin, cladribine, camptothecin, 10-hydroxy-7-ethylcamptothecin (SN38), floxuridine, fludarabine, hydroxyurea, iphosphamide, idarubicin, mesna, irinotecan (CPT-11), nogitecan, mitoxantrone, topotecan, leuprolide, megestrol, melfalan, mercaptopurine, hydroxycarbamide, plicamycin, mitotane, pegasparagase, pentostatin, pipobroman, streptozocin, tamoxifen, goserelin, leuprorelin, flutamide, teniposide, testolactone, thioguanine, thiotepa, uracil mustard, vinorelbine, chlorambucil, hydrocortisone, prednisolone, methylprednisolone, vindesine, nimustine, semustine, capecitabine, Tomudex, azacytidine, UFT, oxaliplatin, gefitinib (Iressa), imatinib (STI 571), elrotinib, FMS-like tyrosine kinase 3 (Flt3) inhibitor, vascular endothelial growth factor receptor (VEGFR) inhibitor, fibroblast growth factor receptor (FGFR) inhibitor, Epidermal Growth Factor Receptor (EGFR) inhibitor such as Iressa and Tarceva, radicicol, 17-allylamino-17-demethoxygeldanamycin, rapamycin, amsacrine, all-trans-retinoic acid, thalidomide, anastrozole, fadrozole, letrozole, exemestane, gold thiomalate, D-penicillamine, bucillamine, azathioprine, mizoribine, cyclosporine, rapamycin, hydrocortisone, bexarotene (Targretin), tamoxifen, dexamethasone, progestin substances, estrogen substances, anastrozole (Arimidex), Leuplin, aspirin, indomethacin, celecoxib, azathioprine, penicillamine, gold thiomalate, chlorpheniramine maleate, chlorpheniramine, clemastine, tretinoin, bexarotene, arsenic, voltezosimib, allopurinol, calicheamicin, ibritumomab tiuxetan, Targretin, ozogamine, clarithromycin, leucovorin, ifosfamide, ketoconazole, aminoglutethimide, suramin, methotrexate, maytansinoid and derivatives thereof.

[0124]

The method for conjugating the agent having low molecular weight with the antibody includes a method in which the agent and an amino group of the antibody are conjugated through glutaraldehyde, a method in which an amino group of the agent and a carboxyl group of the antibody are conjugated through water-soluble carbodiimide, and the like.

[0125]

The agent having a high molecular weight includes polyethylene glycol (hereinafter referred to as "PEG"), albumin, dextran, polyoxyethylene, styrene-maleic acid copolymer, polyvinylpyrrolidone, pyran copolymer,

hydroxypropylmethacrylamide, and the like. By binding these compounds having a high molecular weight to an antibody or antibody fragment, the following effects are expected: (1) improvement of stability against various chemical, physical or biological factors, (2) remarkable prolongation of half life in blood, (3) disappearance of immunogenicity or suppression of antibody production, and the like [*Bioconjugate Drug*, Hirokawa Shoten (1993)]. For example, the method for binding PEG to an antibody includes a method in which an antibody is allowed to react with a PEG-modifying reagent [*Bioconjugate Drug*, Hirokawa Shoten (1993)]. The PEG-modifying reagent includes a modifying agent of ϵ -amino group of lysine (Japanese Published Unexamined Patent Application No. 178926/86), a modifying agent of a carboxyl group of aspartic acid and glutamic acid (Japanese Published Unexamined Patent Application No. 23587/81), a modifying agent of a guanidino group of arginine (Japanese Published Unexamined Patent Application No. 117920/90) and the like.

[0126]

The immunostimulator may be any natural products known as immunoadjuvants. Examples of an agent enhancing immunogen include $\beta(1\rightarrow3)$ glucan (lentinan, schizophyllan), α -galactosylceramide and the like.

[0127]

The protein includes a cytokine or a growth factor which activates a immunocompetent cell, such as NK cell, macrophage or neutrophil, a toxic protein, and the like.

[0128]

Examples of the cytokine or the growth factor include interferon (hereinafter referred to as "IFN")- α , IFN- β , IFN- γ , interleukin (hereinafter referred to as "IL")-2, IL-12, IL-15, IL-18, IL-21, IL-23, granulocyte-colony stimulating factor (G-CSF), granulocyte macrophage-colony stimulating factor (GM-CSF), macrophage-colony stimulating factor (M-CSF) and the like.

[0129]

The toxic protein includes ricin, diphtheria toxin, ONTAK and the like, and also includes a toxic protein wherein mutation is introduced into a protein in order to control the toxicity.

[0130]

The therapeutic antibody includes an antibody against an antigen in which apoptosis is induced by binding of the antibody, an antibody against an antigen participating in formation of pathologic state of tumor, an antibody against an antigen regulating immunological function and an antibody against an antigen relating to angiogenesis in the pathologic part.

[0131]

The antigen in which apoptosis is induced by binding of the antibody includes cluster of differentiation (hereinafter "CD") 19, CD20, CD21, CD22, CD23, CD24, CD37, CD53, CD72, CD73, CD74, CDw75, CDw76, CD77, CDw78, CD79a, CD79b, CD80 (B7.1), CD81, CD82, CD83, CDw84, CD85, CD86 (B7.2), human leukocyte antigen (HLA)-Class II, epidermal growth factor receptor (EGFR) and the like.

[0132]

The antigen participating in formation of pathologic state of tumor or the antigen regulating immunological function includes CD40, CD40 ligand, B7 family molecule (CD80, CD86, CD274, B7-DC, B7-H2, B7-H3, B7-H4), ligand of B7 family molecule (CD28, CTLA-4, ICOS, PD-1, BTLA), OX-40, OX-40 ligand, CD137, tumor necrosis factor (TNF) receptor family molecule (DR4, DR5, TNFR1, TNFR2), TNF-related apoptosis-inducing ligand receptor (TRAIL) family molecule, receptor family of TRAIL family molecule (TRAIL-R1, TRAIL-R2, TRAIL-R3, TRAIL-R4), receptor activator of nuclear factor kappa B (RANK), RANK ligand, CD25, folic acid receptor 4, cytokine [IL-1 α , IL-1 β , IL-4, IL-5, IL-6, IL-10, IL-13, transforming growth factor (TGF) β , TNF α , *etc.*], receptors of these cytokines, chemokine (SLC, ELC, I-309, TARC, MDC, CTACK, *etc.*) and receptors of these chemokines.

[0133]

The antigen for the antibody which inhibits angiogenesis in the pathologic part includes vascular endothelial growth factor (VEGF), angiopoietin, fibroblast growth factor (FGF), EGF, platelet-derived growth factor (PDGF), insulin-like growth factor (IGF), erythropoietin (EPO), TGF β , IL-8, Ephrin, SDF-1, receptors thereof and the like.

[0134]

A fusion antibody with a protein or therapeutic antibody can be produced by linking a cDNA encoding a monoclonal antibody or antibody fragment to a cDNA encoding the protein, constructing a DNA encoding the fusion antibody, inserting the DNA into an expression vector for prokaryote or eukaryote, and then introducing the expression vector into a prokaryote or eukaryote to express the fusion antibody.

[0135]

In the case where the above antibody conjugate is used for the detection method, method for quantitative determination, detection reagent, reagent for quantitative determination or diagnostic agent in the present invention, examples of the agent to which the monoclonal antibody or the antibody fragment of the present invention which specifically recognizes human TIM-3 and binds to an amino acid

sequence of the extracellular region or three-dimensional structure thereof is bound includes a label used in routine immunological detecting or measuring method.

[0136]

The label includes enzymes such as alkaline phosphatase, peroxidase and luciferase, luminescent materials such as acridinium ester and lophine, fluorescent materials such as fluorescein isothiocyanate (FITC) and tetramethyl rhodamine isothiocyanate (RITC), and the like.

[0137]

Furthermore, the present invention includes an agent for treating a disease relating to a TIM-3 positive cell, comprising the monoclonal antibody of the present invention or the antibody fragment thereof as an active ingredient.

[0138]

The disease relating to the TIM-3 positive cell is not limited, so long as it is a disease relating to a cell expressing TIM-3, such as cancer, autoimmune disease, and allergic disease.

[0139]

The cancer includes blood cancer, breast cancer, uterine cancer, colorectal cancer, esophageal cancer, gastric cancer, ovarian cancer, lung cancer, renal cancer, rectal cancer, thyroid cancer, uterine cervix cancer, small intestinal cancer, prostate cancer and pancreatic cancer. Preferable examples of the cancer include blood cancer, esophageal cancer, gastric cancer, colorectal cancer, liver cancer and prostate cancer.

[0140]

Examples of the blood cancer include acute myeloid leukemia (AML), chronic myeloid leukemia (CML), myelodysplastic syndromes (MDS), multiple myeloma, cutaneous T cell lymphoma (CTCL), peripheral T-cell lymphoma (PTCL), anaplastic large cell lymphoma (ALCL), acute lymphocytic leukemia (ALL), chronic lymphocytic leukemia (CLL), other lymphoid leukemia, NK cell lymphoma, Hodgkin lymphoma, non-Hodgkin's lymphoma such as Burkitt's lymphoma, and the like.

[0141]

Specific examples of the autoimmune diseases include rheumatoid arthritis, psoriasis, Crohn's disease, Ankylosing spondylitis, multiple sclerosis, type I diabetes, hepatitis, myocarditis, Sjogren's syndrome, autoimmune hemolytic anemia after transplant rejection, blisters pemphigoid, Graves disease, Hashimoto's thyroiditis, systemic lupus erythematosus (SLE), myasthenia gravis, pemphigus, pernicious anemia, and the like.

[0142]

Examples of the allergic diseases include acute or chronic reactive airway disease, bronchial asthma, atopic dermatitis, allergic rhinitis, urticaria, PIE syndrome, food allergies, hay fever, allergic nose, bronchial asthma, atopic dermatitis, anaphylactic shock and the like.

5 [0143]

The therapeutic agent of the present invention comprises the above monoclonal antibody or the antibody fragment of the present invention as an active ingredient.

[0144]

10 The therapeutic agent comprising the monoclonal antibody of the present invention or antibody fragment thereof, or conjugate thereof may comprise only the antibody or antibody fragment thereof, or conjugate thereof as an active ingredient. It is generally preferred that the therapeutic agent is prepared as a pharmaceutical preparation produced by an appropriate method well known in the technical field of pharmaceuticals, and by mixing it with one or more pharmaceutically acceptable carriers.

15 [0145]

It is preferred to administer the therapeutic agent by the route that is most effective for the treatment. Examples include oral administration and parenteral administration, such as buccal, tracheal, rectal, subcutaneous, intramuscular or intravenous administration and intravenous administration is preferred.

20 [0146]

The pharmaceutical preparation includes sprays, capsules, tablets, powders, granules, syrups, emulsions, suppositories, injections, ointments, tapes and the like.

[0147]

25 Although the dose or the frequency of administration varies depending on the objective therapeutic effect, administration method, treating period, age, body weight and the like, it is usually 10 μ g/kg to 10 mg/kg per day and per adult.

[0148]

30 Further, the present invention relates to a method for immunologically detecting or measuring TIM-3, a reagent for immunologically detecting or measuring TIM-3, a method for immunologically detecting or measuring a cell expressing TIM-3, and a diagnostic agent for diagnosing a disease relating to a TIM-3 positive cell, comprising the monoclonal antibody or the antibody fragment of the present invention which specifically recognizes human TIM-3 and binds to an amino acid sequence of the extracellular region or three-dimensional structure thereof as an active ingredient.

35 [0149]

In the present invention, the method for detecting or measuring the amount of TIM-3 may be any known method. For example, it includes an immunological detecting or measuring method.

[0150]

5 The immunological detecting or measuring method is a method in which an antibody amount or an antigen amount is detected or determined using a labeled antigen or antibody. Examples of the immunological detecting or measuring method include radioactive substance-labeled immunoantibody method (RIA), enzyme immunoassay (EIA or ELISA), fluorescent immunoassay (FIA), luminescent immunoassay, Western blotting method, physicochemical method and the like.

[0151]

The above disease relating to a TIM-3 positive cell can be diagnosed by detecting or measuring a cell expressing TIM-3 by using the monoclonal antibody or antibody fragment of the present invention.

15 [0152]

For the detection of the cell expressing the polypeptide, known immunological detection methods can be used, and an immunoprecipitation method, a fluorescent cell staining method, an immune tissue staining method and the like are preferably used. Also, a fluorescent antibody staining method using FMAT 8100 HTS system (Applied Biosystem) and the like can be used.

[0153]

20 In the present invention, the living body sample to be used for detecting or measuring TIM-3 is not particularly limited, so long as it has a possibility of containing a cell expressing TIM-3, such as tissue cells, blood, blood plasma, serum, pancreatic fluid, urine, fecal matter, tissue fluid or culture fluid.

[0154]

30 The diagnostic agent containing the monoclonal antibody of the present invention or antibody fragment thereof, or conjugate thereof may further contain a reagent for carrying out an antigen-antibody reaction or a reagent for detection of the reaction depending on the desired diagnostic method. The reagent for carrying out the antigen-antibody reaction includes a buffer, a salt, and the like. The reagent for detection includes a reagent generally used for the immunological detecting or measuring method, such as labeled secondary antibody which recognizes the monoclonal antibody, antibody fragment thereof or conjugates thereof and substrate corresponding to the labeling and the like.

35 [0155]

A process for producing the antibody of the present invention, a method for

treating the disease and a method for diagnosing the disease are specifically described below.

[0156]

1. Preparation method of monoclonal antibody

5 (1) Preparation of antigen

TIM-3 or a cell expressing TIM-3 as an antigen can be obtained by introducing an expression vector comprising cDNA encoding a full length of TIM-3 or a partial length thereof is introduced into *Escherichia coli*, yeast, an insect cell, an animal cell or the like. In addition, TIM-3 can be purified and obtained from various human tumor
10 cell lines, human tissue and the like which express a large amount of TIM-3. The tumor cell line and the tissue can be directly allowed to use as antigens. Furthermore, a synthetic peptide having a partial sequence of the TIM-3 can be prepared by a chemical synthesis method such as Fmoc method or tBoc method and used as an antigen.

15 [0157]

TIM-3 used in the present invention can be produced, for example, by expressing a DNA encoding TIM-3 in a host cell using a method described in *Molecular Cloning, A Laboratory Manual*, Second Edition, Cold Spring Harbor Laboratory Press (1989), *Current Protocols in Molecular Biology*, John Wiley & Sons (1987-1997) or the
20 like according to the following method.

[0158]

Firstly, a recombinant vector is prepared by inserting a full length cDNA comprising the region encoding TIM-3 into downstream of a promoter of an appropriate expression vector. At this time, if necessary, a DNA fragment having an appropriate
25 length containing a region encoding the polypeptide prepared based on the full length cDNA may be used instead of the above full length cDNA. Next, a transformant producing polypeptide can be obtained by introducing the recombinant vector into a host cell suitable for the expression vector.

[0159]

30 The expression vector may be any one, so long as it can replicate autonomously in the host cell to be used or it can be integrated into a chromosome comprising an appropriate promoter at such a position that the DNA encoding the polypeptide can be transcribed.

[0160]

35 The host cell may be any one, so long as it can express the objective gene. Examples include a microorganism which belongs to the genera *Escherichia*, such as

Escherichia coli, yeast, an insect cell, an animal cell and the like.

[0161]

When a prokaryote such as *Escherichia coli* is used as the host cell, it is preferred that the recombinant vector used in the present invention is autonomously replicable in the prokaryote and comprising a promoter, a ribosome binding sequence, the DNA encoding TIM-3 and a transcription termination sequence. The recombinant vector is not necessary to have a transcription termination sequence, but a transcription termination sequence is preferably set just below the structural gene. The recombinant vector may further comprise a gene regulating the promoter.

[0162]

Also, the above recombinant vector is preferably a plasmid in which the space between Shine-Dalgarno sequence, which is the ribosome binding sequence, and the initiation codon is adjusted to an appropriate distance (for example, 6 to 18 nucleotides).

[0163]

Furthermore, the nucleotide sequence of the DNA encoding TIM-3 can be substituted with another base so as to be a suitable codon for expressing in a host cell, thereby improve the productivity of the objective TIM-3.

[0164]

Any expression vector can be used, so long as it can function in the host cell to be used. Examples of the expression vector includes pBTrp2, pBTac1, pBTac2 (all manufactured by Roche Diagnostics), pKK233-2 (manufactured by Pharmacia), pSE280 (manufactured by Invitrogen), pGEMEX-1 (manufactured by Promega), pQE-8 (manufactured by QIAGEN), pKYP10 (Japanese Published Unexamined Patent Application No. 110600/83), pKYP200 [*Agricultural Biological Chemistry*, 48, 669 (1984)], pLSA1 [*Agric. Biol. Chem.*, 53, 277 (1989)], pGEL1 [*Proc. Natl. Acad. Sci. USA*, 82, 4306 (1985)], pBluescript II SK(-) (manufactured by Stratagene), pTrs30 [prepared from *Escherichia coli* JM109/pTrs30 (FERM BP-5407)], pTrs32 [prepared from *Escherichia coli* JM109/pTrs32 (FERM BP-5408)], pGHA2 [prepared from *Escherichia coli* IGHA2 (FERM BP-400), Japanese Published Unexamined Patent Application No. 221091/85], pGKA2 [prepared from *Escherichia coli* IGKA2 (FERM BP-6798), Japanese Published Unexamined Patent Application No. 221091/85], pTerm2 (US4686191, US4939094, US5160735), pSupex, pUB110, pTP5, pC194, pEG400 [*J. Bacteriol.*, 172, 2392 (1990)], pGEX (manufactured by Pharmacia), pET system (manufactured by Novagen), pME18SFL3 and the like.

[0165]

Any promoter can be used, so long as it can function in the host cell to be used.

Examples include promoters derived from *Escherichia coli*, phage and the like, such as trp promoter (Ptrp), lac promoter, PL promoter, PR promoter and T7 promoter and the like. Also, artificially designed and modified promoters, such as a promoter in which two Ptrp are tandemly linked, tac promoter, lacT7 promoter and letI promoter, can be used.

[0166]

Examples of host cell include *Escherichia coli* XL1-Blue, *Escherichia coli* XL2-Blue, *Escherichia coli* DH1, *Escherichia coli* MC1000, *Escherichia coli* KY3276, *Escherichia coli* W1485, *Escherichia coli* JM109, *Escherichia coli* HB101, *Escherichia coli* No. 49, *Escherichia coli* W3110, *Escherichia coli* NY49, *Escherichia coli* DH5 α and the like.

[0167]

Any introduction method of the recombinant vector can be used, so long as it is a method for introducing DNA into the host cell, and examples include a method using a calcium ion described in *Proc. Natl. Acad. Sci. USA*, 69, 2110 (1972), *Gene*, 17, 107 (1982) and *Molecular & General Genetics*, 168, 111 (1979) and the like.

[0168]

When an animal cell is used as the host cell, any expression vector can be used, so long as it can function in the animal cell. Examples include pcDNAI, pcDM8 (manufactured by Funakoshi), pAGE107 [Japanese Published Unexamined Patent Application No. 22979/91; *Cytotechnology*, 3, 133 (1990)], pAS3-3 (Japanese Published Unexamined Patent Application No. 227075/90), pCDM8 [*Nature*, 329, 840, (1987)], pcDNAI/Amp (manufactured by Invitrogen), pcDNA3.1 (manufactured by Invitrogen), pREP4 (manufactured by Invitrogen), pAGE103 [*J. Biochemistry*, 101, 1307 (1987)], pAGE210, pME18SFL3, pKANTEX93 (WO 97/10354) and the like.

[0169]

Any promoter can be used, so long as it can function in an animal cell. Examples include a promoter of immediate early (IE) gene of cytomegalovirus (CMV), SV40 early promoter, a promoter of retrovirus, a metallothionein promoter, a heat shock promoter, SR α promoter, Molony murine leukemia virus promoter or enhancer, and the like. Also, the enhancer of the IE gene of human CMV can be used together with the promoter.

[0170]

The host cell includes human Namalwa leukemia cell, monkey COS cell, Chinese hamster ovary (CHO) cell [Journal of Experimental Medicine, 108, 945 (1958); *Proc. Natl. Acad. Sci. USA*, 60, 1275 (1968); *Genetics*, 55, 513 (1968); *Chromosoma*, 41, 129 (1973); *Methods in Cell Science*, 18, 115 (1996); *Radiation Research*, 148, 260

(1997); *Proc. Natl. Acad. Sci. USA*, 77, 4216 (1980); *Proc. Natl. Acad. Sci. USA*, 60, 1275 (1968); *Cell*, 6, 121 (1975); *Molecular Cell genetics*, Appendix I, II (pp.883-900)], CHO/DG44, CHO-K1 (ATCC accession NO: CCL-61), DUKXB11 (ATCC accession NO: CCL-9096), Pro-5 (ATCC accession NO: CCL-1781), CHO-S (Life Technologies, Cat#11619), Pro-3, rat myeloma cell YB2/3HL.P2.G11.16Ag.20 (also called as YB2/0), mouse myeloma cell NSO, mouse myeloma cell SP2/0-Ag14, Syrian hamster cell BHK or HBT5637 (Japanese Published Unexamined Patent Application No. 299/88) and the like.

[0171]

Any introduction method of the recombinant vector can be used, so long as it is a method for introducing DNA into an animal cell, and examples include electroporation [*Cytotechnology*, 3, 133 (1990)], the calcium phosphate method (Japanese Published Unexamined Patent Application No. 227075/90), the lipofection method [*Proc. Natl. Acad. Sci. USA*, 84, 7413 (1987)], and the like.

[0172]

TIM-3 can be produced by culturing the transformant derived from a microorganism, an animal cell or the like having a recombinant vector comprising the DNA encoding TIM-3 in a medium to form and accumulate TIM-3 in the culture, and recovering it from the culture. The method for culturing the transformant in the medium is carried out according to the usual method used in culturing of hosts.

[0173]

When TIM-3 is expressed in a cell derived from eukaryote, TIM-3 to which sugars or sugar chains bind can be obtained.

[0174]

When a microorganism transformed with a recombinant vector containing an inducible promoter is cultured, an inducer can be added to the medium, if necessary. For example, isopropyl- β -D-thiogalactopyranoside or the like can be added to the medium when a microorganism transformed with a recombinant vector using *lac* promoter is cultured; or indoleacrylic acid or the like can be added thereto when a microorganism transformed with a recombinant vector using *trp* promoter is cultured.

[0175]

When a transformant obtained using an animal cell as the host cell is cultured, the medium includes generally used RPMI 1640 medium [*The Journal of the American Medical Association*, 199, 519 (1967)], Eagle's MEM medium [*Science*, 122, 501 (1952)], Dulbecco's modified MEM medium [*Virology*, 8, 396 (1959)] and 199 medium [*Proceeding of the Society for the Biological Medicine*, 73, 1 (1950)], Iscove's modified

Dulbecco's medium (IMDM), the media to which fetal calf serum, *etc.* is added, and the like. Culture is carried out generally at a pH of 6 to 8 and 30 to 40°C for 1 to 7 days in the presence of 5% CO₂. If necessary, an antibiotic such as kanamycin or penicillin can be added to the medium during the culturing.

5 [0176]

Regarding the expression method of the gene encoding TIM-3, in addition to direct expression, secretory production, fusion protein expression and the like can be carried out according to the method described in *Molecular Cloning, A Laboratory Manual*, Second Edition, Cold Spring Harbor Laboratory Press (1989).

10 [0177]

The process for producing TIM-3 includes a method of intracellular expression in a host cell, a method of extracellular secretion from a host cell, a method of producing on a host cell outer membrane, and the like. The appropriate method can be selected by changing the host cell used and the structure of the TIM-3 produced.

15 [0178]

When the TIM-3 is produced in a host cell or on a host cell membrane outer envelope, TIM-3 can be positively secreted extracellularly in accordance with the method of Paulson *et al.* [*J. Biol. Chem.*, 264, 17619 (1989)], the method of Lowe *et al.* [*Proc. Natl. Acad. Sci. USA*, 86, 8227 (1989), *Genes Develop.*, 4, 1288 (1990)], the methods described in Japanese Published Unexamined Patent Application No. 336963/93 and WO 94/23021, and the like.

[0179]

Also, the production amount of TIM-3 can be increased in accordance with the method described in Japanese Published Unexamined Patent Application No. 227075/90 utilizing a gene amplification system using a dihydrofolate reductase gene.

25

[0180]

The resulting TIM-3 can be isolated and purified, for example, as follows.

[0181]

When TIM-3 is intracellularly expressed in a dissolved state, the cells after culturing are recovered by centrifugation, suspended in an aqueous buffer and then disrupted using ultrasonicator, French press, Manton Gaulin homogenizer, dynomill or the like to obtain a cell-free extract.

30

[0182]

The cell-free extract is centrifuged to obtain a supernatant, and a purified preparation can be obtained by subjecting the supernatant to a general protein isolation and purification techniques such as solvent extraction; salting out with ammonium

35

sulfate *etc.*; desalting; precipitation with an organic solvent; anion exchange chromatography using a resin such as diethylaminoethyl (DEAE)-sepharose, DIAION HPA-75 (manufactured by Mitsubishi Chemical); cation exchange chromatography using a resin such as S-Sepharose FF (manufactured by Pharmacia); hydrophobic chromatography using a resin such as butyl-Sepharose or phenyl-Sepharose; gel filtration using a molecular sieve; affinity chromatography; chromatofocusing; electrophoresis such as isoelectric focusing; and the like which may be used alone or in combination.

[0183]

When TIM-3 is expressed intracellularly by forming an inclusion body, the cells are recovered, disrupted and centrifuged in the same manner, and the inclusion body of TIM-3 are recovered as a precipitation fraction. The recovered inclusion body of the TIM-3 protein is solubilized with a protein denaturing agent. The protein is made into a normal three-dimensional structure by diluting or dialyzing the solubilized solution, and then a purified preparation of polypeptide is obtained by the same isolation purification method as above.

[0184]

When TIM-3 or the derivative such as a glycosylated product is secreted extracellularly, TIM-3 or the derivative such as a glycosylated product can be recovered from the culture supernatant. That is, the culture is treated by a method such as centrifugation in the same manner as above to obtain a soluble fraction, a purified preparation of TIM-3 can be obtained from the soluble fraction by the same isolation purification method as above.

[0185]

Also, TIM-3 used in the present invention can be produced by a chemical synthesis method, such as Fmoc method or tBoc method. Also, it can be chemically synthesized using a peptide synthesizer manufactured by Advanced ChemTech, Perkin-Elmer, Pharmacia, Protein Technology Instrument, Synthecell-Vega, PerSeptive, Shimadzu Corporation, or the like.

[0186]

(2) Immunization of animal and preparation of antibody-producing cell for fusion

A mouse, rat or hamster and the like which is 3 to 20-weeks-old is immunized with the antigen prepared in the above (1), and antibody-producing cells within the spleen, lymph node or peripheral blood of the animal are collected. Also, when the increase of a sufficient titer in the above animal is not recognized due to low immunogenicity, a TIM-3 knockout mouse may be used as an animal to be immunized.

[0187]

The immunization is carried out by administering the antigen to the animal through subcutaneous, intravenous or intraperitoneal injection together with an appropriate adjuvant (for example, complete Freund's adjuvant, combination of
5 aluminum hydroxide gel with pertussis vaccine, or the like). When the antigen is a partial peptide, a conjugate is produced with a carrier protein such as BSA (bovine serum albumin), KLH (keyhole limpet hemocyanin) or the like, which is used as the antigen.

[0188]

10 The administration of the antigen is carried out 5 to 10 times every one week or every two weeks after the first administration. On the 3rd to 7th day after each administration, a blood sample is collected from the fundus of the eye, the reactivity of the serum with the antigen is tested, for example, by enzyme immunoassay [*Antibodies-A Laboratory Manual*, Cold Spring Harbor Laboratory (1988)] or the like. An animal
15 showing a sufficient antibody titer in their sera against the antigen used for the immunization is used as the source of antibody-producing cells for fusion.

[0189]

Three to seven days after final administration of the antigen, tissue containing the antibody-producing cells such as the spleen is excised from the immunized animal
20 to collect the antibody-producing cells. When the spleen cells are used, the spleen is cut out and loosened, followed by centrifugation. Then, antibody-producing cells for fusion are obtained by removing erythrocytes.

[0190]

(3) Preparation of myeloma cell

25 An established cell line obtained from mouse is used as myeloma cells. Examples include 8-azaguanine-resistant mouse (derived from BALB/c) myeloma cell line P3-X63Ag8-U1 (P3-U1) [*Current Topics in Microbiology and Immunology*, 18, 1 (1978)], P3-NS1/1-Ag41 (NS-1) [*European J. Immunology*, 6, 511 (1976)], SP2/0-Ag14 (SP-2) [*Nature*, 276, 269 (1978)], P3-X63-Ag8653 (653) [*J. Immunology*, 123, 1548
30 (1979)], P3-X63-Ag8 (X63) [*Nature*, 256, 495 (1975)] and the like.

[0191]

The myeloma cells are subcultured in a normal medium [a medium in which glutamine, 2-mercaptoethanol, gentamicin, FBS and 8-azaguanine are added to RPMI-1640 medium] and they are subcultured in the normal medium 3 or 4 days before cell
35 fusion to ensure the cell number of 2×10^7 or more on the day for fusion.

[0192]

(4) Cell fusion and preparation of hybridoma for producing monoclonal antibody

The antibody-producing cells for fusion obtained by the above (2) and myeloma cells obtained by the above (3) were sufficiently washed with a minimum essential medium (MEM) or PBS (1.83 g of disodium hydrogen phosphate, 0.21 g of potassium dihydrogen phosphate, 7.65 g of sodium chloride, 1 liter of distilled water, pH 7.2) and mixed to give a ratio of the antibody-producing cells: the myeloma cells = 5 to 10: 1, followed by centrifugation. Then, the supernatant is discarded.
[0193]

The precipitated cell group is sufficiently loosened. After loosening the precipitated cell, the mixture of polyethylene glycol-1000 (PEG-1000), MEM and dimethylsulfoxide is added to the cell under stirring at 37°C. In addition, 1 to 2 mL of MEM medium is added several times every one or two minutes, and MEM is added to give a total amount of 50 mL. After centrifugation, the supernatant is discarded. After the cells are gently loosened, the cells are gently suspended in HAT medium [a normal medium containing hypoxanthine, thymidine and aminopterin]. The suspension is cultured in a 5% CO₂ incubator for 7 to 14 days at 37°C.
[0194]

After the culturing, a portion of the culture supernatant is sampled and a hybridoma which is reactive to an antigen containing TIM-3 and is not reactive to an antigen not containing TIM-3 is selected by binding assay as described below. Then, cloning is carried out twice by a limiting dilution method [Firstly, HT medium (HAT medium from which aminopterin is removed) is used, and secondly, the normal medium is used], and a hybridoma which stably shows a high antibody titer is selected as the monoclonal antibody-producing hybridoma.
[0195]

(5) Preparation of purified monoclonal antibody

The hybridoma cells producing a monoclonal antibody obtained by the above (4) are administered by intraperitoneal injection into 8- to 10-week-old mice or nude mice treated with 0.5 mL of pristane (2,6,10,14-tetramethylpentadecane (pristane) is intraperitoneally administered, followed by feeding for 2 weeks). The hybridoma develops ascites tumor in 10 to 21 days. The ascitic fluid is collected from the mice, centrifuged to remove solids, subjected to salting out with 40 to 50% ammonium sulfate and then precipitated by caprylic acid, passed through a DEAE-Sepharose™ column, a protein A column or a gel filtration column to collect an IgG or IgM fraction as a purified monoclonal antibody.

[0196]

Furthermore, a monoclonal antibody-producing hybridoma obtained by the above (4) is cultured in RPMI1640 medium containing 10% FBS or the like and the supernatant is removed by centrifugation. The precipitated cells are suspended in Hybridoma-SFM medium and cultured for 3 to 7 days. The purified monoclonal antibody can be obtained by centrifusing the obtained cell suspension, followed by purification from the resulting supernatant with Protein A column or Protein G column to collect the IgG fractions. Additionally, Hybridoma-SFM medium can contain 5% DIGO GF21.

10 [0197]

The subclass of the antibody can be determined using a subclass typing kit by enzyme immunoassay. The amount of the protein can be determined by the Lowry method or from the absorbance at 280 nm.

[0198]

15 (6) Selection of monoclonal antibody

Selection of monoclonal antibody is carried out by the following binding assay using an enzyme immunoassay method and inhibition assay of intracellular uptake of amino acids.

[0199]

20 (6-a) Binding assay

As the antigen, a gene-introduced cell obtained by introducing an expression vector containing a cDNA encoding TIM-3 obtained in (1) into *Escherichia coli*, yeast, an insect cell, an animal cell or the like, a recombinant protein, or a purified polypeptide or partial peptide obtained from a human tissue is used. When the antigen is a partial peptide, a conjugate is prepared with a carrier protein such as BSA or KLH is prepared and is used.

[0200]

After making these antigens into a solid layer by dispensing in a 96-well plate, a substance to be tested such as serum, a culture supernatant of a hybridoma or a purified monoclonal antibody is dispensed therein as the primary antibody and allowed to react. After thoroughly washing with PBS, PBS-Tween™ and the like, an anti-immunoglobulin antibody labeled with biotin, an enzyme, a chemiluminescent material, a radiation compound or the like is dispensed therein as the secondary antibody and allowed to react. After thoroughly washing with PBS-Tween, the reaction appropriate to the label of the secondary antibody is carried out to select a monoclonal antibody which specifically reacts with the antigen.

[0201]

In addition, a monoclonal antibody which competes with the anti-TIM-3 monoclonal antibody of the present invention in the binding of an extracellular region of human TIM-3 can be obtained by adding a subject antibody to the above binding assay system to allow to react. Namely, a monoclonal antibody which competes with the obtained monoclonal antibody in the binding of an amino acid sequence of the extracellular region of human TIM-3 or a three-dimensional structure thereof can be obtained by screening a subject antibody which inhibits the binding of the monoclonal antibody upon adding to the antibody.

10 [0202]

Furthermore, an antibody which binds to the same epitope to which the monoclonal antibody of the present invention which binds to an amino acid sequence of the extracellular region of TIM-3 or three-dimensional structure thereof can be obtained by identifying an epitope of the antibody obtained by the above binding assay system, preparing a partial synthetic peptide of the epitope or a synthetic peptide which mimics the three-dimensional structure of the epitope and immunizing with the peptide.

[0203]

(6-b) Kinetic analysis with Biacore

The kinetics between an antigen and a test substance is measured using Biacore T100 and then the obtained results are analyzed using analysis software accompanied with the apparatus. After anti-mouse IgG antibody is immobilized onto to a CM 5 sensor chip by an amine coupling method, a test substance such as culture supernatant of a hybridoma, a purified monoclonal antibody is allowed to flow and bind at an appropriate amount, and an antigen at plural known concentrations is further allowed to flow. And then, the binding and dissociation are measured.

[0204]

Using the obtained data and the software accompanied with the apparatus, the kinetics analysis is carried out using the 1:1 binding model to obtain necessary parameters. Otherwise, after human TIM-3 is immobilized onto the sensor chip by an amino coupling method, a purified monoclonal antibody is allowed to flow at plural known concentrations followed by measuring the binding and dissociation. Using the obtained data and the software accompanied with the apparatus, the kinetics analysis is carried out using bivalent analyte model to obtain necessary parameters.

[0205]

35 2. Preparation of recombinant antibody

As production examples of recombinant antibodies, processes for producing a human chimeric antibody and a human CDR grafted antibody are shown below.

(1) Construction of vector for expression of recombinant antibody

A vector for expression of recombinant antibody is an expression vector for animal cell into which DNAs encoding CH and CL of a human antibody have been inserted, and is constructed by cloning each of DNAs encoding CH and CL of a human antibody into an expression vector for animal cell.

[0206]

The C region of a human antibody may be used CH and CL of any human antibody. Examples include CH belonging to $\gamma 1$ subclass, CL belonging to κ class, and the like. As the DNAs encoding CH and CL of a human antibody, the cDNA may be generally used and a chromosomal DNA comprising an exon and an intron can be also used.

[0207]

As the expression vector for animal cell, any expression vector can be used, so long as a gene encoding the C region of a human antibody can be inserted therein and expressed therein. Examples include pAGE107 [*Cytotechnol.*, 3, 133 (1990)], pAGE103 [*J. Biochem.*, 101, 1307 (1987)], pHSG274 [*Gene*, 27, 223 (1984)], pKCR [*Proc. Natl. Acad. Sci. USA*, 78, 1527 (1981)], pSG1bd2-4 [*Cytotechnol.*, 4, 173 (1990)], pSE1UK1Sed1-3 [*Cytotechnol.*, 13, 79 (1993)] and the like.

[0208]

Examples of a promoter and enhancer used for an expression vector for animal cell include an SV40 early promoter [*J. Biochem.*, 101, 1307 (1987)], a Moloney mouse leukemia virus LTR [*Biochem. Biophys. Res. Commun.*, 149, 960 (1987)], an immunoglobulin H chain promoter [*Cell*, 41, 479 (1985)] and enhancer [*Cell*, 33, 717 (1983)] and the like.

[0209]

The vector for expression of recombinant antibody may be either of a type in which a gene encoding an antibody H chain and a gene encoding an antibody L chain exist on separate vectors or of a type in which both genes exist on the same vector (tandem type). In respect of easiness of construction of a vector for expression of recombinant antibody, easiness of introduction into animal cells, and balance between the expression amounts of antibody H and L chains in animal cells, a tandem type of the vector for expression of recombinant antibody is more preferred [*J. Immunol. Methods*, 167, 271 (1994)]. Examples of the tandem type of the vector for expression of recombinant antibody include pKANTEX93 (WO 97/10354), pEE18 [*Hybridoma*, 17,

559 (1998)], and the like.

[0210]

(2) Obtaining of cDNA encoding V region of antibody derived from non-human animal and analysis of amino acid sequence

5 Obtaining of cDNAs encoding VH and VL of a non-human antibody and analysis of amino acid sequence are carried out as follows.

[0211]

 mRNA is extracted from hybridoma cells producing a non-human antibody to synthesize cDNA. The synthesized cDNA is cloned into a vector such as a phage or a
10 plasmid, to prepare a cDNA library.

[0212]

 Each of a recombinant phage or recombinant plasmid containing cDNA encoding VH or VL is isolated from the library using DNA encoding a part of the C region or V region of a mouse antibody as the probe. The full length of the nucleotide
15 sequences of VH and VL of a mouse antibody of interest on the recombinant phage or recombinant plasmid are determined, and the full length of the amino acid sequences of VH and VL are deduced from the nucleotide sequences, respectively.

[0213]

 Examples of the non-human animal for preparing a hybridoma cell which
20 produces a non-human antibody include mouse, rat, hamster, rabbit or the like. Any animals can be used so long as a hybridoma cell can be produced therefrom.

[0214]

 Examples of the method for preparing total RNA from a hybridoma cell include a guanidine thiocyanate-caesium trifluoroacetate method [*Methods in Enzymol.*,
25 154, 3 (1987)], the use of a kit such as RNA easy kit (manufactured by Qiagen) and the like.

[0215]

 Examples of the method for preparing mRNA from total RNA include an oligo (dT) immobilized cellulose column method [*Molecular Cloning, A Laboratory Manual*,
30 Second Edition, Cold Spring Harbor Laboratory Press (1989)], a method using a kit such as Oligo-dT30 <Super> mRNA Purification Kit (manufactured by Takara Bio) and the like. Additional examples of the method for preparing mRNA include method using a kit Fast Track mRNA Isolation kit (manufactured by Invitrogen) or QuickPrep mRNA Purification Kit (manufactured by Pharmacia) and the like.

35 [0216]

 Examples of the method for synthesizing cDNA and preparing a cDNA library

include known methods [*Molecular Cloning, A Laboratory Manual*, Second Edition, Cold Spring Harbor Laboratory Press (1989); *Current Protocols in Molecular Biology*, Supplement 1, John Wiley & Sons (1987-1997)]; a method using a kit such as Super Script Plasmid System for cDNA Synthesis and Plasmid Cloning (manufactured by
 5 Invitrogen), ZAP-cDNA Synthesis Kit (manufactured by Stratagene), *etc.*; and the like.
 [0217]

The vector into which the synthesized cDNA using mRNA extracted from a hybridoma cell as the template is inserted for preparing a cDNA library may be any vector, so long as the cDNA can be inserted. Examples include ZAP ExPress
 10 [Strategies, 5, 58 (1992)], pBluescript II SK(+) [Nucleic Acids Research, 17, 9494 (1989)], λ ZAPII (manufactured by Stratagene), λ gt10 and λ gt11 [DNA Cloning: A Practical Approach, I, 49 (1985)], Lambda BlueMid (manufactured by Clontech), λ ExCell and pT7T3-18U (manufactured by Pharmacia), pcD2 [Mol. Cell. Biol., 3, 280 (1983)], pUC18 [Gene, 33, 103 (1985)], and the like.

15 [0218]

Any *Escherichia coli* for introducing the cDNA library constructed by a phage or plasmid vector may be used, so long as the cDNA library can be introduced, expressed and maintained. Examples include XL1-Blue MRF' [Strategies, 5, 81 (1992)], C600 [Genetics, 39, 440 (1954)], Y1088 and Y1090 [Science, 222: 778
 20 (1983)], NM522 [J. Mol. Biol., 166, 1 (1983)], K802 [J. Mol. Biol., 16, 118 (1966)], JM105 [Gene, 38, 275 (1985)], and the like.
 [0219]

A colony hybridization or plaque hybridization method using an isotope- or fluorescence-labeled probe may be used for selecting cDNA clones encoding VH or VL
 25 of a non-human antibody or the like from the cDNA library [*Molecular Cloning, A Laboratory Manual*, Second Edition, Cold Spring Harbor Laboratory Press (1989)].
 [0220]

Also, the cDNAs encoding VH and VL can be prepared through polymerase chain reaction (hereinafter referred to as "PCR"; *Molecular Cloning, A Laboratory
 30 Manual*, Second Edition, Cold Spring Harbor Laboratory Press (1989); *Current Protocols in Molecular Biology*, Supplement 1, John Wiley & Sons (1987-1997)) by preparing primers and using cDNA prepared from mRNA or a cDNA library as the template.
 [0221]

35 The nucleotide sequence of the cDNA can be determined by digesting the cDNA selected with appropriate restriction enzymes and the like, cloning the fragments

into a plasmid such as pBluescript SK(-) (manufactured by Stratagene), carrying out the reaction by a usually used nucleotide sequence analyzing method. For example, a nucleotide sequence analyzing method is carried out by using an automatic nucleotide sequence analyzer such as ABI PRISM3700 (manufactured by PE Biosystems) and

5 A.L.F. DNA sequencer (manufactured by Pharmacia) after a reaction such as the dideoxy method [*Proc. Natl. Acad. Sci. USA*, 74, 5463 (1977)].

[0222]

Whether the obtained cDNAs encode the full amino acid sequences of VH and VL of the antibody containing a secretory signal sequence can be confirmed by

10 estimating the full length of the amino acid sequences of VH and VL from the determined nucleotide sequence and comparing them with the full length of the amino acid sequences of VH and VL of known antibodies [A.L.F. DNA sequencer, US Dept. Health and Human Services (1991)].

[0223]

15 With regard to the full amino acid sequences of VH and VL of the antibody containing a secretory signal sequence, the length of the secretory signal sequence and N-terminal amino acid sequence can be estimated by comparing them with the full length of the amino acid sequences of VH and VL of known antibodies [A.L.F. DNA sequencer, US Dept. Health and Human Services (1991)], and furthermore the subgroup

20 to which they belong can be determined. In addition, the amino acid sequence of each CDR of VH and VL can be determined by comparing them with the full length of the amino acid sequences of VH and VL of known antibodies [A.L.F. DNA sequencer, US Dept. Health and Human Services (1991)].

[0224]

25 Moreover, the novelty of the full length of the amino acid sequence of VH and VL can be examined by carrying out a homology search with sequences in any database, for example, SWISS-PROT, PIR-Protein or the like using the obtained full length of the amino acid sequences of VH and VL, for example, according to the BLAST method [*J. Mol. Biol.*, 215, 403 (1990)] or the like.

30 [0225]

(3) Construction of vector for expression of human chimeric antibody

cDNA encoding each of VH and VL of antibody of non-human animal is cloned in the upstream of genes encoding CH or CL of human antibody of vector for expression of recombinant antibody mentioned in the above (1) to thereby construct a

35 vector for expression of human chimeric antibody.

[0226]

In order to ligate cDNA comprising a nucleotide sequence of 3'-terminal of VH or VL of antibody of non-human animal and a nucleotide sequence of 5'-terminal of CH or CL of human antibody, each cDNA encoding VH or VL of a non-human animal antibody is prepared so as to encode appropriate amino acids and have an appropriate recognition sequence of a restriction enzyme at a linkage portion.
[0227]

The prepared cDNAs encoding VH and VL of antibody are respectively cloned so that each of them is expressed in an appropriate form in the upstream of gene encoding CH or CL of the human antibody of the vector for expression of the human CDR-grafted antibody mentioned in the above (1) to construct a vector for expression of human chimeric antibody.
[0228]

In addition, cDNA encoding VH or VL of a non-human animal antibody is amplified by PCR using a synthetic DNA having a recognition sequence of an appropriate restriction enzyme at both ends and each of them is cloned to the vector for expression of recombinant antibody obtained in the above (1).
[0229]

(4) Construction of cDNA encoding V region of human CDR-grafted antibody
cDNAs encoding VH or VL of a human CDR-grafted antibody can be obtained as follows.
[0230]

Amino acid sequences of framework region (hereinafter referred to as "FR") in VH or VL of a human antibody to which amino acid sequences of CDRs in VH or VL of an antibody derived from a non-human animal antibody are transplanted are respectively selected. Any amino acid sequences of FR of a human antibody can be used, so long as they are derived from human.
[0231]

Examples include amino acid sequences of FRs of human antibodies registered in database such as Protein Data Bank or the like, and amino acid sequences common to subgroups of FRs of human antibodies [*Sequences of Proteins of Immunological Interest*, US Dept. Health and Human Services (1991)], and the like. In order to inhibit the decrease in the binding activity of the antibody, amino acid sequences having high homology (at least 60% or more) with the amino acid sequence of FR in VH or VL of the original antibody is selected.
[0232]

Then, amino acid sequences of CDRs of the original antibody are grafted to the

selected amino acid sequence of FR in VH or VL of the human antibody, respectively, to design each amino acid sequence of VH or VL of a humanized antibody. The designed amino acid sequences are converted to DNA sequences by considering the frequency of codon usage found in nucleotide sequences of genes of antibodies [*Sequence of Proteins of Immunological Interest*, US Dept. Health and Human Services (1991)], and the DNA sequence encoding the amino acid sequence of VH or VL of a humanized antibody is designed.

[0233]

Based on the designed nucleotide sequences, several synthetic DNAs having a length of about 100 nucleotides are synthesized, and PCR is carried out using them. In this case, it is preferred that 6 synthetic DNAs per each of the H chain and the L chain are designed in view of the reaction efficiency of PCR and the lengths of DNAs which can be synthesized.

[0234]

Furthermore, the cDNA encoding VH or VL of a human CDR-grafted antibody can be easily cloned into the vector for expression of human CDR-grafted antibody constructed in (1) by introducing the recognition sequence of an appropriate restriction enzyme to the 5' terminal of the synthetic DNAs existing on the both ends.

[0235]

Otherwise, it can be carried out using a synthetic DNA as one DNA encoding each of the full-length H chain and the full-length L chain based on the designed DNA sequence.

[0236]

After the PCR, an amplified product is cloned into a plasmid such as pBluescript SK (-) (manufactured by Stratagene) or the like, and the nucleotide sequence is determined according to a method similar to the method described in (2) to obtain a plasmid having a DNA sequence encoding the amino acid sequence of VH or VL of a desired humanized antibody.

[0237]

(5) Modification of amino acid sequence of V region of human CDR-grafted antibody

It is known that when a human CDR-grafted antibody is produced by simply grafting only CDRs in VH and VL of an antibody derived from a non-human animal into FRs of VH and VL of a human antibody, its antigen binding activity is lower than that of the original antibody derived from a non-human animal [*BIO/TECHNOLOGY*, 9, 266 (1991)].

[0238]

In human CDR-grafted antibodies, among the amino acid sequences of FRs in VH and VL of a human antibody, an amino acid residue which directly relates to binding to an antigen, an amino acid residue which interacts with an amino acid residue in CDR, and an amino acid residue which maintains the three-dimensional structure of an antibody and indirectly relates to binding to an antigen are identified and modified to an amino acid residue which is found in the original non-humanized antibody to thereby increase the antigen binding activity which has been decreased.

[0239]

In order to identify the amino acid residues relating to the antigen binding activity in FR, constructing the three-dimensional structure of an antibody and analyzing can be done by X-ray crystallography [*J. Mol. Biol.*, 112, 535 (1977)], computer-modeling [*Protein Engineering*, 7, 1501 (1994)] or the like. In addition, modified human CDR-grafted antibody having sufficient binding activity against antigen can be obtained by various attempts, such as producing several modified antibodies of each antibody and examining their binding activities.

[0240]

The modification of the amino acid sequence of FR in VH and VL of a human antibody can be accomplished using various synthetic DNA for modification according to PCR as described in (4). With regard to the amplified product obtained by the PCR, the nucleotide sequence is determined according to the method as described in (2) so that whether the objective modification has been carried out is confirmed.

[0241]

(6) Construction of vector for expression of human CDR-grafted antibody

A vector for expression of human CDR-grafted antibody can be constructed by cloning each cDNA encoding VH or VL of a constructed recombinant antibody into upstream of each gene encoding CH or CL of the human antibody in the vector for expression of recombinant antibody as described in (1).

[0242]

For example, when recognizing sequences of an appropriate restriction enzymes are introduced to the 5'-terminal of synthetic DNAs positioned at both ends among synthetic DNAs used in the construction of VH or VL of the human CDR-grafted antibody in (4) and (5), cloning can be carried out so that they are expressed in an appropriate form in the upstream of each gene encoding CH or CL of the human antibody in the vector for expression of a human CDR-grafted antibody as described in (1).

[0243]

(7) Transient expression of recombinant antibody

In order to efficiently evaluate the antigen binding activity of various human CDR-grafted antibodies produced, the recombinant antibodies can be expressed transiently using the vector for expression of antibody as described in (3) and (6) or the modified expression vector thereof.

5 [0244]

Any cell can be used as a host cell, so long as the host cell can express a recombinant antibody. For example, COS-7 cell (ATCC CRL1651) is used in view of its high expression amount [*Methods in Nucleic Acids Res.*, CRC Press, 283 (1991)].

[0245]

10 Examples of the method for introducing the expression vector into COS-7 cell include a DEAE-dextran method [*Methods in Nucleic Acids Res.*, CRC Press, 283 (1991)], a lipofection method [*Proc. Natl. Acad. Sci. USA*, 84, 7413 (1987)], and the like.

[0246]

15 After introduction of the expression vector, the expression amount and antigen binding activity of the recombinant antibody in the culture supernatant can be determined by the enzyme immunoassay [*Monoclonal Antibodies-Principles and practice*, Third edition, Academic Press (1996), *Antibodies-A Laboratory Manual*, Cold Spring Harbor Laboratory (1988), *Monoclonal Antibody Experiment Manual*, Kodansha Scientific (1987)] and the like.

20 [0247]

(8) Obtaining transformant which stably expresses recombinant antibody and preparation of recombinant antibody

25 A transformant which stably expresses a recombinant antibody can be obtained by introducing the vector for expression of recombinant antibody described in (3) and (6) into an appropriate host cell.

[0248]

30 Examples of the method for introducing the expression vector into a host cell include electroporation [Japanese Published Unexamined Patent Application No. 257891/90, *Cytotechnology*, 3, 133 (1990)] and the like.

[0249]

35 As the host cell into which a vector for expression of a recombinant antibody is introduced, any cell can be used, so long as it is a host cell which can produce the recombinant antibody. Examples include CHO-K1 (ATCC CCL-61), DUKXB11 (ATCC CCL-9096), Pro-5 (ATCC CCL-1781), CHO-S (Life Technologies, Cat # 11619), rat myeloma cell YB2/3HL.P2.G11.16Ag.20 (also referred to as YB2/0), mouse myeloma cell NSO, mouse myeloma cell SP2/0-Ag14 (ATCC No. CRL1581), mouse

P3X63-Ag8653 cell (ATCC No. CRL1580), CHO cell in which a dihydrofolate reductase gene (hereinafter referred to as "dhfr") is defective [*Proc. Natl. Acad. Sci. U.S.A.*, 77, 4216 (1980)], lection resistance-acquired Lec13 [*Somatic Cell and Molecular genetics*, 12, 55 (1986)], CHO cell in which α 1,6-fucosyltransferase gene is
 5 defected (WO 2005/35586, WO 02/31140), rat YB2/3HL.P2.G11.16Ag.20 cell (ATCC No. CRL1662), and the like.

[0250]

In addition, host cells in which activity of a protein such as an enzyme relating to synthesis of an intracellular sugar nucleotide, GDP-fucose, a protein such as an
 10 enzyme relating to the modification of a sugar chain in which 1-position of fucose is bound to 6-position of N-acetylglucosamine in the reducing end through α -bond in a complex type N-glycoside-linked sugar chain, or a protein relating to transport of an intracellular sugar nucleotide, GDP-fucose, to the Golgi body is decreased or deleted, preferably CHO cell in which α 1,6-fucosyltransferase gene is defected as described in
 15 WO2005/35586, WO02/31140 or the like, can also be used.

[0251]

After introduction of the expression vector, transformants which express a recombinant antibody stably are selected by culturing in a medium for animal cell culture containing an agent such as G418 sulfate (hereinafter referred to as "G418") or
 20 the like (Japanese Published Unexamined Patent Application No. 257891/90).

[0252]

Examples of the medium for animal cell culture include RPMI1640 medium (manufactured by Invitrogen), GIT medium (manufactured by Nihon Pharmaceutical), EX-CELL301 medium (manufactured by JRH), IMDM medium (manufactured by
 25 Invitrogen), Hybridoma-SFM medium (manufactured by Invitrogen), media obtained by adding various additives such as FBS to these media, and the like.

[0253]

The recombinant antibody can be produced and accumulated in a culture supernatant by culturing the obtained transformants in a medium. The expression
 30 amount and antigen binding activity of the recombinant antibody in the culture supernatant can be measured by ELISA or the like. Also, in the transformant, the expression amount of the recombinant antibody can be increased by using DHFR amplification system or the like according to the method disclosed in Japanese Published Unexamined Patent Application No. 257891/90.

35 [0254]

The recombinant antibody can be purified from the culture supernatant of the transformant by using a protein A column [*Monoclonal Antibodies-Principles and*

practice, Third edition, Academic Press (1996), *Antibodies-A Laboratory Manual*, Cold Spring Harbor Laboratory (1988)]. In addition, the recombinant antibody can be purified by a combination of the methods for purification such as gel filtration, ion-exchange chromatography, ultrafiltration and the like.

5 [0255]

The molecular weight of the H chain or the L chain of the purified recombinant antibody or the antibody molecule as a whole is determined by polyacrylamide gel electrophoresis (hereinafter referred to as "SDS-PAGE") [*Nature*, 227, 680 (1970)], Western blotting [*Monoclonal Antibodies-Principles and practice*, Third edition, Academic Press (1996), *Antibodies-A Laboratory Manual*, Cold Spring Harbor Laboratory (1988)], and the like.

[0256]

3. Activity evaluation of the monoclonal antibody or antibody fragment

The activity of the purified monoclonal antibody or antibody fragment of the present invention can be evaluated in the following manner.

15 [0257]

The binding activity to TIM-3-expressing cell is evaluated by the binding assay described in the above 1-(6a) and a surface plasmon resonance method using such as the Biacore system described in the above (6b). Furthermore, it can be measured by fluorescent antibody technique [*Cancer Immunol. Immunother.*, 36, 373 (1993)] and the like.

20 [0258]

Complement-Dependent Cytotoxicity (hereinafter, referred to as "CDC activity") or ADCC activity against an antigen positive cell line is evaluated by a known method [*Cancer Immunol. Immunother.*, 36, 373 (1993)].

25 [0259]

4. Method of controlling effector activity of antibody

As a method for controlling an effector activity of the monoclonal antibody of the present invention, a method for controlling an amount of fucose (hereinafter, referred to also as "core fucose") which is bound in α -1,6 linkage to N-acetylglucosamine (GlcNAc) present in a reducing end of a complex type N-linked sugar chain which is bound to asparagine (Asn) at position 297 of an Fc region of an antibody (WO2005/035586, WO2002/31140, and WO00/61739), a method for controlling an effector activity of a monoclonal antibody by modifying amino acid group(s) of an Fc region of the antibody, and the like are known. The effector activity of the anti-TIM-3 monoclonal antibody of the present invention can be controlled by using any of the methods.

30
35

[0260]

The "effector activity" means an antibody-dependent activity which is induced via an Fc region of an antibody. As the effector activity, ADCC activity, CDC activity, an antibody-dependent phagocytosis (ADP activity) by phagocyte such as macrophages or dendritic cells, and the like are known.

[0261]

By controlling a content of core fucose of a complex type N-linked sugar chain of Fc of an antibody, an effector activity of the antibody can be increased or decreased. According to a method for lowering a content of fucose which is bound to a complex type N-linked sugar chain bound to Fc of the antibody, an antibody to which fucose is not bound can be obtained by the expression of an antibody using a CHO cell which is deficient in a gene encoding α 1,6-fucosyltransferase. The antibody to which fucose is not bound has a high ADCC activity.

[0262]

On the other hand, according to a method for increasing a content of fucose which is bound to a complex type N-linked sugar chain bound to Fc of an antibody, an antibody to which fucose is bound can be obtained by the expression of an antibody using a host cell into which a gene encoding α 1,6-fucosyltransferase is introduced. The antibody to which fucose is bound has a lower ADCC activity than the antibody to which fucose is not bound.

[0263]

Further, by modifying amino acid residue(s) in an Fc region of an antibody, the ADCC activity or CDC activity can be increased or decreased. For example, the binding activity to an antibody can be increased by using the amino acid sequence of the Fc region described in US2007/0148165. Further, the ADCC activity or CDC activity can be increased or decreased by modifying the amino acid as described in US Patent Nos. 6,737,056, or 7,297,775 or 7,317,091.

[0264]

Furthermore, an antibody in which the effector activity is controlled can be obtained by combining the above method within one antibody.

[0265]

5. Method for treating disease using the anti-TIM-3 monoclonal antibody or antibody fragment of the present invention

The monoclonal antibody or an antibody fragment thereof of the present invention can be used for treating a disease relating to a TIM-3 positive cell.

[0266]

The therapeutic agent comprising the antibody or antibody fragment of the present invention or derivatives thereof may be only the antibody or antibody fragment or derivatives thereof as an active ingredient, and is preferably supplied as a pharmaceutical preparation produced by an appropriate method well known in the technical field of pharmaceuticals, by mixing it with one or more pharmaceutically acceptable carriers.

[0267]

Examples of a route of administration include oral administration and non-oral administration, such as buccal, tracheal, rectal, subcutaneous, intramuscular or intravenous administration. Examples of the dosage form includes sprays, capsules, tablets, powder, granules, syrups, emulsions, suppositories, injections, ointments, tapes and the like.

[0268]

The pharmaceutical preparation suitable for oral administration includes emulsions, syrups, capsules, tablets, powders, granules and the like.

[0269]

Liquid preparations such as emulsions and syrups can be produced using, as additives, water; sugars such as sucrose, sorbitol and fructose; glycols such as polyethylene glycol and propylene glycol; oils such as sesame oil, olive oil and soybean oil; antiseptics such as p-hydroxybenzoic acid esters; flavors such as strawberry flavor and peppermint; and the like.

[0270]

Capsules, tablets, powders, granules and the like can be produced using, as additives, excipients such as lactose, glucose, sucrose and mannitol; disintegrating agents such as starch and sodium alginate; lubricants such as magnesium stearate and talc; binders such as polyvinyl alcohol, hydroxypropylcellulose and gelatin; surfactants such as fatty acid ester; plasticizers such as glycerin; and the like.

[0271]

The pharmaceutical preparation suitable for parenteral administration includes injections, suppositories, sprays and the like.

[0272]

Injections can be prepared using a carrier such as a salt solution, a glucose solution or a mixture of both thereof.

[0273]

Suppositories can be prepared using a carrier such as cacao butter, hydrogenated fat or carboxylic acid.

[0274]

Sprays can be prepared using the antibody or antibody fragment as such or using it together with a carrier which does not stimulate the buccal or airway mucous membrane of the patient and can facilitate absorption of the compound by dispersing it as fine particles. The carrier includes lactose, glycerol and the like. It is possible to produce pharmaceutical preparations such as aerosols and dry powders.

[0275]

In addition, the components exemplified as additives for oral preparations can also be added to the parenteral preparations.

10 [0276]

6. Method for diagnosing disease using the anti-TIM-3 monoclonal antibody or antibody fragment thereof in the present invention

A disease relating to TIM-3 can be diagnosed by detecting or determining TIM-3 or a cell expressing TIM-3 using the monoclonal antibody or antibody fragment of the present invention.

15 [0277]

A diagnosis of cancer which is one of the diseases relating to TIM-3 can be carried out by, for example, the following detection or measurement of TIM-3.

[0278]

20 The diagnosis of cancer can be carried out by detecting TIM-3 expression on the cell in a patient's body by an immunological method such as a flow cytometry.

[0279]

An immunological method is a method in which an antibody amount or an antigen amount is detected or determined using a labeled antigen or antibody.

25 Examples of the immunological method include radioactive substance-labeled immunoantibody method, enzyme immunoassay, fluorescent immunoassay, luminescent immunoassay, Western blotting method, physico-chemical means and the like.

[0280]

30 Examples of the radioactive substance-labeled immunoantibody method include a method, in which the antibody or antibody fragment of the present invention is allowed to react with an antigen, a cell expressing an antigen or the like, then anti-immunoglobulin antibody subjected to a radioactive labeling or a binding fragment thereof is allowed to react therewith, followed by determination using a scintillation counter or the like.

35 [0281]

Examples of the enzyme immunoassay include a method, in which the antibody or antibody fragment of the present invention is allowed to react with an

antigen, a cell expressing an antigen or the like, then an anti-immunoglobulin antibody or an binding fragment thereof subjected to antibody labeling is allowed to react therewith and the colored pigment is measured by a spectrophotometer, and, for example, sandwich ELISA may be used.

5 [0282]

As a label used in the enzyme immunoassay, any known enzyme label (*Enzyme Immunoassay*, published by Igaku Shoin, 1987) can be used as described previously. Examples include alkaline phosphatase labeling, peroxidase labeling, luciferase labeling, biotin labeling and the like.

10 [0283]

Sandwich ELISA is a method in which an antibody is bound to a solid phase, antigen to be detected or measured is trapped and another antibody is allowed to react with the trapped antigen. In the ELISA, two kinds of antibody which recognizes the antigen to be detected or measured or the antibody fragment thereof in which antigen recognizing site is different are prepared and the first antibody or antibody fragments is previously adsorbed on a plate (such as a 96-well plate) and the second antibody or antibody fragment is labeled with a fluorescent substance such as FITC, an enzyme such as peroxidase, or biotin.

[0284]

20

The plate to which the above antibody is adsorbed is allowed to react with the cell separated from living body or disrupted cell suspension thereof, tissue or disintegrated solution thereof, supernatant of cell culture, serum, pleural effusion, ascites, eye solution or the like, then allowed to react with a labeled monoclonal antibody or an antibody fragment and a detection reaction corresponding to the labeled substance is carried out. The antigen concentration in the sample to be tested can be calculated from a calibration curve prepared by a stepwise dilution of antigen of known concentration.

[0285]

30

As antibody used for sandwich ELISA, any of polyclonal antibody and monoclonal antibody may be used or antibody fragments such as Fab, Fab' and F(ab)₂ may be used. As a combination of 2 kinds of antibodies used in sandwich ELISA, a combination of monoclonal antibodies or antibody fragments recognizing different epitopes may be used or a combination of polyclonal antibody with monoclonal antibody or antibody fragments may be used.

35 [0286]

A fluorescent immunoassay includes a method described in the literatures [*Monoclonal Antibodies - Principles and practice*, Third Edition, Academic Press

(1996); *Manual for Monoclonal Antibody Experiments*, Kodansha Scientific (1987)] and the like. As a label for the fluorescent immunoassay, any of known fluorescent labels [*Fluorescent Immunoassay*, by Akira Kawao, Soft Science, (1983)] may be used. Examples of the label include FITC, RITC and the like.

5 [0287]

The luminescent immunoassay can be carried out using the methods described in the literature [*Bioluminescence and Chemical Luminescence*, *Rinsho Kensa*, 42, Hirokawa Shoten (1998)] and the like. As a label used for luminescent immunoassay, any of known luminescent labels can be included. Examples include acridinium ester,

10 lophine or the like may be used.
[0288]

Western blotting is a method in which an antigen or a cell expressing an antigen is fractionated by SDS (Sodium dodecyl sulfate)-PAGE [*Antibodies-A Laboratory Manual* (Cold Spring Harbor Laboratory, 1988)], the gel is blotted onto

15 PVDF membrane or nitrocellulose membrane, the membrane is allowed to react with antigen-recognizing antibody or antibody fragment, further allowed to react with an anti-mouse IgG antibody or antibody fragment which is labeled with a fluorescent substance such as FITC, an enzyme label such as peroxidase, a biotin labeling, or the like, and the label is visualized to confirm the reaction. An example thereof is

20 described below.

[0289]

Cells or tissues in which a polypeptide having the amino acid sequence represented by SEQ ID NO: 53 is expressed are dissolved in a solution and, under reducing conditions, 0.1 to 30 μ g as a protein amount per lane is electrophoresed by an

25 SDS-PAGE method. The electrophoresed protein is transferred onto a PVDF membrane and allowed to react with PBS containing 1 to 10% of BSA (hereinafter referred to as "BSA-PBS") at room temperature for 30 minutes for blocking.

[0290]

Here, the monoclonal antibody of the present invention is allowed to react

30 therewith, washed with PBS containing 0.05 to 0.1% Tween 20 (hereinafter referred to as "Tween-PBS") and allowed to react with goat anti-mouse IgG labeled with peroxidase at room temperature for 2 hours. It is washed with Tween-PBS and a band to which the monoclonal antibody is bound is detected using ECL Western Blotting Detection Reagents (manufactured by Amersham) or the like to thereby detect a

35 polypeptide having the amino acid sequence represented by SEQ ID NO: 1. As an antibody used for the detection in Western blotting, an antibody which can be bound to a polypeptide having no three-dimensional structure of a natural type is used.

[0291]

The physicochemical method is specifically carried out by reacting TIM-3 as the antigen with the antibody or antibody fragment of the present invention to form an aggregate, and detecting this aggregate. Other examples of the physicochemical methods include a capillary method, a one-dimensional immunodiffusion method, an immunoturbidimetry, a latex immunoturbidimetry [*Handbook of Clinical Test Methods*, Kanehara Shuppan, (1988)] and the like.

[0292]

For example, in a latex immunodiffusion method, a carrier such as polystyrene latex having a particle size of about of 0.1 to 1 μm sensitized with antibody or antigen may be used and when an antigen-antibody reaction is carried out using the corresponding antigen or antibody, scattered light in the reaction solution increases while transmitted light decreases. When such a change is detected as absorbance or integral sphere turbidity, it is possible to measure antigen concentration, etc. in the sample to be tested.

[0293]

In addition, for the detection of the cell expressing TIM-3, known immunological detection methods can be used, and an immunoprecipitation method, an immuno cell staining method, an immune tissue staining method, a fluorescent antibody staining method and the like are preferably used.

[0294]

An immunoprecipitation method is a method in which a cell expressing TIM-3 is allowed to react with the monoclonal antibody or antibody fragment of the present invention and then a carrier having specific binding ability to immunoglobulin such as protein G-Sepharose is added so that an antigen-antibody complex is precipitated. Also, the following method can be carried out. The above-described antibody or antibody fragment of the present invention is solid-phased on a 96-well plate for ELISA and then blocked with BSA-PBS.

[0295]

When the antibody is in a non-purified state such as a culture supernatant of hybridoma cell, anti-mouse immunoglobulin or rat immunoglobulin or protein A or Protein G or the like is previously adsorbed on a 96-well plate for ELISA and blocked with BSA-PBS and a culture supernatant of hybridoma cell is dispensed thereto for binding. After BSA-PBS is discarded and the residue is sufficiently washed with PBS, reaction is carried out with a dissolved solution of cells or tissues expressing TIM-3. An immune precipitate is extracted from the well-washed plate with a sample buffer for SDS-PAGE and detected by the above-described Western blotting.

[0296]

An immune cell staining method or an immune tissue staining method are a method where cells or tissues in which antigen is expressed are treated, if necessary, with a surfactant, methanol or the like to make an antibody easily permeate to the cells or tissues, then the monoclonal antibody of the present invention is allowed to react therewith, then further allowed to react with an anti-immunoglobulin antibody or binding fragment thereof subjected to fluorescent labeling such as FITC, enzyme label such as peroxidase or biotin labeling and the label is visualized and observed under a microscope.

10 [0297]

In addition, cells can be detected by an immunofluorescent staining method where cells are allowed to react with a fluorescence-labeled antibody and analyzed by a flow cytometer [*Monoclonal Antibodies - Principles and practice*, Third Edition, Academic Press (1996), *Manual for Experiments of Monoclonal Antibodies*, Kodansha Scientific (1987)] in which cells are allowed to react with a fluorescence-labeled antibody and analyzed by a flow cytometer.

[0298]

Particularly, the monoclonal antibody or antibody fragment of the present invention which binds to amino acids sequences of an extracellular region of the TIM-3 or a three-dimensional structure thereof can detect a cell expressing the polypeptide maintaining a natural three-dimensional structure by a fluorescence antibody method.

[0299]

In addition, in the case of using FMAT8100HTS system (manufactured by Applied Biosystems) and the like among fluorescent antibody staining methods, the antigen quantity or antibody quantity can be measured without separating the formed antibody-antigen complex and the free antibody or antigen which is not concerned in the formation of the antibody-antigen complex.

[0450]

The present invention can provide a monoclonal antibody or an antibody fragment of thereof, which binds to amino acids sequences of an extracellular region of TIM-3 or a three-dimensional structure and expresses ADCC activity; a hybridoma which produces the antibody; a DNA which encodes the antibody; a vector which comprises the DNA; a transformant obtained by transforming the vector; a process for producing an antibody or an antibody fragment thereof using the hybridoma or the transformant; and a therapeutic agent or a diagnostic agent comprising the antibody or the antibody fragment thereof as an active ingredient.

[0300]

Hereinafter, exemplary embodiments of the present invention will be described specifically. However, the present invention is not limited to the exemplary embodiments described below.

5 Example

[0301]

[Example 1]

(Molecular cloning of human TIM-3 cDNA and establishment of stable expression cell)

10 Human TIM-3 cDNA was amplified by PCR using ExTaq (manufactured by Takara Bio Inc.) and Human MTC panel (manufactured by Clontech) as a template. For primers, TIM-3 Fw2 (SEQ ID NO: 31) and TIM-3 Re2 (SEQ ID NO: 32) were used. The obtained PCR product was inserted into pGEM-T Easy vector (manufactured by Promega Corp.), and the plasmid was introduced into TOP10 One
15 shot competent cells (manufactured by Invitrogen) to amplify. The plasmid DNA was extracted by the miniprep method.

[0302]

By analyzing the sequence of purified DNA using primers TIM-3 Fw and TIM-3 Re2, the clone having the same sequence as the coding region of GenBank accession
20 number NM_032782 was selected. A human TIM-3 retrovirus (hTIM-3/pMCs-IG) was constructed by recombination of the insert of the selected clone into pMCs-IRES-GFP vector (manufactured by Cell Biolabs Inc.) using Retrovirus Constructive System Amphi (manufactured by Takara Bio Inc.).

[0303]

25 The human TIM-3 retrovirus was infected into Jurkat cell (ATCC accession NO: CRL-2063), EoL-1 cell (RIKEN CELL BANK NO: RCB0641) and L929 cell (manufactured by Sigma-Aldrich Co., LLC.) which were confirmed not to endogenously express TIM-3 was confirmed by flow cytometry analysis. After several passages, TIM-3 positive cells were collected by FACS Aria (manufactured by BD
30 Biosciences). Human TIM-3 stable expression cell line was established by recollecting the TIM-3 positive cells by FACS Aria after several passages.

[0304]

[Example 2]

(Preparation of expression vector of fusion protein of soluble extracellular
35 human TIM-3-human Fc)

The cDNA encoding the extracellular region of human TIM-3 was amplified by PCR using ExTaq (manufactured by Takara Bio Inc.) and hTIM-3/pMCs-Ig

constructed in Example 1 as a template. For primers, pMCs-Fw (SEQ ID NO: 33) and TIM3ED-FcReXba 2 (SEQ ID NO: 34) were used.

[0305]

The amplified PCR product was inserted into pTracer-CMV-FLAG-human Fc
 5 vetctor [modified vector in which FLAG and Fc domain of human IgG1 were inserted
 into pTracer-CMV (manufactured by Invitrogen) vector between *Xba*I site and *Apa*I
 site]. After the plasmid was introduced into TOP10 One shot competent cells
 (manufactured by Invitrogen) to amplify, the plasmid DNA (sTIM-3-FLAG-
 Fc/pTracerCMV) was extracted by miniprep method.

10 [0306]

By the analysis of the DNA sequence using T7 (SEQ ID NO: 35) and hTIM-3
 Fw1 (SEQ ID NO: 36) as a primer, the purified sTIM-3-FLAG-Fc/pTracerCMV was
 confirmed to have the same nucleotide sequence as the corresponding region in
 GenBank accession number NM_032782. The nucleotide sequence (from *Eco*RI
 15 recognition site to *Apa*I recognition site) was identical to the nucleotide sequence
 represented by SEQ ID NO: 37.

[0307]

[Example 3]

(Preparation of expression vector of soluble extracellular human TIM-3)

20 The cDNA encoding the extracellular region of human TIM-3 was amplified
 by PCR using ExTaq (manufactured by Takara Bio Inc.) and sTIM-3-FLAG-
 Fc/pTracerCMV established in Example 2 as a template. As primers, TIM-3 Fw2
 (SEQ ID NO: 31) and TIM3ED-FLAG4aa (SEQ ID NO: 39) were used.

[0308]

25 Next, FLAG epitope was ligated by PCR method using ExTaq (manufactured
 by Takara Bio Inc.), TIM-3 Fw2 (SEQ ID NO: 31) and C-FLAG-NotR2 (SEQ ID NO:
 40) as primers and the obtained PCR product as a template. The PCR product was
 inserted into pGEM-T Easy vector (manufactured by Promega Corp.). After the
 plasmid was introduced into TOP10 One shot competent cells (manufactured by
 30 Invitrogen) to amplify the plasmid DNA (sTIM-3-FLAG/pEF6Myc_HisC) was
 extracted by the miniprep method.

[0309]

By the DNA sequence analysis using T7 (SEQ ID NO: 35) and BGH-R (SEQ
 ID NO: 41) as a primer, the purified sTIM-3-FLAG-Fc/pEF6 Myc_HisC was confirmed
 35 to have the same nucleotide sequence as the corresponding region in GenBank
 accession number NM_032782.

[0310]

[Example 4]

(Preparation of the fusion protein of soluble extracellular human TIM-3-human Fc and soluble extracellular human TIM-3)

Each of sTIM-3-FLAG-Fc/pTracerCMV plasmid DNA and sTIM-3-FLAG-Fc/pEF6 Myc_HisC plasmid DNA obtained in Example 2 and Example 3, respectively, was introduced into HEK293F cells (manufactured by Invitrogen) and was transiently expressed. Six days after, each of the cell supernatant was recovered and used for protein purification.

[0311]

The culture supernatant containing the fusion protein of soluble extracellular human TIM-3-human Fc or soluble extracellular human TIM-3 was recovered by centrifugation six days after transfection. The fusion proteins were purified by an anti-FLAG column prepared using Anti-FLAG M2 Agarose Affinity gel (manufactured by Sigma-Aldrich Co., LLC.) and by FLAG peptides (manufactured by Sigma-Aldrich Co., LLC.) according to the manufacturer's protocols.

[0312]

The eluted samples were fractionated and then each fraction was analyzed by SDS-PAGE under reduced conditions, and then silver staining and Western blotting were carried out. For Western blotting, an anti-FLAG M2 antibody (manufactured by Sigma-Aldrich Co., LLC.) and an alkaline phosphatase labeled rabbit anti-mouse immunoglobulin antibody was used (manufactured by Dako). The fraction containing the target protein was concentrated using Amicon Ultra 4 10K (manufactured by Millipore) and was applied for gel filtration chromatography using Superdex 200 gp column (manufactured by GE Healthcare).

[0313]

After fractionation, each fraction was applied to SDS-PAGE under reduced condition, silver stained and then Western blotted. The fraction in which the target protein was found was concentrated and washed with 0.5 ml of PBS. The soluble extracellular human TIM-3-human Fc fusion protein or soluble extracellular human TIM-3 was collected after filtering through the MILLEX-GV sterilizing filter (manufactured by Millipore) having a pore diameter of 0.22 μm . The purity of the protein was measured by Limulus ES-II kit Wako (manufactured by Wako Pure Chemical Industries, Ltd.) which is a kit to detect endotoxin and confirmed that the fraction was sufficiently purified.

[0314]

[Example 5]

(Preparation of human antibody expressing mouse)

The mice used for immunization has a genetic background in which both of endogenous Ig heavy chain locus and κ light chain locus were homozygously disrupted and maintained a chromosome 14 fragment (SC20) comprising a human heavy chain transchromosome, and a human Igk chain transgene (KCo5) at the same time. This mouse strain was established by cross breeding mice strain A which had human Ig heavy chain loci and mice strain B which maintained human Igk chain transgene. [0315]

Mouse strain A is a homozygote in which both of the endogenous Ig heavy chain locus and κ light chain locus are homozygously disrupted, and maintains a chromosome 14 fragment (SC20) which can be transmitted to the progeny and for example, described in Tomizuka *et al.* (Tomizuka, K. *et al.*, 2000, *Proc. Natl. Acad. Sci. U.S.A.* 97:722-727). [0316]

Mouse Strain B is a mouse strain (transgenic mouse) in which both of the endogenous Ig heavy chain locus and κ light chain locus are homozygously disrupted, and maintains a human Igk light chain transgene (KCo5), and is, for example, described in Fishwild *et al.* (1996) [*Nature Biotechnology* 14:845-851]. [0317]

The animal individual was obtained by cross-breeding male mouse of strain A and female mouse of strain B, or female mouse of strain A and male mouse of strain B and was a mouse in which human Ig heavy chain and Igk light chain could be detected at the same time in their serum [Ishida& Lonberg, *IBC's 11th Antibody Engineering*, Abstract 2000] was further used for immunological experiments. For your information,, the human antibody expressing mouse (hereinafter referred to as "KM mouse") can be obtained from Kyowa Hakko Kirin by establishing a license. [0318]

[Example 6]

(Preparation of anti-human TIM-3 monoclonal antibody)

The preparation of monoclonal antibody in the present Example was carried out according to the general methods, such as published in *Monoclonal Antibody Experiment Manual*, (Yasuhigashi Tamie *et al.*, Kodansha, 1991). Either TIM-3 expressing L929 cell prepared in Example 1 or the soluble extracellular human TIM-3-human Fc fusion protein prepared in Example 4 was used as a TIM-3 immunogen. The immunized animal was KM mouse described above. [0319]

The TIM-3 expressing L929 cell was intraperitoneally injected into mice at a dose of 1×10^7 cells/animal. After the first immunization, the same cell was further

administered for another three times or more thereafter. Three days before obtaining the spleen, the soluble extracellular human TIM-3-human Fc fusion protein prepared in Example 4 was administered from caudal vein at 20 µg/mouse. The spleen was surgically removed from the immunized mouse, put into 4 ml of PBS and mashed on a mesh (cell strainer: manufactured by Falcon) using a syringe piston.

[0320]

The cells were precipitated by centrifuging the cell suspension which was passed through the mesh, and the cells were resuspended in 1 ml of Red Blood Cell Lysis Buffer (manufactured by Sigma-Aldrich Co., LLC.). After incubating for 5 min at room temperature, 10 ml of serum free DMEM medium (manufactured by Invitrogen) (hereinafter referred to as "serum free DMEM medium") containing 50 unit/ml penicillin and 50 µg/ml streptomycin was added, and the cells were precipitated by centrifugation.

[0321]

The cell pellets were resuspended in serum free DMEM medium. On the other hand, myeloma cell line SP2/0 (ATCC NO: CRL-1581) was cultured in DMEM medium containing 10% FBS, 50 unit/ml penicillin and 50 µg/ml streptomycin (hereinafter referred to as "DMEM medium containing serum") and incubated at 37°C under 5% CO₂ so as not exceed the cell number of 1×10^6 cells/ml.

[0322]

The SP2/0 cells were washed with 10 ml of serum free DMEM medium and suspended in serum free DMEM medium as in the case of the spleen derived cells. These suspension of spleen derived cells and suspension of myeloma cell were mixed at a ratio of 5:1, centrifuged, and the supernatant was completely removed. To fuse the cells, 1 ml of 50% (w/v) of polyethylene glycol (manufactured by Boehringer Mannheim Corp.) was slowly added while stirring the pellet with the pipette tip, and then 1 ml of serum free DMEM medium preheated at 37°C was added. Slowly, 5 ml and 10 ml of serum free DMEM was added followed by 5 min incubation at 37°C under 5% CO₂.

[0323]

After the centrifugation and removal of supernatant, the fused cells were resuspended in 50 ml of DMEM medium containing 10% FBS (manufactured by Invitrogen), penicillin-streptomycin-glutamine (manufactured by Invitrogen, 100-fold dilution of Catalog No.10378-016), IL-6 (5 ng/ml), and 2-mercaptoethanol (manufactured by Invitrogen, 1000-fold dilution of Catalog No. 21985-023) (hereinafter referred to as "DMEM medium containing IL-6") and incubated at 37°C under 5% CO₂.

[0324]

The next day, cells were harvested by pipetting, centrifuged and the pellet was resuspended in 10 ml of DMEM medium containing IL-6. On the next day, Hypoxanthine-aminopterin-thymidine (hereinafter referred to as "HAT", manufactured by Sigma-Aldrich Co., LLC.) was added. After incubating for about 7 to 10 days, the culture supernatant was collected for hybridoma screening.

[0325]

[Example 7]

(Preparation of anti-human TIM-3 mouse monoclonal antibody)

The preparation of monoclonal antibody in the present Example was carried out according to the general methods published in Introduction to Monoclonal Antibody Experiment (Yasuhigashi Tamie *et al.*, Kodansha, 1991). Either TIM-3 expressing L929 cell prepared in Example 1 or soluble extracellular human TIM-3 prepared in Example 4 was used as a TIM-3 immunogen. The immunized animal was Balb/c mouse (purchased from Nihon Charles River).

[0326]

First, a Balb/c mouse was immunized by injecting TIM-3 expressing L929 cells intraperitoneally at a dose of 1×10^7 cells/animal. After the first immunization, the same cell was further administered for another three times or more thereafter. Three days before extracting the spleen, the soluble extracellular human TIM-3 protein prepared in Example 4 was administered from caudal vein at 20 μ g/mouse. The spleen was surgically removed from the immunized mouse, put into 4 ml of PBS and mashed on a mesh (cell strainer: manufactured by Falcon) using a syringe piston.

[0327]

The cells were precipitated by centrifuging the cell suspension which was passed through the mesh, and the cells were resuspended in 1 ml of Red Blood Cell Lysis Buffer (manufactured by Sigma-Aldrich Co., LLC.). After incubating for 5 min at room temperature, 10 ml of serum free DMEM medium was added, and then cells were precipitated by centrifugation. The pellets were resuspended in serum free DMEM medium. On the other hand, myeloma cell line SP2/0 (ATCC NO: CRL-1581) were cultured in DMEM medium by incubating at 37°C under 5% CO₂ to the cell number of 1×10^6 cells/ml or less.

[0328]

Similar to the spleen derived cells, the SP2/0 cells were washed with 10 ml of serum free DMEM medium and suspended in serum free DMEM medium. The suspension of spleen cell and the suspension of myeloma cell were mixed at a ratio of 5:1. After centrifugation, the supernatant was removed. To this pellet, 1 ml of 50% (w/v) of polyethylene glycol (manufactured by Boehringer Mannheim Corp.) was

slowly added while stirring the pellet with the pipette tip, and then 1 ml of serum free DMEM medium preheated to 37°C was added.

[0329]

To this suspension, 5 ml of DMEM medium was slowly added. After further adding 10 ml of serum free DMEM, the suspension was incubated for 5 min at 37°C under 5% CO₂. After the suspension was centrifuged, the cell pellets were resuspended in 50 ml of DMEM medium containing IL-6 and cultured at 37°C under 5% CO₂. After incubation for one day, cells were collected by pipetting. After centrifugation, the pellet was resuspended in 10 ml of DMEM medium containing IL-6. On the next day, HAT medium (manufactured by Sigma-Aldrich Co., LLC.) was added. After incubation for about 7 to 10 days, the culture supernatant was recovered and used for hybridoma screening.

[0330]

[Example 8]

(Screening of hybridoma producing a human or mouse monoclonal antibody which binds to human TIM-3)

The hybridoma was screened using the cell supernatant prepared in Example 6 and Example 7. The method to be used was a flow cytometry method using human TIM-3 expressing cell lines. First, the human TIM-3 expressing Jurkat cell or EoL-1 cell prepared in Example 1 were washed with staining medium (PBS containing 2% FBS and 0.05% sodium azide), and then resuspended in 1 ml of staining medium to give a cell density of 1×10^6 cells/ml. The cell suspension was dispensed at 10 μ l/well into a 96-well culture plate.

[0331]

Then, 50 μ l of the hybridoma supernatant was added and incubated for 30 min at 4°C. After the cells were washed twice with the staining medium, 50 μ l of labeled antibody which was diluted 200-fold with staining medium was added to each well and incubated for 30 min at 4°C. As for labeled antibodies, Goat F(ab')₂ Anti-Human IgG (γ chain specific)-R-PE (manufactured by SouthernBiotech) were used for the human monoclonal antibody and Goat F(ab')₂ Anti-Mouse IgG(H+L)R-PE (manufactured by SouthernBiotech) was used for the mouse monoclonal antibody.

[0332]

After washing twice with staining medium, the cells were analysed using FACSCalibur (manufactured by BD Biosciences) as a primary screening. After positive clones were picked and expanded, the hybridoma cells were clone-sorted by FACSARIA (manufactured by BD Biosciences) and cultured for seven days in DMEM medium containing IL-6 which further contains Hypoxanthine-thymidine (hereinafter

referred to as "HT", manufactured by Sigma-Aldrich Co., LLC.).

[0333]

Harvested supernatants were screened as the same as in the primary screening method for cloning of hybridomas expressing anti-human TIM-3 human monoclonal antibody and hybridomas expressing anti-human TIM-3 mouse monoclonal antibody and selected hybridoma clone was used for purification of monoclonal antibody.

[0334]

[Example 9]

(Purification of hybridoma derived monoclonal antibody)

An anti-TIM-3 human or mouse monoclonal antibody was purified from the anti-human TIM-3 human or mouse monoclonal antibody expressing hybridoma prepared in Example 8. Briefly, hybridoma supernatant containing a high concentration of the anti-TIM-3 antibody was prepared using a CELLline antibody production system (manufactured by BD Biosciences) and the anti-human TIM-3 monoclonal antibody was purified from the supernatant. First, to adapt the cloned hybridoma to the serum free medium, the hybridomas were cultured for several days in a medium mixing DMEM medium containing HT and IL-6 and BD Cell MAb serum free medium (manufactured by BD Biosciences) at a ratio of 1:1, and then cultured for several days in a medium having a mixing ratio of 1:2.

[0335]

Next, the hybridomas were cultured in a BD Cell MAb serum free medium (manufactured by BD Biosciences) and adapted hybridomas to the serum free medium. The hybridoma cells adapted to the serum free medium were cultured in CL-1000 flasks according to the manufacturer's instructions and the supernatant of the hybridoma containing high concentration of the anti-TIM-3 antibody was collected from the flasks. The antibody from the supernatant of the hybridoma was purified in accordance with the standard procedures using Protein A.

[0336]

Specifically, MabSelect (manufactured by GE Healthcare) were packed in an open column and the supernatant diluted 2-fold by PBS was loaded and then eluted with 0.1 mol/L Glycine-HCl (pH 2.7), followed by concentration with Amicon Ultra (manufactured by Millipore). Next, by using a NAP-5 column (manufactured by GE Healthcare), the obtained solution was equilibrated with PBS buffer, and then sterilized by filtration to obtain 4 clones of the anti-human TIM-3 human monoclonal antibodies (antibody 512, antibody 644, antibody 4545 and antibody 4177) and one clone (antibody 8213) of the anti-human TIM-3 mouse monoclonal antibody.

[0337]

[Example 10]**(Identification of isotype of anti-TIM-3 human monoclonal antibody)**

Each of the isotype of anti-TIM-3 human monoclonal antibodies which was prepared in Example 9 was determined by a solid-phase ELISA and flow cytometry.

5 Specifically, as for the solid-phase ELISA, soluble extracellular human TIM-3 obtained by Example 4 was diluted with a Carbonate-Biacarbonate Buffer (manufactured by Sigma-Aldrich Co., LLC.) to give a concentration of 1 µg/ml and dispensed at 50 µl/well into a 96-well culture plate (Maxisorp, manufactured by Nunc). The soluble extracellular human TIM-3 was adsorbed to the microplate by incubating

10 overnight at 4°C.

[0338]

After the supernatant was discarded, SuperBlock Blocking Buffer in TBS (manufactured by PIERCE) was added to the plate and then incubated for 10 min at room temperature and 50 µl of the culture supernatant of the hybridoma was added and

15 then incubated for 30 min at room temperature. After washing each well with Tris-buffered saline containing 0.1% Tween20 (TBS-T), 50 µl of each of HRP-labeled mouse anti-human IgG1, anti-human IgG2, anti-human IgG3 or anti-human IgG4 antibodies, each antibody was diluted 2000, 2000, 2000 and 4000-fold with TBS-T containing 10% SuperBlock Blocking Buffer, respectively; manufactured by SouthernBiotech), were

20 added and incubated for 30 minutes at room temperature.

[0339]

After washing each well with TBS-T, 50 µl of substrate buffer (TMB, manufactured by DAKO) was added and then incubated for 20 min at room temperature. The reaction was stopped by adding 50 µl of 0.5 mol/L sulfuric acid

25 (manufactured by Wako Pure Chemical Industries, Ltd.). The absorbance at wavelength of 450 nm (reference wavelength: 570 nm) was measured on a microplate reader (VersaMax, manufactured by Molecular Devices, LLC.).

[0340]

In addition, in flow cytometry method, the Jurkat cell which expressed human

30 TIM-3 prepared in Example 1 was washed with staining medium, and then 50 µl of the supernatant of the hybridoma was added and incubated for 30 min at 4°C. After washing, 50 µl of each of Mouse anti-Human IgG1-PE, Mouse anti-Human IgG2-PE, Mouse anti-Human IgG3 (Hinge)-PE and Mouse anti-Human IgG4(Fc)-PE (manufactured by SouthernBiotech) which was diluted 100-fold with staining medium

35 was added, allowed to stand still for 30 min at 4°C and then analyzed using FACSCalibur flow cytometer (manufactured by BD Biosciences).

[0341]

Based on the result, the isotypes of antibody 512, antibody 644, and antibody 4545 were IgG1, IgG4 and IgG2, respectively.

[0342]

[Example 11]

5 (Identification of the isotype of the mouse monoclonal antibody for human TIM-3)

The isotype of the anti-human TIM-3 mouse monoclonal antibody prepared in Example 9 was determined using Iso Strip Mouse Monoclonal Antibody Isotyping Kit (manufactured by Roche-diagnostics). By using the supernatant of the hybridoma containing the anti-TIM-3 antibody prepared in Example 8, the isotype was determined according to the manufacturer's instructions. As a result, the isotype of antibody 8213 was determined as IgG2b.

[0343]

[Example 12]

15 (Isolation of anti-TIM-3 monoclonal antibody gene)

The gene of anti TIM-3 human or mouse monoclonal antibody which was prepared in Example 9 was isolated from the hybridoma which produced anti-human TIM-3 human or mouse monoclonal antibody prepared in Example 9. Total RNA was extracted from the cloned hybridoma using High Pure RNA Isolation Kit (manufactured by Roche-Diagnostics), according to the manufacturer's instructions. The cloning of the cDNA encoding the variable region was carried out using SMART RACE cDNA amplification Kit (manufactured by Clontech) in accordance with the instructions attached thereto.

[0344]

25 The heavy chain (VH) of the human monoclonal antibody was amplified by PCR using UPM (SMART RACE cDNA amplification Kit; manufactured by Clontech) and primer hh-6 (SEQ ID NO: 44). Using part of the reaction product as a template, PCR was carried out using NUP (SMART RACE cDNA amplification Kit; manufactured by Clontech) and primer hh-3 (SEQ ID NO: 45). The cloning of the PCR product was carried out using Zero Blunt TOPO PCR Cloning Kit (manufactured by Invitrogen). The nucleotide sequence was analyzed by universal primers of the vector (e.g., T7 or M13R primer) and the amino acid sequence was deduced from the nucleotide sequence.

[0345]

35 As a result, the nucleotide sequence and the amino acid sequence of VH of antibody 512 were represented by SEQ ID NO: 54, was and SEQ ID NO: 55, respectively, the nucleotide sequence and the amino acid sequence of VH of antibody

644 were represented by SEQ ID NO: 58 and SEQ ID NO: 59, respectively, the nucleotide sequence and the amino acid sequence of VH of antibody 4545 were represented by SEQ ID NO: 7 and SEQ ID NO: 8 (with amino acids 1 to 19 defining the signal peptide), respectively, and the nucleotide sequence and the amino acid sequence of VH of antibody 4177 were represented by SEQ ID NO: 17 and SEQ ID NO: 18 (with amino acids 1 to 19 defining the signal peptide), respectively. Each of the obtained variable regions obtained and the constant region of human IgG1 were inserted and ligated into the expression vector, N5KG1 (manufactured by Biogen IDEC Inc.).

[0346]

Human monoclonal antibody light chain (VL) was amplified by PCR using UPM (SMART RACE cDNA amplification Kit; manufactured by Clontech) and primer hk-2 (SEQ ID NO: 46). Using part of the reaction product as a template, PCR was carried out using NUP (SMART RACE cDNA amplification Kit; manufactured by Clontech) and primer hk-6 (SEQ ID NO: 47). The PCR product was cloned using Zero Blunt TOPO PCR Cloning Kit (manufactured by Invitrogen). The nucleotide sequence was analyzed by universal primers of the vector (e.g., T7 or M13R) and the amino acid sequence was deduced from the nucleotide sequence.

[0347]

As a result, the nucleotide sequence and the amino acid sequence of VL of antibody 512 were represented by SEQ ID NO: 56 and SEQ ID NO: 57, respectively, the nucleotide sequence and the amino acid sequence of VL of antibody 644 were represented by SEQ ID NO: 60 and SEQ ID NO: 61, respectively, the nucleotide sequence and the amino acid sequence of VL of antibody 4545 were represented by SEQ ID NO: 9 and SEQ ID NO: 10 (with amino acids 1 to 20 defining the signal peptide), respectively, and the nucleotide sequence and the amino acid sequence of VH of antibody 4177 were represented by SEQ ID NO: 19 and SEQ ID NO: 20 (with amino acids 1 to 22 defining the signal peptide), respectively. Each of the obtained variable regions and constant region of κ chain were inserted and ligated into the expression vector, N5KG1 (manufactured by Biogen IDEC Inc.).

[0348]

The heavy chain (VH) of mouse monoclonal antibody was amplified by PCR using UPM (SMART RACE cDNA amplification Kit; manufactured by Clontech) and a primer, mH_Rv1 (SEQ ID NO: 48). Using part of the reaction product as template, PCR was carried out using NUP (SMART RACE cDNA amplification Kit; manufactured by Clontech) and primer mH_Rv2 (SEQ ID NO: 49).

[0349]

The cloning of the PCR product was carried out using Zero Blunt TOPO PCR Cloning Kit (manufactured by Invitrogen). The nucleotide sequence was analyzed by universal primers of the vector (e.g., T7 or M13R) and the amino acid sequence was

deduced from the nucleotide sequence.

[0350]

As a result, the nucleotide sequence and the amino acid sequence of VH of antibody 8213 were represented by SEQ ID NO: 27 and SEQ ID NO: 28, respectively.

5 The obtained variable region and the constant region of mouse IgG2a were ligated and inserted into the expression vector, N5KG1 (manufactured by Biogen IDEC Inc.).

[0351]

The light chain (VL) of the mouse monoclonal antibody was amplified by PCR using UPM (SMART RACE cDNA amplification Kit; manufactured by Clontech) and primer mK_Rv1 (SEQ ID NO: 50). Additionally, part of the reaction product was used as a template, and PCR was carried out using NUP (SMART RACE cDNA amplification Kit; manufactured by Clontech) and primer mK_Rv2 (SEQ ID NO: 51). The PCR product was cloned using Zero Blunt TOPO PCR Cloning Kit (manufactured by Invitrogen). Nucleotide sequences were analyzed by universal primers of the vector (e.g., T7 or M13R) and the amino acid sequence was deduced from the

15 nucleotide sequence.

[0352]

As a result, the nucleotide sequence and the amino acid sequence of the VL of antibody 8213 were represented by SEQ ID NO: 29 and SEQ ID NO: 30, respectively.

20 The variable region obtained and the constant region of κ chain were ligated and inserted into the above mentioned expression vector encoding VH of antibody 8213.

[0353]

In addition, in order to obtain anti-dinitrophenyl (DNP) human IgG1 antibody as a negative control, the nucleotide sequence of the heavy chain (VH) of the antibody (SEQ ID NO: 62), the nucleotide sequence of the light chain of the antibody (SEQ ID NO: 64), and the constant region of human IgG1 and the κ chain were inserted into expression vector N5KG1 (manufactured by Biogen IDEC Inc.).

25 [0354]

[Example 13]

30 (Purification of recombinant anti-TIM-3 human monoclonal defucose antibody)

A cell expressing a recombinant antibody was produced by introducing the recombinant antibody expression vector prepared in Example 12 into the host cell. As the host cell for expression, FUT8^{-/-} CHO cells were used in accordance with a published report (*Clin Cancer Res* 2006; 12(9) Iida *et al.*). Briefly, the expression vectors for each of 512, 644, 4545 and 4177 prepared in Example 12 were introduced into FUT8^{-/-} CHO cell using FreeStyleTM MAX Reagent (manufactured by Invitrogen). The FUT8^{-/-}

CHO cells were cultured on a shaker at 37°C under 5% CO₂. The culture supernatant was recovered after about five days.

[0355]

The recovered supernatant was purified using Protein A (manufactured by GE Healthcare) and further using 0.8×40 cm column (manufactured by BioRad) and the like, depending on the sample amount. Antibodies were affinity purified using PBS as the binding buffer and 0.02 mol/L sodium citrate (pH 2.7, 50 mmol/L NaCl) buffer as the elution buffer. The elution fraction was added with 0.2 mol/L of sodium phosphate buffer (pH 7.0).

10 [0356]

The prepared antibody solution was equilibrated with PBS using NAP-25 column (manufactured by GE Healthcare) and concentrated with Amicon Ultra (10000 cut, manufactured by Millipore). After sterilization by filtration, the recombinant anti-TIM-3 human monoclonal defucose antibodies (antibody 512, antibody 644, antibody 4545 and antibody 4177) were obtained. The purity of the protein was determined by Limulus ES-II kit Wako (manufactured by Wako Pure Chemical Industries, Ltd.) and found that these antibodies were sufficiently purified.

The vector for expressing anti-DNP prepared in Example 12 was introduced into CHO-DG44 cells. The CHO-DG44 cells were cultured on a shaker at 37°C under 5% CO₂. The cultured supernatant was recovered following incubation for 5 days. The collected supernatant was purified using Protein A (manufactured by GE Healthcare) and further using 0.8×40 cm column (manufactured by BioRad) and the like, depending on the sample amount. The affinity purification of the antibodies was carried out using PBS as the binding buffer and 0.02 mol/L of sodium citrate (pH 2.7, 50 mmol/L NaCl) buffer as the elution buffer. The elution fraction was added with 0.2 mol/L of sodium phosphate buffer (pH 7.0). The prepared antibody solution was equilibrated with PBS and concentrated using NAP-25 column (manufactured by GE Healthcare) with Amicon Ultra (10000 cut, manufactured by Millipore) respectively. After sterilization by filtration, the recombinant anti-DNP antibody was obtained. The purity of the protein was determined using a Limulus ES-II kit Wako (manufactured by Wako Pure Chemical Industries, Ltd.) and found that the antibody was sufficiently purified.

[0357]

[Example 14]

35 (Purification of recombinant anti-TIM-3 mouse monoclonal antibody)

The vector for expressing antibody 8213 prepared in Example 12 was introduced into HEK293F cells (manufactured by Invitrogen) using 293 fectin

(manufactured by Invitrogen). HEK293F cells were incubated on a shaker at 37°C under 5% CO₂. The cultured supernatant was collected after incubation for five days. The collected supernatant was purified using Protein A (manufactured by GE Healthcare) and further using 0.8×40 cm column (manufactured by BioRad) and the like, depending on the sample amount. The affinity purification of the antibody was carried out using PBS as a binding buffer and 0.02 mol/L sodium citrate buffer (pH 2.7, 50 mmol/L NaCl) as an elution buffer.

[0358]

To the elution fraction, 0.2 mol/L of sodium phosphate buffer (pH 7.0) was added. The prepared antibody solution was equilibrated with PBS using NAP-25 column (manufactured by GE Healthcare) and concentrated with Amicon Ultra (10000 cut, manufactured by Millipore). After sterilization by filtration, the recombinant anti-TIM-3 mouse monoclonal antibody (8213 antibody) was obtained. The purity of the protein was determined using a Limulus ES-II kit Wako (manufactured by Wako Pure Chemical Industries, Ltd.) and found that the antibody was sufficiently purified.

[0359]

[Example 15]

(Fluorescent labeling of purified monoclonal antibody)

The fluorescent labeling of the hybridoma derived monoclonal antibody and recombinant monoclonal antibody was carried out by using Alexa Fluor 647 Monoclonal Antibody Labeling Kit (manufactured by Invitrogen) according to the manufacturer's instructions. After the labeling, each antibody was confirmed to be positively labeled with Alexa Fluor 647 (hereinafter referred to as "Alexa-647") by FACSCalibur (manufactured by BD Biosciences) analysis for TIM-3 expressing cells.

[0360]

[Example 16]

(Classification of epitopes using competition test-1)

The relation of epitopes between antibodies prepared in Example 13 and Example 14, and commercially available anti-TIM-3 antibody 344823 (Clone 344823, manufactured by R&D Systems) was analyzed by a competition test. In brief, the test antibody was allowed to interact with the TIM-3 expression cell prepared in Example 1, and then whether another anti-TIM-3 antibody could further bind to TIM-3 expressing cells was evaluated by flow cytometry method.

[0361]

In the first step, whether or not the competition between each of the monoclonal antibodies prepared in Example 13 and Example 14 (antibody 512, antibody 644, antibody 4177 and antibody 8213) and antibody 34823 were examined.

First, human TIM-3 expressing EoL-1 cells and the parent cell, EoL-1 cells were washed with staining medium and then allowed to react with each of the purified subjective monoclonal antibodies (antibody 512, antibody 644, antibody 4177 and antibody 8213) (4°C, 30 min). The final concentration was 10 µg/ml. Next, the PE labeled antibody 344823 (Clone 344823, manufactured by R&D Systems) was added and allowed to react (4°C, 30 min). After washing with staining medium, 7-ADD (manufactured by BD Biosciences) was added and analyzed using FACSCalibur (manufactured by BD Biosciences).

[0362]

As a result, the goat derived anti-human TIM-3 polyclonal antibody (manufactured by R&D Systems) used as a positive control and antibody 644 almost completely blocked the binding of PE-labeled antibody 344823 to TIM-3 expressing cell. However, antibody 512, 4545 and 8213 did not inhibit the binding of PE-labeled antibody 344823 to TIM-3 expressing cell. Antibody 4177 inhibited the binding of PE-labeled antibody 344823 to TIM-3 expressing cells, but this inhibition was weaker than that of antibody 644. Accordingly, antibody 644 competed with antibody 344823, but antibodies 512, 4545 and 8213 did not compete with antibody 344823. It was found that the antibody 4177 and antibody 344823 competed with each other, but they competed partially.

[0363]

In the second step, among the anti-TIM-3 monoclonal antibodies tested, antibodies 512, 4545 and 8213 which did not interact with antibody 344823 were examined whether or not they competed. The experiment was carried out in the same manner as the first step except for using Alexa-647 labeled antibody 512 or Alexa-647 labeled antibody 8213 prepared in Example 15 as a labeled antibody. As a result, antibody 4545 and antibody 8213 did not inhibit the binding of Alexa-647 labeled antibody 512 to the TIM-3 expressing cells.

[0364]

However, antibody 4545 inhibited the binding of Alexa-647 labeled antibody 8213 to TIM-3 expressing cells. Therefore, it was found that antibody 4545 and antibody 8213 competed with each other, but these two antibodies did not compete with antibody 512. This result suggested that antibody 512 recognized different epitope from antibody 344823 and antibody 8213.

[0365]

In the third step, a competitive assay with antibody 512 and antibody 8213 was carried out on antibody 4177 which was shown to partially compete with antibody 344823 in the first step. The experiment was performed in the same manner as

described in second step. As a result, antibody 4177 did not inhibit the binding of the Alexa-647 labeled antibody 512 to the TIM-3 expressing cells, but inhibited the binding of the Alexa-647 labeled antibody 8213 to the TIM-3 expressing cells. Therefore, it was found that antibody 4177 did not compete with antibody 512, but only with antibody 8213.

[0366]

Based on these results, among the 5 antibodies prepared in Example 13 and Example 14, antibody 644 recognized an epitope which was near the epitope to which antibody 344823 recognized; antibody 512 recognized an epitope different from of the epitope to which antibody 344823 and other four antibodies (antibody 644, antibody 4545, antibody 4177 and antibody 8213) recognized.

[0367]

It was suggested that antibody 8213 recognized epitope different from of the epitope to which antibodies 344823 or 512 recognized. It was suggested that antibody 4545 recognized an epitope which was near the epitope to which antibody 8213 recognized. However, antibody 4177 recognized the epitope which was near the epitope to which antibody 8213 recognized, and also weakly recognized an epitope which was near the epitope to which antibody 344823 recognized.

[0368]

[Example 17]

(Antibody dependent cellular cytotoxicity test of recombinant anti-TIM-3 human monoclonal defucose antibody)

Regarding the cellular cytotoxic activity via antibody, the ADCC activity against the target cell was measured by using human Peripheral Blood Mononuclear Cells (hereinafter referred to as "PBMC") as an effector in the presence of the antibody. First, peripheral blood was collected from the healthy human donor and mixed with anticoagulant. The obtained blood was loaded onto Ficoll-Plaque Plus (manufactured by GE Healthcare), and centrifuged at 2000 rpm for 20 min using a large scale centrifuge (CF9RX, manufactured by Hitachi Koki Co., Ltd.) so as not to disturb the boundary.

[0369]

The middle fraction containing cells were collected and washed with PBS, and then centrifuged at 900 rpm for 20 min to remove the platelets. Thus obtained PBMC was used for the measurement. Next, the Daudi cell used as a target cell and the PBMC were mixed at the ratio of effector/target = 50.

[0370]

Each of the recombinant anti-human monoclonal defucose antibodies (antibody

512, antibody 644, antibody 4545 and antibody 4177) prepared in Example 13 and Example 14, and anti-DNP antibody as a human IgG1 control was suspended in the medium to give a final concentration of 1 $\mu\text{g/ml}$ and a total volume of 100 μl . After mixing, the solution was incubated at 37°C under 5% CO_2 for 4 hr. The lysis ratio of the target cell was evaluated based on the amount of LDH released into the medium. The LDH activity and lysis ratio were calculated using CytoTox 96 Non-Radioactive Cytotoxicity Assay (manufactured by Promega Corp.) in accordance with the instructions attached thereto. As statistical analysis, standard Student's t-test was used wherein a sample having a risk rate (p) of less than 0.05 was considered as one which was significantly different.

[0371]

As the result that the ADCC activity on Daudi cells was measured, it was found that antibody 4545 and antibody 4177 exhibited the significant increase in the lysis ratio of the target cell as compared to anti-DNP antibody. This result suggests that anti-TIM-3 mouse antibody 8213 and anti-TIM-3 antibody which competes with anti-TIM-3 mouse antibody 8213 have high ADCC activity.

[0372]

Similarly, the ADCC activity was measured by using recombinant anti-TIM-3 human monoclonal defucose antibodies (antibody 4545 and antibody 4177) prepared in Example 13, commercially available anti-TIM-3 monoclonal antibody 344823, and anti-DNP antibody as a negative control.

[0373]

First, peripheral blood was collected from the healthy human donor and mixed with anticoagulant. The obtained blood was then loaded onto Ficoll-Plaque Plus (manufactured by GE Healthcare), and centrifuged at 2000 rpm for 20 min using a large scale centrifuge (CF9RX, manufactured by Hitachi Koki Co., Ltd.) so as not to disturb the boundary. The middle fraction containing cells were collected and washed with PBS, and then centrifuged at 900 rpm for 20 min to remove the platelets. Thus obtained PBMC fraction was used for the measurement of the ADCC activity.

[0374]

Next, the Daudi cell used as a target cell and the PBMC were mixed at the ratio of effector/target = 25. Each of the antibody 4545, antibody 4177, antibody 344823, anti-DNP antibody and PBS were suspended in the medium to give a final concentration of 1 $\mu\text{g/ml}$ and a total volume of 100 μl . After mixing, the solution was incubated at 37°C under 5% CO_2 for 4 hr. The lysis ratio of the target cell was evaluated based on using the amount of LDH released into the medium.

[0375]

The LDH activity and the lysis ratio were calculated using CytoTox 96 Non-Radioactive Cytotoxicity Assay (manufactured by Promega Corp.) in accordance with the instructions attached thereto. As statistical analysis, standard Student's t-test was used wherein a sample having a risk rate (p) of less than 0.05 was considered as one which was significantly different. As the result of the ADCC activity on Daudi cells was measured, it was found that antibody 4545 and antibody 4177 exhibited the significant increase in the lysis ratio of the target cell as compared to anti-DNP antibody. On the other hand, antibody 344823 exhibited no significant increase in the lysis ratio of the target cell as compared to anti-DNP antibody and PBS.

10 [0376]

[Example 18]

(Calculating the bound/dissociation constant using anti-TIM-3 antibody)

The bound/dissociation constant was analyzed using surface plasmon resonance based biosensor (Biacore, manufactured by GE Healthcare). In brief, an anti-human antibody or an anti-mouse antibody was immobilized on the CM5 sensor chips. Next, the anti-TIM-3 human or mouse antibody were made to flow to bind the chip, and then soluble extracellular human TIM-3 prepared in Example 4 was made to flow to examine the bound/association constant of TIM-3 to the anti-TIM-3 antibody. Throughout the experimental process, basically the experimental method provided by GE Healthcare for calculating bound/dissociation constant was used.

20 [0377]

Specifically, CM5 was used as the sensor chip (Research grade, manufactured by GE Healthcare). First, CM5 chip was activated by flowing through a mixed solution of equal parts of 400 mmol/L EDC (N-ethyl-N'-(3-dimethylaminopropyl)carbodiimide hydrochloride) and 100 mmol/L NHS(N-hydroxysuccinimide). Next, the anti-human antibody attached to the Human Antibody Capture Kit (manufactured by GE Healthcare) was diluted with the solution attached to the kit and the obtained solution was made to flow so that the required amount of the antibody to an antibody for a human antibody was immobilized on the CM5 chip.

30 [0378]

For the mouse antibody, the antibody against mouse antibody was immobilized on the CM5 surface by diluting in the solution, which was provided in the Mouse Antibody Capture Kit (manufactured by GE Healthcare antibody). The activated chip surface was blocked by the passing through 1 mol/L for ethanolamide hydrochloride and inactivated.

35 [0379]

Next, one kind of the anti-TIM-3 antibodies was diluted with HBS-EP buffer (manufactured by GE Healthcare) per one flow cell and passed through so as to bind the antibody for the human antibody or antibody for the mouse antibody immobilized on the chip surface. Then soluble extracellular human TIM-3 was flown through. To dissociate the bound anti-TIM-3 antibody from the soluble extracellular human TIM-3, either the total volume of 3 mol/L of MgCl_2 which was attached to the Human Antibody Capture Kit or Glycine-HCl (pH 1.7) which was attached to the Mouse Antibody Capture Kit were flown through the cell.

[0380]

The above described procedures were considered as one step, and the similar procedure was repeated using different concentrations of the soluble extracellular human TIM-3, to collect data (sensorgram) for calculating the bound/association constant. The concentration of soluble extracellular human TIM-3 used as an analyte was calculated by measuring the absorbance at 280 nm and then converting the value of 1.4 OD to 1 mg/mL.

[0381]

The molecular weight of the soluble extracellular human TIM-3 was calculated as 42.8 kDa based on the mobility on electrophoresis. The data was analyzed using Biaevaluation soft-ware (manufactured by GE Healthcare) according to the Biaevaluation Software Handbook. Specifically, the simultaneous Kinetics analysis was performed and the association rate constant (K_a) and dissociation rate constant (K_d) was calculated, by basically adopting a 1:1 Langmuir Binding reaction model was used for fitting. Then the value of the dissociation constant (K_D) was calculated from K_d/K_a .

[0382]

Most of the anti-human TIM-3 human monoclonal antibody had the K_D value of the order of 10^{-9} mol/L. In this aspect, there was no correlation between ADCC activity and binding affinity targeting for TIM-3.

[0383]

When the anti-human TIM-3 monoclonal antibody was monitored (e.g., monitored the dissociation state for 30 min), there was no dissociation detected with the antigen soluble extracellular human TIM-3 as an antigen. As a result, it was found that it was possible to produce a monoclonal antibody having a very high affinity for human TIM-3.

[0384]

[Example 19]

(Classification of epitopes using competition test-2)

The epitopes of anti-TIM-3 antibodies, i.e., antibody 512, antibody 644, antibody 4545, antibody 8213, antibody 344823, antibody F38-2E2 and anti-DNP antibody as a control were analyzed by a competitive assay. In brief, the unlabeled target antibody was allowed to interact with the TIM-3 expression cell prepared in Example 1, and whether or not other fluorescence labeled anti-TIM-3 antibody was further bound to TIM-3 expression cells were evaluated by flow cytometry method. [0385]

Human TIM-3 expressing EoL-1 cells were washed with staining medium and allowed to react with purified test monoclonal antibodies [antibody 512, antibody 644, antibody 4545, antibody 8213, antibody 344823 (manufactured by R&D Systems), antibody F38-2E2 (manufactured by Imgenex)] (4°C, 30 min). The final concentration was 10 µg/ml. Next, the Alexa-647 or APC labeled anti-TIM-3 antibodies [antibody 344823 (manufactured by R&D Systems) and antibody F38-2E2 (manufactured by eBiosciences)] were added and were allowed to react (4°C, 30 min). After washing with staining medium, 7-ADD (manufactured by BD Biosciences) was added before analyzing with FACSCalibur (manufactured by BD Biosciences). [0386]

The results are shown in Table 1. As shown in Table 1, the case the degree of the binding to the TIM-3 expression cell to which the unlabeled anti-TIM-3 antibody was bound was similar to that of a negative control were indicated as "+", the case where the degree to the binding to the TIM-3 expression cell to which the unlabeled anti-TIM-3 antibody was bound was found but was lower than that of a negative control was indicated as "+/-" and the case where the binding to the TIM-3 expression cell to which the unlabeled anti-TIM-3 antibody was bound was not detected, it was indicated as "-". [0387]

[Table 1]

		Unlabeled antibody						
		DNP	512	644	4545	8213	344823	F38-2E2
Alexa-647 or APC labeled antibody	DNP	-	-	-	-	-	-	-
	512	+	-	+	+	+	+	+
	644	+	+	+/-	+	+	+/-	+/-
	4545	+	+	+	-	-	+	+
	8213	+	+	+	-	-	+	+
	344823	+	+	-	+	+	-	+/-
	F38-2E2	+	+	-	+	+	-	-

[0388]

5 As shown in Table 1, since Alexa-647 labeled antibody 512 was found to bind to the TIM-3 expressing cell to which the other unlabeled anti-TIM-3 antibodies were bound, this antibody was suggested to recognize an independent epitope with which antibody 644, antibody 4545, antibody 8213, antibody 344823 and antibody F38-2E2 did not compete.

[0389]

10 Since it was found that Alexa-647 labeled antibody 644 did not bind or reduced in binding to the TIM-3 expressing cell to which the unlabeled anti-TIM-3 antibody 344823 or F38-2E2 was bound, it was indicated that this antibody competed with antibody 344823 or F38-2E2 in the recognition of the epitope close to each other.

[0390]

15 Since it was found that Alexa-647 labeled antibody 4545 did not bind to the TIM-3 expressing cell to which the unlabeled anti-TIM-3 antibody 8213 was bound, it was indicated that this antibody competed with antibody 8213 in the recognition of the epitope close to each other.

[0391]

20 Since it was found that Alexa-647 labeled antibody 8213 did not bind to the TIM-3 expressing cell to which the unlabeled anti-TIM-3 antibody 4545 was bound, it was indicated that this antibody competed with antibody 4545 in the recognition of the epitope close to each other.

[0392]

25 Since it was found that APC labeled antibody 344823 did not bind to the TIM-3 expressing cell to which the unlabeled anti-TIM-3 antibody 644 or F38-2E2 was

bound, it was indicated that this antibody competed with antibody 644 or F38-E2E antibody in the recognition of the epitope close to each other.

[0393]

5 Since it was found that APC labeled Antibody F38-2E2 did not bind to the TIM-3 expressing cell to which the unlabeled anti-TIM-3 antibody 644 or 344823 was bound, it was indicated that this antibody competed with antibody 644 or antibody 344823 in the recognition of the epitope close to each other.

[0394]

[Example 20]

10 (Molecular cloning of mouse TIM-3 cDNA)

The cDNA of mouse TIM-3 was prepared in the same manner as described in Example 1. Total RNA was extracted from Balb/c mouse derived bone marrow cells using High Pure RNA isolation Kit (manufactured by Roche). Template cDNA was synthesized using ThermoScript RT-PCR system (manufactured by Invitrogen). For primers, mTim-3 Fw3 (SEQ ID NO: 70) and mTim-3 Re3 (SEQ ID NO: 71) were used. The cDNA was inserted into pGEM-T Easy Vector (manufactured by Promega Corp.), and the sequence was analyzed. The clone having identical nucleotide sequence with the coding region of GenBank accession number AF450241 was selected.

[0395]

20 PCR was carried out using the selected clone as the template and inserting the DNA into NotI site of the pEF6/Myc-HisC vector (manufactured by Invitrogen) (mTim-3/pEF6 Myc_HisC). For PCR primers, mTim-3 Fw4NotI (SEQ ID NO: 72) and mTim-3 Re4NotI (SEQ ID NO: 73) were used.

[0396]

25 [Example 21]

(Construction of hTim-3/pEF6 Myc_HisC)

The plasmid DNA hTIM-3/pMCs-IG prepared in Example 1 and pEF6 Myc_HisC were both digested with NotI to construct human TIM-3 expressing pEF6 Myc_HisC vector (hTim-3/pEF6 Myc_HisC). DNA sequence analysis confirmed that the vector sequence matched the coding region of the GenBank accession number NM_032782.

[0397]

[Example 22]

35 (Cross-reactivity of anti-human TIM-3 antibody to anti-mouse TIM-3 antibody)

Each of the plasmid DNAs, mTim-3/pEF6 Myc_HisC and hTim-3/pEF6 Myc_HisC prepared in Example 20 and Example 21, and an empty vector control was

introduced into HEK293F cell in the same manner as Example 4. Two days later, in the same manner as Example 15, the binding activity of Alexa-647 labeled antibodies (antibody 512, antibody 644, antibody 4545 and antibody 8213), commercially available APC labeled anti-human TIM-3 antibodies (antibody 344823 and antibody F38-2E2) and commercially available PE labeled anti-mouse TIM-3 antibody (RMT3-23 antibody, manufactured by BioLegend Inc.) to human TIM-3 and mouse TIM-3 was evaluated using flow cytometry analysis.

[0398]

As a result, antibody 512, antibody 644, antibody 4545, antibody 8213, antibody 344823 and antibody F38-2E2 exclusively interacted with human TIM-3 expressing 293F cells. However, RMT3-23 antibody interacted exclusively with mouse TIM-3 expressing 293F cells. Therefore, it was found that antibody 512, antibody 644, antibody 4545, antibody 8213, antibody 344823 and antibody F38-2E2 did not cross-react with mouse TIM-3.

[0399]

[Example 23]

(Construction of expression system for TIM-3 chimeric protein with IgV domain substituted for mouse TIM-3)

The objective sequence was amplified by the PCR using hTim-3/pEF6 Myc_HisC plasmid DNA as a template, hTIM3+mIgV_vecR1 primer (SEQ ID NO: 74) and hTIM3+mIgV_vecF1 primer (SEQ ID NO: 75), and PrimeSTAR GXL DNA Polymerase (manufactured by Takara Bio Inc.). The objective sequence was amplified by PCR using mTim-3/pEF6 Myc_HisC plasmid DNA as a template, hTIM3+mIgV_insF1 primer (SEQ ID NO: 76) and hTIM3+mIgV_insR1 primer (SEQ ID NO: 77), and PrimeSTAR GXL DNA Polymerase (manufactured by Takara Bio Inc.).

[0400]

The two PCR products obtained were ligated using GENEART seamless cloning and assembly kit (manufactured by Invitrogen). The sequence from the transformant was analyzed and it was found that the PCR products had the objective sequences (IgV chimeraTIM-3/pEF6 Myc_HisC, SEQ ID NO: 78).

[0401]

[Example 24]

(Construction of expression system for TIM-3 chimeric protein with Mucin domain substituted for mouse TIM-3)

The objective sequence was amplified by PCR using hTim-3/pEF6 Myc_HisC plasmid DNA as a template, hTIM3+mMucin_vecR2 primer (SEQ ID NO: 80) and

hTIM3+mMucin_vecF2 primer (SEQ ID NO: 81), and PrimeSTAR GXL DNA Polymerase (manufactured by Takara Bio Inc.). The objective sequence was amplified by PCR using mTim-3/pEF6 Myc_HisC plasmid DNA as a template, hTIM3+mMucin_insF2 primer (SEQ ID NO: 82) and hTIM3+mMucin_insR2 primer (SEQ ID NO: 83), and PrimeSTAR GXL DNA Polymerase (manufactured by Takara Bio Inc.).

[0402]

The two PCR products obtained were ligated using GENEART seamless cloning and assembly kit (manufactured by Invitrogen). The sequence from the transformant was analyzed and it was found that the PCR products had the objective sequences(Mucin chimeraTIM-3/pEF6 Myc_HisC, SEQ ID NO: 84).

[0403]

[Example 25]

(Binding assay of anti-TIM-3 antibody to TIM-3 chimeric protein in which IgV domain was substituted with mouse TIM-3 and TIM-3 chimeric protein in which Mucin domain was substituted with mouse TIM-3)

Each of the plasmid DNAs prepared in Example 23 and Example 24, IgV chimeraTIM-3/pEF6 Myc_HisC, Mucin chimeraTIM-3/pEF6 Myc_HisC, hTim-3/pEF6 Myc_HisC, mTim-3/pEF6 Myc_HisC, and an empty vector control was introduced into HEK293F cell in the same manner as Example 4. Two days later, in the same manner as Example 22, the binding activity of anti-TIM-3 antibody was evaluated using flow cytometry.

[0404]

As a result, antibody 512, antibody 644, antibody 4545, antibody 8213, antibody 4177, antibody 344823 and antibody F38-2E2 bound to the human TIM-3 expressing cells and Mucin chimeraTIM-3 expressing cells only. However, RMT-23 antibody bound to the mouse TIM-3 expressing cells and the IgV chimeraTIM-3 expressing cells only.

[0405]

Therefore, as a result, it was found that all of the anti-human TIM-3 antibodies tested (antibody 512, antibody 644, antibody 4545, antibody 8213, antibody 344823 and antibody F38-2E2) and mouse TIM-3 antibody (antibody RMT3-23) recognized the IgV domain.

[0406]

[Example 26]

(Construction of TIM-3 chimera 22-47/pEF6 Myc_HisC)

A vector which expressed TIM-3 chimeric protein in which the amino acid of

human TIM-3 (SEQ ID NO: 53) at position 22 to position 47 were substituted with the corresponding amino acid of mouse TIM-3 (hereinafter referred to as "TIM-3 chimera 22-47") was constructed. By using hTim-3/pEF6 Myc_HisC plasmid DNA prepared in Example 21 as a template, and hTIM3chimera22-47F1 primer (SEQ ID NO: 86) and hTIM3chimera22-47R1 primer (SEQ ID NO: 87), and PCR was carried out using PrimeSTAR GXL DNA Polymerase (manufactured by Takara Bio Inc.).

[0407]

Using the obtained PCR product as a template, the objective sequence was amplified by PCR using hTIM3chimera22-47F2 primer (SEQ ID NO: 88) and

hTIM3chimera22-47R2 primer (SEQ ID NO: 89) and using PrimeSTAR GXL DNA Polymerase (manufactured by Takara Bio Inc.).

[0408]

Using the obtained PCR product as a template, the objective sequence was amplified by PCR using hTIM3chimera22-47F3 primer (SEQ ID NO: 90) and

hTIM3chimera22-47R3 primer (SEQ ID NO: 91), and using PrimeSTAR GXL DNA Polymerase (manufactured by Takara Bio Inc.).

[0409]

After the obtained PCR product obtained from the third PCR was digested with *DpnI* (manufactured by New England Biolabs), it was subjected to agarose gel electrophoresis. The DNA was extracted and ligated using GENEART seamless cloning and assembly kit (manufactured by Invitrogen). The sequence of the clone obtained from the transformant was analyzed and confirmed that the clone had the objective sequence (TIM-3 chimera 22-47/pEF6 Myc_HisC, SEQ ID NO: 92).

[0410]

[Example 27]

(Construction of TIM-3 chimera 57-66/pEF6 Myc_HisC)

A vector which expressed TIM-3 chimeric protein in which the amino acid of human TIM-3 (SEQ ID NO: 53) at position 57 to position 66 were substituted with the corresponding amino acid of mouse TIM-3 (hereinafter referred to as "TIM-3 chimera 57-66") was constructed. PCR was carried out using hTim-3/pEF6 Myc_HisC plasmid DNA prepared in Example 21 as a template, hTIM3chimera57-66F primer (SEQ ID NO: 94) and hTIM3chimera57-66R primer (SEQ ID NO: 95) phosphorylated by T4 Polynucleotide Kinase (manufactured by New England Biolabs) and PrimeSTAR GXL DNA Polymerase (manufactured by Takara Bio Inc.) to amplify the objective sequence.

[0411]

After the obtained PCR product was digested with *DpnI* (manufactured by New England Biolabs), it was subjected to the agarose gel electrophoresis. The DNA

was extracted and ligated with LigaFast™ Rapid DNA Ligation System (manufactured by Promega Corp.). The sequence of the clone obtained from the transformant was analyzed and confirmed that it was the objective sequence (TIM-3 chimera 57-66/pEF6 Myc_HisC, SEQ ID NO: 96).

5 [0412]

[Example 28]

(Construction of TIM-3 chimera 67-105/pEF6 Myc_HisC)

A vector which expressed TIM-3 chimeric protein in which the amino acid of human TIM-3 (SEQ ID NO: 53) at position 67 to position 105 were substituted with the
10 corresponding amino acid of mouse TIM-3 (hereinafter referred to as "TIM-3 chimera 67-105") was constructed. PCR was carried out using hTim-3/pEF6 Myc_HisC plasmid DNA as a template, hTIM3chimera67-105F primer (SEQ ID NO: 98) and hTIM3chimera67-105R primer (SEQ ID NO: 99) and using PrimeSTAR GXL DNA Polymerase (manufactured by Takara Bio Inc.) to amplify the objective sequence..

15 [0413]

PCR was carried out using mTim-3/pEF6 Myc_HisC plasmid DNA as a template, mTIM3chimera67-105F primer (SEQ ID NO: 100) and mTIM3chimera67-105R primer (SEQ ID NO: 101) and using PrimeSTAR GXL DNA Polymerase (manufactured by Takara Bio Inc.). The two PCR products were ligated by
20 GENEART seamless cloning and assembly kit (manufactured by Invitrogen). The sequence of the clone obtained from the transformant was analyzed and confirmed that it was the objective sequence (TIM-3 chimera 67-105/pEF6 Myc_HisC, SEQ ID NO: 102).

[0414]

25 [Example 29]

(Construction of TIM-3 chimera 74-81/pEF6 Myc_HisC)

A vector which expressed TIM-3 chimeric protein in which the amino acid of human TIM-3 (SEQ ID NO: 53) at position 74 to position 81 were substituted with the
30 corresponding amino acid of mouse TIM-3 (hereinafter referred to as "TIM-3 chimera 74-81") was constructed. PCR was carried out using hTim-3/pEF6 Myc_HisC plasmid DNA prepared in Example 21 as a template, hTIM3chimera74-81F primer (SEQ ID NO: 104) and hTIM3chimera74-81R primer (SEQ ID NO: 105) and using PrimeSTAR GXL DNA Polymerase (manufactured by Takara Bio Inc.).

[0415]

35 After the PCR product was digested with *DpnI* (manufactured by New England Biolabs), it was subjected to agarose gel electrophoresis. The DNA was extracted and ligated with GENEART seamless cloning and assembly kit (manufactured by

Invitrogen). The sequence of the clone obtained from the transformant was analyzed and confirmed that it was the objective sequence (TIM-3 chimera 74-81/pEF6 Myc_HisC, SEQ ID NO: 106).

[0416]

5 [Example 30]

(Construction of TIM-3 chimera 88-96/pEF6 Myc_HisC)

A vector which expressed TIM-3 chimeric protein in which the amino acid of human TIM-3 (SEQ ID NO: 53) at position 88 to position 96 were substituted with the corresponding amino acid of mouse TIM-3 (hereinafter referred to as “TIM-3 chimera 88-96”) was constructed. The PCR was carried out by preparing a reaction solution containing hTim-3/pEF6 Myc_HisC plasmid DNA prepared in Example 21 as a template, hTIM3chimera88-96F primer (SEQ ID NO: 108) and hTIM3chimera88-96R primer (SEQ ID NO: 109) and using PrimeSTAR GXL DNA Polymerase (manufactured by Takara Bio Inc.).

15 [0417]

After the obtained PCR product was digested with *DpnI* (manufactured by New England Biolabs), it was subjected to agarose gel electrophoresis. The DNA was extracted and ligated with GENEART seamless cloning and assembly kit (manufactured by Invitrogen). The sequence of the clone obtained from the transformant was analyzed and confirmed that it was the objective sequence (TIM-3 chimera 88-96/pEF6 Myc_HisC, SEQ ID NO: 110).

[0418]

[Example 31]

(Construction of TIM-3 chimera 96-105/pEF6 Myc_HisC)

25 A vector which expressed TIM-3 chimeric protein in which the amino acid of human TIM-3 (SEQ ID NO: 53) at position 96 to position 105 were substituted with the corresponding amino acid of mouse TIM-3 (hereinafter referred to as “TIM-3 chimera 96-105”) was constructed. The PCR was carried out by preparing a reaction solution containing hTim-3/pEF6 Myc_HisC plasmid DNA prepared in Example 21 as a template, hTIM3chimera96-105F primer (SEQ ID NO: 112) and hTIM3chimera96-105R primer (SEQ ID NO: 113) and using PrimeSTAR GXL DNA Polymerase (manufactured by Takara Bio Inc.).

30 [0419]

After the obtained PCR product was digested with *DpnI* (manufactured by New England Biolabs), it was subjected to agarose gel electrophoresis. The DNA was extracted and ligated with GENEART seamless cloning and assembly kit (manufactured by Invitrogen). The sequence of the clone obtained from the transformant was

analyzed and confirmed that it was the objective sequence (TIM-3 chimera 96 - 105/pEF6 Myc_HisC, SEQ ID NO: 114).

[0420]

[Example 32]

5 (Binding assay of anti-TIM-3 antibody to TIM-3 chimeric protein in which part of the IgV domain was substituted with mouse TIM-3)

Each of various TIM-3 vectors prepared in Examples 26 to 31 and an empty vector as a control were introduced into HEK293F in the same manner as Example 4. The introduced vectors and the expressed TIM-3 chimeric proteins thereof were as follows:

10 (1) TIM-3 chimera 22-47: TIM-3 chimeric protein in which the amino acid sequence at position 22 to position 47 of human TIM-3 (SEQ ID NO: 53) were substituted with the corresponding amino acids of mouse TIM-3;

15 (2) TIM-3 chimera 57-66: TIM-3 chimeric protein in which the amino acid sequence at position 57 to position 66 of human TIM-3 (SEQ ID NO: 53) were substituted with the corresponding amino acids of mouse TIM-3;

(3) TIM-3 chimera 67-105: TIM-3 chimeric protein in which the amino acid sequence at position 67 to position 105 of human TIM-3 (SEQ ID NO: 53) were substituted with the corresponding amino acids of mouse TIM-3;

20 (4) TIM-3 chimera 74-81: TIM-3 chimeric protein in which the amino acid sequence at position 74 to position 81 of human TIM-3 (SEQ ID NO: 53) were substituted with the corresponding amino acids of mouse TIM-3;

(5) TIM-3 chimera 88-96: TIM-3 chimeric protein in which the amino acid sequence at position 88 to position 96 of human TIM-3 (SEQ ID NO: 53) were substituted with the corresponding amino acids of mouse TIM-3; and

25 (6) TIM-3 chimera 96-105: TIM-3 chimeric protein in which the amino acid sequence at position 96 to position 105 of human TIM-3 (SEQ ID NO: 53) were substituted with the corresponding amino acids of mouse TIM-3.

30 Two days after transfection, in the same manner as Example 22, the binding activity of anti-TIM-3 antibody was evaluated using flow cytometry.

[0421]

The results are shown in Table 2. As shown in Table 2, the case where the binding of the antibody to the transfected cell was detected was indicated as "+", the case where the binding of the antibody to the transfected cell was detected but the degree of the binding was reduced was indicated as "+/-" and the case where the binding of the antibody to the transfected cell was not detected was indicated as "-".

[Table 2]

Vector name	4545	8213	4177	512	644	344823	F38-2E2
TIM-3 chimera 22-47	+	+	+/-	-	+	+	+
TIM-3 chimera 57-66	+	+	+/-	+	-	-	-
TIM-3 chimera 67-105	-	-	+/-	+	+	+	+
TIM-3 chimera 74-81	-	-	+	+	+	+	+
TIM-3 chimera 88-96	+	+	+	+	+	+	+
TIM-3 chimera 96-105	+	+	+	+	+	+	+

[0423]

As shown in Table 2, antibody 4545 and antibody 8213 bound to the cells transfected with TIM3-chimera 22-47, TIM3-chimera 57-66, TIM3-chimera 88-96 or TIM3-chimera 96-105 transfected cells. However, these antibodies did not bind to the cell into which TIM-3 chimera 67-105 were introduced.

[0424]

The antibody 512 bound to the cells transfected with TIM3-chimera 57-66, TIM3-chimera 88-96, TIM3-chimera 96-105, TIM-3 chimera 67-105 or TIM-3 chimera 74-81. However, antibody 512 did not bind to the cells transfected with TIM-3 chimera 22-47.

[0425]

The antibody 644, antibody 344823 and antibody F38-2E2 bound to the cells transfected with TIM3-chimera 22-47, TIM3-chimera 88-96, TIM3-chimera 96-105, TIM-3 chimera 67-105 or TIM-3 chimera 74-81. However, these antibodies did not bind to the cells transfected with to TIM-3 chimera 57-66.

The antibody 4177 bound to the cells transfected with TIM3-chimera 88-96, TIM3-chimera 96-105 or TIM-3 chimera 74-81. Antibody 4177 weakly bound to TIM-3 the cells transfected with chimera 22-47, TIM-3 chimera 57-66 or TIM-3 chimera 67-105.

[0426]

Based on the above result and results from Example 16 and Example 19, it was suggested that antibody 4545 and antibody 8213 bound to the amino acid sequence at position 67 to 87 of human TIM-3. Since antibody 4545 and antibody 8213 did not bind to the cells transfected with TIM-3 chimera 74-81, it was suggested that the amino acids required for binding of antibody 4545 and antibody 8213 to human TIM-3 were included in the amino acid at position 74 to 81.

[0427]

In addition, it was suggested that antibody 512 bound to the amino acids up to

at position 47 of human TIM-3 and that antibody 644, antibody 344823 and antibody F38- 2E2 bound to the amino acid sequence at position 57 to 66 of human TIM-3.
[0428]

Furthermore, it was suggested that antibody 4177 bound to the amino acids
5 other than at position 74 to 81 within the amino acids at position 67 to 87 of human TIM-3 to which antibody 4545 and antibody 8213 bind although antibody 512, antibody 644, antibody 344823 and antibody F38-2E2 did not bind.
[0429]

[Example 33]

10 (Preparation of anti-human TIM-3 antibody 8213 humanized antibody)
(1) Design of amino acid sequences of VH and VL of antibody 8213 humanized antibody

The amino acid sequence of VH of antibody 8213 humanized antibody was designed in the following manner. The amino acid sequences of FRs in VH of human
15 antibody which is suitable for the grafting of the amino acid sequences (SEQ ID NOs: 21 to 23) of CDRs1 to 3 of antibody 8213 were selected as follows.
[0430]

Kabat *et al.*, have classified the VH of conventionally known various human antibodies into three subgroups (HSG I to III) based on the homology of their amino
20 acid sequences and reported the consensus sequences for each of the subgroups [*Sequences of Proteins of Immunological Interest*, US Dept. Health and Human Services (1991)]. Therefore, the homology search of the amino acid consensus sequences of FR of VH subgroups I to III of human antibodies with the amino sequence of FR of VH of antibody 8213 was conducted.
25 [0431]

As a result of the homology search, the homologies of HSGI, HSGII, and HSGIII were 77.0%, 55.2%, and 58.6%, respectively. Therefore, the amino acid sequence of FR of the VH region of antibody 8213 had the highest homology to the subgroup I.
30 [0432]

Based on the above results, the amino acid sequence of CDR of the VH of antibody 8213 (SEQ ID NOs: 21 to 23) was grafted to an appropriate position of the FR amino acid sequence of the consensus sequence of subgroup I of human antibody VH. In this manner, the 8213 antibody HV0 represented by SEQ ID NO: 67, i.e., the amino
35 acid sequence of VH of an anti-human TIM-3 antibody 8213 humanized antibody was designed.
[0433]

Next, the amino acid sequence of VL of antibody 8213 humanized antibody was designed in the following manner. The amino acid sequences of FR in VL of human antibody which were suitable for the grafting of the amino acid sequences (SEQ ID NOs: 24 to 26) of CDRs1 to 3 in VL of antibody 8213 were selected as follows.

5 [0434]

Kabat *et al.*, have classified the VL of various known human antibodies into four subgroups (HSG I to IV) based on the homology of their amino acid sequences and reported the consensus sequences for each of the subgroups [*Sequences of Proteins of Immunological Interest*, US Dept. Health and Human Services (1991)]. Therefore, the homology search among the FR amino acid consensus sequences of VL subgroup I to IV of human antibodies were searched for sequence homology with FR amino sequence of VL of antibody 8213.

[0435]

As a result of the homology search, the homologies of HSGI, HSGII, HSGIII and HSGIV were 76.3%, 61.3%, 61.3%, and 68.8%, respectively. Therefore, the amino acid sequence of FR of the VL region of antibody 8213 had the highest homology to the subgroup I.

[0436]

Based on the above results, each of the amino acid sequences of CDRs of the VL of antibody 8213 (SEQ ID NOs: 24 to 26) was grafted into an appropriate position in the amino acid sequence of FR of the consensus sequence of subgroup I of VL of an human antibody. In this manner, the 8213 antibody LV0 represented by SEQ ID NO: 69, i.e., the amino acid sequence of VL of an anti-human TIM-3 antibody 8213 humanized antibody, was designed.

25 [0437]

The amino acid sequence of 8213 antibody HV0 which was VH of antibody 8213 humanized antibody; and the amino acid sequence of 8213 antibody LV0 which was VL of antibody 8213 humanized antibody designed in the above were the sequences in which only the amino acid sequences of CDRs of the mouse monoclonal antibody 8213 were grafted into the amino acid sequence of the selected FR of human antibody.

[0438]

However, in general, it is known that a humanized antibody prepared merely by grafting CDRs of a mouse antibody to FRs of a human antibody has a lower binding activity. In order to avoid decreasing of the binding activity, attempts have been made in the preparation of a humanized antibody to raise the lowered binding activity by modifying the amino acid residues which were considered to have influence on the

35

binding activity among the amino acid sequences of FRs of a human antibody which are different from a mouse antibody as well as grafting amino acid sequences of CDRs. Therefore, in Examples, the inventors decided to identify and modify the amino acid residues of FR which were considered to have influence on the binding activity in the following manner.

[0439]

First, three-dimensional structure of the above designed antibody V region (hereinafter referred to as “HV0LV0”) comprising the amino acid sequence of antibody 8213 HV0 which was VH of the antibody 8213 humanized antibody and the amino acid sequence of antibody 8213 LV0 which was VL of antibody 8213 humanized antibody was constructed using a computer modeling technique. Discovery Studio (manufactured by Accelrys Inc.) was used for preparation of the three-dimensional structure and display of the three-dimensional structure. A computer model of the three-dimensional structure of V region of antibody 8213 was constructed in the same manner.

[0440]

Furthermore, amino acid residues which were different from those of antibody 8213 in the amino acid sequence of FRs of VH and VL of HV0LV0 were selected, prepared an amino acid sequence in which such amino acid residues were substituted with the corresponding amino acid residues of 8213 antibody and then a three-dimensional structure model was constructed in the same manner. The amino acids which were considered to have influence on the binding activity were selected by comparing the three-dimensional structures of the V regions of antibody 8213 and HV0LV0 and the modified product.

[0441]

As a result, as amino acid residues of FR in HV0LV0 which were considered to change the three-dimensional structure of the antigen binding region and have influence on the binding activity, Lys at position 12, Val at position 20, Arg at position 38, Ala at position 40, Met at position 48, Arg at position 67, Val at position 68, Ile at position 70, Ala at position 72, Thr at position 74, Arg at position 98 and Val at position 113 were selected in antibody 8213 HV0; and Leu at position 11, Ala at position 13, Val at position 15, Tyr at position 36, Ala at position 43, Pro at position 44, Leu at position 46, Phe at position 71 and Thr at position 85 were selected in antibody 8213 LV0.

[0442]

Among the selected amino acid residues, at least one or more amino acid residues was substituted with amino acid residues which were present at the corresponding sites of antibody 8213 and VHs and VLs of the humanized antibody comprising various modifications were constructed.

[0443]

Specifically, as for VH, at least one modification was introduced among the amino acid modifications for substituting Lys at position 12 with Val, Val at position 20 with Leu, Arg at position 38 with Lys, Ala at position 40 with Arg, Met at position 48 with Ile, Arg at position 67 with Lys, Val at position 68 with Ala, Ile at position 70 with Leu, Ala at position 72 with Val, Thr at position 74 with Lys, Arg at position 98 with Gly, or Val at position 113 with Leu in the amino acid sequence represented by SEQ ID NO: 67.

[0444]

As for VL, at least one modification was introduced among the amino acid modifications for substituting Leu at position 11 with Met, Ala at position 13 with Val, Val at position 15 with Leu, Tyr at position 36 with Leu, Ala at position 43 with Ser, Pro at position 44 with Phe, Leu at position 46 with Gly, Phe at position 71 with Tyr and Thr at position 85 with Asp in the amino acid sequence represented by SEQ ID NO: 69.

[0445]

As the antibody V region of 8213 antibody-humanized antibody in which at least one amino acid existing in FR in HV0LV0 was modified, HV0LV0, HV0LV2, HV0LV4, HV0LV5, HV0LV6, HV0LV7, HV0LV9, HV3LV0, HV3LV2, HV3LV4, HV3LV5, HV3LV6, HV3LV7, HV3LV9, HV4LV0, HV4LV2, HV4LV4, HV4LV5, HV4LV6, HV4LV7, HV4LV9, HV5LV0, HV5LV2, HV5LV4, HV5LV5, HV5LV6, HV5LV7, HV5LV9, HV6LV0, HV6LV2, HV6LV4, HV6LV5, HV6LV6, HV6LV7, HV6LV9, HV7LV0, HV7LV2, HV7LV4, HV7LV5, HV7LV6, HV7LV7, HV7LV9, HV8LV0, HV8LV2, HV8LV4, HV8LV5, HV8LV6, HV8LV7, HV8LV9, HV10LV0, HV10LV2, HV10LV4, HV10LV5, HV10LV6, HV10LV7, HV10LV9, HV12LV0, HV12LV2, HV12LV4, HV12LV5, HV12LV6, HV12LV7, and HV12LV9 were designed.

[0446]

The amino acid sequences of each of the H chain variable regions, HV3, HV4, HV5, HV6, HV7, HV8, HV10 and HV12; and the amino acid sequence of the L chain variable region, LV2, LV4, LV5, LV6, LV7 and LV9 were shown in Fig. 1 and Fig. 2, respectively.

[0447]

(2) Preparation of 8213 antibody-humanized antibody

DNA encoding the amino acid sequence of the variable region of 8213 antibody-humanized antibody was designed using codons used in the DNAs (SEQ ID NO: 27 and 29) encoding the amino acid sequence of VH of 8213 antibody and VL of 8213 antibody, respectively. When the amino acid modification was introduced, DNA

was designed using a codon which was used in a mammal cell with a high frequency.
[0448]

Using these DNA sequences, vectors for expressing an antibody were constructed and humanized antibodies were expressed.

5 [0449]

While the invention has been described in detail and with reference to specific embodiments thereof, it will be apparent to one skill in the art that various changes and modifications can be made therein without departing from the spirit and scope thereof.

10 Industrial Applicability

[0450]

The present invention can provide a monoclonal antibody or an antibody fragment thereof which binds to the amino acid sequence or the three-dimensional structure thereof of the extracellular region of human TIM-3 and has ADCC activity; a
15 hybridoma which produces the antibody; a DNA which encodes the antibody; a vector which comprises the DNA; a transformant which is obtained by transforming the vector; a process for producing an antibody or an antibody fragment thereof using the hybridoma or the transformant; and a diagnostic agent or a therapeutic agent using the antibody or the antibody fragment thereof as an active ingredient.

20

Free text of Sequence Listing

[0451]

SEQ ID NO: 1: The amino acid sequence of Human 4545 H chain CDR1

SEQ ID NO: 2: The amino acid sequence of Human 4545 H chain CDR2

25 SEQ ID NO: 3: The amino acid sequence of Human 4545 H chain CDR3

SEQ ID NO: 4: The amino acid sequence of Human 4545 L chain CDR1

SEQ ID NO: 5: The amino acid sequence of Human 4545 L chain CDR2

SEQ ID NO: 6: The amino acid sequence of Human 4545 L chain CDR3

SEQ ID NO: 11: The amino acid sequence of Human 4177 H chain CDR1

30 SEQ ID NO: 12: The amino acid sequence of Human 4177 H chain CDR2

SEQ ID NO: 13: The amino acid sequence of Human 4177 H chain CDR3

SEQ ID NO: 14: The amino acid sequence of Human 4177 L chain CDR1

SEQ ID NO: 15: The amino acid sequence of Human 4177 L chain CDR2

SEQ ID NO: 16: The amino acid sequence of Human 4177 L chain CDR3

- SEQ ID NO: 21: The amino acid sequence of Mouse 8213 H chain CDR1
 SEQ ID NO: 22: The amino acid sequence of Mouse 8213 H chain CDR2
 SEQ ID NO: 23: The amino acid sequence of Mouse 8213 H chain CDR3
 SEQ ID NO: 24: The amino acid sequence of Mouse 8213 L chain CDR1
 5 SEQ ID NO: 25: The amino acid sequence of Mouse 8213 L chain CDR2
 SEQ ID NO: 26: The amino acid sequence of Mouse 8213 L chain CDR3
 SEQ ID NO: 31: The nucleotide sequence of primer TIM-3 Fw2
 SEQ ID NO: 32: The nucleotide sequence of primer TIM-3 Re2
 SEQ ID NO: 33: The nucleotide sequence of primer pMCs-Fw
 10 SEQ ID NO: 34: The nucleotide sequence of primer TIM3ED-FcReXba
 SEQ ID NO: 35: The nucleotide sequence of primer T7
 SEQ ID NO: 36: The nucleotide sequence of primer hTIM-3 Fw1
 SEQ ID NO: 37: The nucleotide sequence of insert hTIM-3 ECD Fc fusion
 SEQ ID NO: 38: The amino acid sequence of insert hTIM-3 ECD Fc fusion
 15 SEQ ID NO: 39: The nucleotide sequence of primer TIM3ED-FLAG4aa
 SEQ ID NO: 40: The nucleotide sequence of primer C-FLAG-NotR2
 SEQ ID NO: 41: The nucleotide sequence of primer BGH-R
 SEQ ID NO: 42: The nucleotide sequence of insert hTIM-3 ECD
 SEQ ID NO: 43: The amino acid sequence of insert hTIM-3 ECD
 20 SEQ ID NO: 44: The nucleotide sequence of primer hh-6
 SEQ ID NO: 45: The nucleotide sequence of primer hh-3
 SEQ ID NO: 46: The nucleotide sequence of primer hk-2
 SEQ ID NO: 47: The nucleotide sequence of primer hk-6
 SEQ ID NO: 48: The nucleotide sequence of primer mH_Rv1
 25 SEQ ID NO: 49: The nucleotide sequence of primer mH_Rv2
 SEQ ID NO: 50: The nucleotide sequence of primer mK_Rv1
 SEQ ID NO: 51: The nucleotide sequence of primer mK_Rv2
 SEQ ID NO: 66: The nucleotide sequence of 8213 antibody HV0 variable region
 SEQ ID NO: 67: The amino acid sequence of 8213 antibody HV0 variable region
 30 SEQ ID NO: 68: The nucleotide sequence of 8213 antibody LV0 variable region
 SEQ ID NO: 69: The amino acid sequence of 8213 antibody LV0 variable region
 SEQ ID NO: 70: The nucleotide sequence of primer mTim-3 Fw3
 SEQ ID NO: 71: The nucleotide sequence of primer mTim-3 Re3
 SEQ ID NO: 72: The nucleotide sequence of primer mTim-3 Fw4NotI
 35 SEQ ID NO: 73: The nucleotide sequence of primer mTim-3 Re4NotI
 SEQ ID NO: 74: The nucleotide sequence of primer hTIM3+mIgV_vecR1
 SEQ ID NO: 75: The nucleotide sequence of primer hTIM3+mIgV_vecF1

- SEQ ID NO: 76: The nucleotide sequence of primer hTIM3+mIgV_insF1
 SEQ ID NO: 77: The nucleotide sequence of primer hTIM3+mIgV_insR1
 SEQ ID NO: 78: The nucleotide sequence of insert IgV chimeraTIM-3/pEF6 Myc_HisC
 SEQ ID NO: 79: The amino acid sequence of insert IgV chimeraTIM-3/pEF6
 5 Myc_HisC
 SEQ ID NO: 80: The nucleotide sequence of primer hTIM3+mMucin_vecR2
 SEQ ID NO: 81: The nucleotide sequence of primer hTIM3+mMucin_vecF2
 SEQ ID NO: 82: The nucleotide sequence of primer hTIM3+mMucin_insF2
 SEQ ID NO: 83: The nucleotide sequence of primer hTIM3+mMucin_insR2
 10 SEQ ID NO: 84: The nucleotide sequence of insert Mucin chimeraTIM-3/pEF6
 Myc_HisC
 SEQ ID NO: 85: The amino acid sequence of insert Mucin chimeraTIM-3/pEF6
 Myc_HisC
 SEQ ID NO: 86: The nucleotide sequence of primer hTIM3chimera22-47F1
 15 SEQ ID NO: 87: The nucleotide sequence of primer hTIM3chimera22-47R1
 SEQ ID NO: 88: The nucleotide sequence of primer hTIM3chimera22-47F2
 SEQ ID NO: 89: The nucleotide sequence of primer hTIM3chimera22-47R2
 SEQ ID NO: 90: The nucleotide sequence of primer hTIM3chimera22-47F3
 SEQ ID NO: 91: The nucleotide sequence of
 20 primer hTIM3chimera22-47R3SEQ ID NO: 92 : The nucleotide sequence of insert
 TIM-3 chimera 22-47/pEF6 Myc_HisC
 SEQ ID NO: 93: The amino acid sequence of insert TIM-3 chimera 22-47/pEF6
 Myc_HisC
 SEQ ID NO: 94: The nucleotide sequence of primer hTIM3chimera57-66F
 25 SEQ ID NO: 95: The nucleotide sequence of primer hTIM3chimera57-66R
 SEQ ID NO: 96: The nucleotide sequence of insert TIM-3 chimera 57-66/pEF6
 Myc_HisC
 SEQ ID NO: 97: The amino acid sequence of insert TIM-3 chimera 57-66/pEF6
 Myc_HisC
 30 SEQ ID NO: 98: The nucleotide sequence of primer hTIM3chimera67-105F
 SEQ ID NO: 99: The nucleotide sequence of primer hTIM3chimera67-105R
 SEQ ID NO: 100: The nucleotide sequence of primer mTIM3chimera67-105F
 SEQ ID NO: 101: The nucleotide sequence of primer mTIM3chimera67-105R
 SEQ ID NO: 102: The nucleotide sequence of insert TIM-3 chimera 67-105/pEF6
 35 Myc_HisC
 SEQ ID NO: 103: The amino acid sequence of insert TIM-3 chimera 67-105/pEF6
 Myc_HisC

- SEQ ID NO: 104: The nucleotide sequence of primer hTIM3chimera74-81F
 SEQ ID NO: 105: The nucleotide sequence of primer hTIM3chimera74-81R
 SEQ ID NO: 106: The nucleotide sequence of insert TIM-3 chimera 74-81/pEF6
 Myc_HisC
- 5 SEQ ID NO: 107: The amino acid sequence of insert TIM-3 chimera 74-81/pEF6
 Myc_HisC
 SEQ ID NO: 108: The nucleotide sequence of primer hTIM3chimera88-96F
 SEQ ID NO: 109: The nucleotide sequence of primer hTIM3chimera88-96R
 SEQ ID NO: 110: The nucleotide sequence of insert TIM-3 chimera 88-96/pEF6
 10 Myc_HisC
 SEQ ID NO: 111: The amino acid sequence of insert TIM-3 chimera 88-96/pEF6
 Myc_HisC
 SEQ ID NO: 112: The nucleotide sequence of primer hTIM3chimera96-105F
 SEQ ID NO: 113: The nucleotide sequence of primer hTIM3chimera96-105R
 15 SEQ ID NO: 114: The nucleotide sequence of insert TIM-3 chimera 96-105/pEF6
 Myc_HisC
 SEQ ID NO: 115: The amino acid sequence of insert TIM-3 chimera 96-105/pEF6
 Myc_HisC
 SEQ ID NO: 116: The amino acid sequence of the mature form of VH of antibody 4545
 20 SEQ ID NO: 117: The amino acid sequence of the mature form of VL of antibody 4545
 SEQ ID NO: 118: The amino acid sequence of the mature form of VH of antibody 4177
 SEQ ID NO: 119: The amino acid sequence of the mature form of VL of antibody 4177

Claims

[Claim 1]

5 A monoclonal antibody or an antigen-binding fragment thereof, which binds to the amino acid sequences at positions 67 to 105, positions 67 to 96 or positions 67 to 87 in the amino acid sequence of IgV domain of human TIM-3 represented by SEQ ID NO: 53, wherein said monoclonal antibody or antigen-binding fragment thereof comprises:

(i) heavy (H) chain complementarity determining regions (CDRs) 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 1 to 3, respectively, and light (L) chain CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 4 to 6, respectively, or

(ii) a variable heavy chain (VH) comprising the amino acid sequence represented by SEQ ID NO: 116 and a variable light chain (VL) comprising the amino acid sequence represented by SEQ ID NO: 117.

15 [Claim 2]

The monoclonal antibody or the antigen-binding fragment thereof according to claim 1, which comprises heavy (H) chain complementarity determining regions (CDRs) 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 1 to 3, respectively, and light (L) chain CDRs 1 to 3 comprising the amino acid sequences represented by SEQ ID NOs: 4 to 6, respectively.

[Claim 3]

25 The monoclonal antibody or the antigen-binding fragment thereof according to claim 1, which comprises a variable heavy chain (VH) comprising the amino acid sequence represented by SEQ ID NO: 116 and a variable light chain (VL) comprising the amino acid sequence represented by SEQ ID NO: 117.

[Claim 4]

The monoclonal antibody or the antigen-binding fragment thereof according to claim 2 or 3, which is a monoclonal antibody.

[Claim 5]

30 The monoclonal antibody or the antigen-binding fragment thereof according to claim 2 or 3, which is an antigen-binding fragment of a monoclonal antibody.

[Claim 6]

The monoclonal antibody or the antigen-binding fragment thereof according to any one of claims 1 to 5, which is a recombinant antibody.

35 [Claim 7]

The monoclonal antibody or the antigen-binding fragment thereof according to claim 6, wherein the recombinant antibody is a human chimeric antibody, a humanized

antibody or a human antibody.

[Claim 8]

The monoclonal antibody or the antigen-binding fragment thereof according to any one of claims 1 to 7, wherein the antigen-binding fragment is an Fab, Fab', F(ab')₂,
5 a single chain antibody (scFv), a dimerized V region (diabody), a disulfide stabilized V region (dsFv) or a peptide comprising CDR.

[Claim 9]

A DNA which encodes the monoclonal antibody or the antigen-binding fragment thereof according to any one of claims 1 to 8.

10 [Claim 10]

A recombinant vector which comprises the DNA according to claim 9.

[Claim 11]

A host cell comprising the recombinant vector according to claim 10.

[Claim 12]

15 A process for producing the monoclonal antibody or the antigen-binding fragment thereof according to any one of claims 1 to 8, which comprises culturing the host cell according to claim 11 in a culture to form and accumulate the monoclonal antibody or the antigen-binding fragment thereof according to any one of claims 1 to 8, and recovering the monoclonal antibody or the antigen-binding fragment thereof from
20 the culture.

[Claim 13]

A method for immunologically detecting or measuring a human TIM-3 in a sample, the method comprising:

- 25 - contacting the sample with the monoclonal antibody or the antigen-binding fragment thereof according to any one of claims 1 to 8; and
- detecting or measuring the human TIM-3 on the basis of the reactivity of the monoclonal antibody or the antigen-binding fragment thereof with the sample.

[Claim 14]

30 A detection agent for detecting or measuring a human TIM-3 which comprises the monoclonal antibody or the antigen-binding fragment thereof according to any one of claims 1 to 8, and a detection compatible reagent.

[Claim 15]

The detection agent of claim 14, wherein the detection compatible reagent comprises a detectable label.

35 [Claim 16]

A diagnostic agent for a disease relating to a human TIM-3 positive cell which comprises the monoclonal antibody or the antigen-binding fragment thereof according

to any one of claims 1 to 8, and a diagnostic compatible reagent.

[Claim 17]

The diagnostic agent of claim 16, wherein the diagnostic compatible reagent comprises a detectable label.

5 [Claim 18]

An *in vitro* method for diagnosing a disease relating to a human TIM-3 positive cell, which comprises detecting or measuring a human TIM-3 positive cell using (i) the monoclonal antibody or the antigen-binding fragment thereof according to any one of claims 1 to 8, or (ii) the diagnostic agent according to claim 16 or 17.

10 [Claim 19]

Use of the monoclonal antibody or the antigen-binding fragment thereof according to any one of claims 1 to 8 for the manufacture of a diagnostic agent for a disease relating to a human TIM-3 positive cell.

[Claim 20]

15 Use of the monoclonal antibody or the antigen-binding fragment thereof according to any one of claims 1 to 8 for diagnosis of a disease relating to a human TIM-3 positive cell.

[Claim 21]

20 A pharmaceutical composition for treating a disease relating to a human TIM-3 positive cell, which comprises the monoclonal antibody or the antigen-binding fragment thereof according to any one of claims 1 to 8, and one or more pharmaceutically acceptable carriers.

[Claim 22]

25 The monoclonal antibody or the antigen-binding fragment thereof according to any one of claims 1 to 8, for use in the treatment of a disease relating to a human TIM-3 positive cell.

[Claim 23]

30 Use of the monoclonal antibody or the antigen-binding fragment thereof according to any one of claims 1 to 8 for the manufacture of a therapeutic agent for a disease relating to a human TIM-3 positive cell.

[Claim 24]

35 Use of the monoclonal antibody or the antigen-binding fragment thereof according to any one of claims 1 to 8 for the treatment of a disease relating to a human TIM-3 positive cell.

1/2

Fig. 1

	1	2	3	4	5	6
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
8213 antibody HV0	QVQLVQSGAE	VKRRGASVKV	SCKASGYTFT	SYMMHWVRQA	PGQGLEWNGE	INPSNGRTNY
8213 antibody HV3				K	I	
8213 antibody HV4				K	I	
8213 antibody HV5				K R	I	
8213 antibody HV6		V				
8213 antibody HV7				K R	I	
8213 antibody HV8			L	K	I	
8213 antibody HV10		V		K R	I	
8213 antibody HV12		V	L	K R	I	

	7	8	9	10	11
	1234567890	1234567890	1234567890	1234567890	1234567890
8213 antibody HV0	NEKFKTRVTL	TADTSTSTAY	MELSSLRSD	TAIVYCARGY	YLFPDYWGOG
8213 antibody HV3				G	TLVTVSS
8213 antibody HV4	K	K			
8213 antibody HV5	K			G	
8213 antibody HV6	KA	V K		G	
8213 antibody HV7	K	V K		G	
8213 antibody HV8	A L	V		G	L
8213 antibody HV10	KA L	V K		G	
8213 antibody HV12	KA L	V K		G	

2/2

Fig. 2

	1	2	3	4	5	6
	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890
8213 antibody LV0	DICMTQSPSS	LSASVGDRTV	TTCNASQGIS	INIGWYQKP	GKAPKLLIYH	GTNLEDGVP
8213 antibody LV2				L	F	
8213 antibody LV4			L	L	G	
8213 antibody LV5				L	SF G	
8213 antibody LV6		L		L	F G	
8213 antibody LV7	M	L		L	F G	
8213 antibody LV9	M V L			L	SF G	

	7	8	9	10
	1234567890	1234567890	1234567890	1234567890
8213 antibody LV0	RFSGSGSGTD	FTLTSSLOP	EDFATYYCVQ	YGQFPWTFGQ
8213 antibody LV2				GTKLEIK
8213 antibody LV4		Y		
8213 antibody LV5			D	
8213 antibody LV6		Y	D	
8213 antibody LV7		Y	D	
8213 antibody LV9		Y	D	