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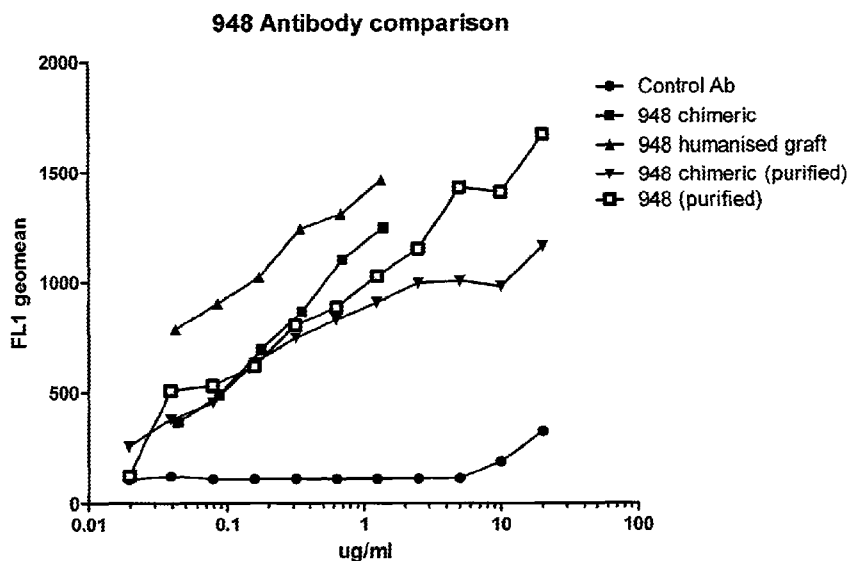
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(54) Title: PD-1 ANTIBODY

Figure 12



(57) Abstract: A humanised agonistic antibody which binds human PD-1 comprising a heavy chain wherein the variable domain of the heavy chain comprises the sequence given in SEQ ID NO:1 for CDR-H1, the sequence given in SEQ ID NO : 2 for CDR-H2 and the sequence given in SEQ ID NO: 3 for CDR-H3 and the heavy chain framework region is derived from human subgroup sequence VH4 3-1 4-30.4 + JH4 (SEQ ID NO: 33). The disclosure also extends to therapeutic uses of the antibody molecules, compositions and methods for producing said antibody molecules.

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PD-1 Antibody

The present invention relates to antibody molecules having specificity for antigenic determinants of human PD-1 and compositions comprising the same. The present invention also
5 relates to the therapeutic uses of the antibody molecules, compositions and methods for producing said antibody molecules.

Programmed Death 1 (PD-1), also known as CD279; gene name PDCD1; accession number NP_005009 is a cell surface receptor with a critical role in regulating the balance between stimulatory and inhibitory signals in the immune system and maintaining peripheral
10 tolerance (Ishida, Y et al. 1992 EMBO J 11 3887; Kier, Mary E et al. 2008 Annu Rev Immunol 26 677-704; Okazaki, Taku et al. 2007 International Immunology 19 813-824). It is an inhibitory member of the immunoglobulin super-family with homology to CD28. The structure of PD-1 is a monomeric type 1 transmembrane protein, consisting of one immunoglobulin variable-like extracellular domain and a cytoplasmic domain containing an immunoreceptor
15 tyrosine-based inhibitory motif (ITIM) and an immunoreceptor tyrosine-based switch motif (ITSM). Expression of PD-1 is inducible on T cells, B cells, natural killer (NK) cells and monocytes, for example upon lymphocyte activation via T cell receptor (TCR) or B cell receptor (BCR) signalling (Kier, Mary E et al. 2008 Annu Rev Immunol 26 677-704; Agata, Y et al 1996 Int Immunol 8 765-72). PD-1 has two known ligands, PD-L1 (B7-H1, CD274) and
20 PD-L2 (B7-DC, CD273), which are cell surface expressed members of the B7 family (Freeman, Gordon et al. 2000 J Exp Med 192 1027; Latchman, Y et al. 2001 Nat Immunol 2 261). Upon ligand engagement, PD-1 recruits phosphatases such as SHP-1 and SHP-2 to its intracellular tyrosine motifs which subsequently dephosphorylate effector molecules activated by TCR or BCR signalling (Chemnitz, J et al. 2004 J Immunol 173 945-954; Riley, James L 2009
25 Immunological Reviews 229 114-125) In this way, PD-1 transduces inhibitory signals into T and B cells only when it is engaged simultaneously with the TCR or BCR.

PD-1 has been demonstrated to down-regulate effector T cell responses via both cell-intrinsic and cell-extrinsic functional mechanisms. Inhibitory signalling through PD-1 induces a
30 state of anergy or unresponsiveness in T cells, resulting in the cells being unable to clonally expand or produce optimal levels of effector cytokines. PD-1 may also induce apoptosis in T cells via its ability to inhibit survival signals from co-stimulation, which leads to reduced expression of key anti-apoptotic molecules such as Bcl-XL (Kier, Mary E et al. 2008 Annu Rev Immunol 26 677-704). In addition to these direct effects, recent publications have implicated PD-1 as being involved in the suppression of effector cells by promoting the induction and

maintenance of regulatory T cells (T_{REG}). For example, PD-L1 expressed on dendritic cells was shown to act in synergy with TGF- β to promote the induction of CD4⁺ FoxP3⁺ T_{REG} with enhanced suppressor function (Francisco, Loise M et al. 2009 J Exp Med 206 3015-3029).

The first indication of the importance of PD-1 in peripheral tolerance and inflammatory disease came from the observation that PD-1 knockout (*Pdcd1*^{-/-}) mice develop spontaneous autoimmunity. Fifty percent of *Pdcd1*^{-/-} mice on a C57BL/6 background develop lupus-like glomerulonephritis and arthritis by 14 months of age and BALB/c-*Pdcd1*^{-/-} mice develop a fatal dilated cardiomyopathy and production of autoantibodies against cardiac troponin I from 5 weeks onwards (Nishimura, H et al. 1999 Immunity 11 141-151; Nishimura, H et al. 2001 Science 291 319-322). Furthermore, introduction of PD-1 deficiency to the non-obese diabetic (NOD) mouse strain dramatically accelerates the onset and incidence of diabetes resulting in all NOD-*Pdcd1*^{-/-} mice developing diabetes by 10 weeks of age (Wang, J et al. 2005 Proc Natl Acad Sci USA 102 11823). Additionally, using induced murine models of autoimmunity such as experimental autoimmune encephalomyelitis (EAE), or transplantation / graft-versus-host (GVHD) models, several groups have shown that blocking the PD-1-PD-L interaction exacerbates disease, further confirming the key role of PD-1 in inflammatory diseases. Importantly, evidence suggests that PD-1 has a comparable immune modulatory function in humans as mice, as polymorphisms in human *PDCDI* have been associated with a range of autoimmune diseases including systemic lupus erythematosus (SLE), multiple sclerosis (MS), type I diabetes (T1D), rheumatoid arthritis (RA) and Grave's disease (Okazaki, Taku et al. 2007 International Immunology 19 813-824; Prokunina, L et al. 2002 Nat Genet 32 666-669; Kroner, A et al. 2005 Ann Neurol 58 50-57; Prokunina, L et al 2004 Arthritis Rheum 50 1770). Several therapeutic approaches to enhance PD-1 signalling and modulate inflammatory disease have been reported, using murine models of autoimmunity. One such approach tried was to generate artificial dendritic cells which over-express PD-L1. Injection of mice with antigen-loaded PD-L1-dendritic cells before or after induction of EAE by MOG peptide immunisation reduced the inflammation of the spinal cord as well as the clinical severity of the disease (Hirata, S et al. 2005 J Immunol 174 1888-1897). Another approach was to try and cure lupus-like syndrome in BXSB mice by delivering a PD-1 signal using a recombinant adenovirus expressing mouse PD-L1. Injection of this virus partially prevented the development of nephritis as shown by lower frequency of proteinuria, reduced serum anti-dsDNA Ig and better renal pathology (Ding, H et al. 2006 Clin Immunol 118 258). These results suggest that enhancing the PD-1 signal could have therapeutic benefit in human autoimmune disease. An alternative therapeutic approach more appropriate as a human drug treatment would be to use

an agonistic monoclonal antibody against human PD-1. Such an antibody may work as a 'ligand mimic' by binding to the ligand binding site of PD-1 and thereby inducing an inhibitory signalling cascade in the same way that engagement of the endogenous PD-1 ligands do. An agonistic anti-PD-1 mAb would be predicted to modulate a range of immune cell types involved in inflammatory disease including T cells, B cells, NK cells and monocytes and would therefore have utility in the treatment of a wide range of human autoimmune or inflammatory disorders.

A number of antagonistic anti-PD-1 antibodies have been described, and some agonistic antibodies see for Example, WO2004/056875.

10 There is still a need in the art for improved agonistic anti-PD-1 antibodies suitable for treating patients.

We have now identified high affinity agonistic anti-PD-1 antibodies suitable for use in the treatment or prophylaxis of immune disorders, for example by reducing the T cell response. Non limiting examples of immune disorders that can be treated via the administration of PD-1 specific antibodies to a subject include, but are not limited to, rheumatoid arthritis, multiple sclerosis, inflammatory bowel disease, Crohn's disease, systemic lupus erythematosus, type I diabetes, transplant rejection, graft-versus-host disease, hyperproliferative immune disorders, cancer and infectious diseases.

20 **Brief Description of the Drawings**

Figures 1-3 shows amino acid sequences relating to antibody 948 according to the disclosure

Figures 3-11 shows certain amino acid or DNA sequences relating to an antibody according to the disclosure

Figure 12 Comparison of 948 chimeric and humanised grafts binding to cell expressed human PD-1

Figure 13 shows an alignment of the light and heavy chains for the murine, acceptor frameworks and humanised light and heavy chains.

The parental murine antibody hybridoma from which the humanised antibodies are derived is referred to herein as Clone 10. The cloned recombinant antibody derived from Clone 10 is referred to herein as antibody CA051_00948 also referred to herein as 948.

The residues in antibody variable domains are conventionally numbered according to a system devised by Kabat *et al.* This system is set forth in Kabat *et al.*, 1987, in Sequences of Proteins of Immunological Interest, US Department of Health and Human Services, NIH, USA

(hereafter “Kabat *et al. (supra)*”). This numbering system is used in the present specification except where otherwise indicated.

The Kabat residue designations do not always correspond directly with the linear numbering of the amino acid residues. The actual linear amino acid sequence may contain
5 fewer or additional amino acids than in the strict Kabat numbering corresponding to a shortening of, or insertion into, a structural component, whether framework or complementarity determining region (CDR), of the basic variable domain structure. The correct Kabat numbering of residues may be determined for a given antibody by alignment of residues of homology in the sequence of the antibody with a “standard” Kabat numbered sequence.

10 The CDRs of the heavy chain variable domain are located at residues 31-35 (CDR-H1), residues 50-65 (CDR-H2) and residues 95-102 (CDR-H3) according to the Kabat numbering system. However, according to Chothia (Chothia, C. and Lesk, A.M. J. Mol. Biol., 196, 901-917 (1987)), the loop equivalent to CDR-H1 extends from residue 26 to residue 32. Thus unless indicated otherwise ‘CDR-H1’ as employed herein is intended to refer to residues 26 to
15 35, as described by a combination of the Kabat numbering system and Chothia’s topological loop definition.

The CDRs of the light chain variable domain are located at residues 24-34 (CDR-L1), residues 50-56 (CDR-L2) and residues 89-97 (CDR-L3) according to the Kabat numbering system.

20 As used herein, the term ‘agonistic antibody’ describes an antibody that is capable of stimulating the biological signalling activity of PD-1, leading to phosphatase recruitment to its intracellular domain and hence inactivation of T or B cell receptor signaling and phenotypic characteristics associated with activation.

Antibodies for use in the present invention may be obtained using any suitable method
25 known in the art. The PD-1 polypeptide/protein including fusion proteins, for example PD-1-Fc fusions proteins or cells (recombinantly or naturally) expressing the polypeptide (such as activated T cells) can be used to produce antibodies which specifically recognise PD-1. The PD-1 polypeptide may be the ‘mature’ polypeptide or a biologically active fragment or derivative thereof. Suitably the PD-1 polypeptide is the mature human polypeptide or the
30 extracellular domain or fragment thereof. The extracellular domain typically comprises amino acids 21-170 of the PD-1 protein (SWISS PROT entry Q15116). PD-1 polypeptides may be prepared by processes well known in the art from genetically engineered host cells comprising expression systems or they may be recovered from natural biological sources. In the present application, the term “polypeptides” includes peptides, polypeptides and proteins. These are

used interchangeably unless otherwise specified. The PD-1 polypeptide may in some instances be part of a larger protein such as a fusion protein for example fused to an affinity tag.

Antibodies generated against the PD-1 polypeptide may be obtained, where immunisation of an animal is necessary, by administering the polypeptides to an animal, preferably a non-human animal, using well-known and routine protocols, see for example Handbook of Experimental Immunology, D. M. Weir (ed.), Vol 4, Blackwell Scientific Publishers, Oxford, England, 1986). Many warm-blooded animals, such as rabbits, mice, rats, sheep, cows, camels or pigs may be immunized. However, mice, rabbits, pigs and rats are generally most suitable.

Monoclonal antibodies may be prepared by any method known in the art such as the hybridoma technique (Kohler & Milstein, 1975, Nature, 256:495-497), the trioma technique, the human B-cell hybridoma technique (Kozbor *et al.*, 1983, Immunology Today, 4:72) and the EBV-hybridoma technique (Cole *et al.*, Monoclonal Antibodies and Cancer Therapy, pp77-96, Alan R Liss, Inc., 1985).

Antibodies for use in the invention may also be generated using single lymphocyte antibody methods by cloning and expressing immunoglobulin variable region cDNAs generated from single lymphocytes selected for the production of specific antibodies by, for example, the methods described by Babcook, J. *et al.*, 1996, Proc. Natl. Acad. Sci. USA 93(15):7843-78481; WO92/02551; WO2004/051268 and International Patent Application number WO2004/106377.

Screening for antibodies can be performed using assays to measure binding to human PD-1 and/or assays to measure the ability to agonise PD1 activity. An example of a binding assay is an ELISA, in particular, using a fusion protein of human PD-1 and human Fc, which is immobilized on plates, and employing a conjugated secondary antibody to detect anti-PD-1 antibody bound to the fusion protein.

Humanised antibodies (which include CDR-grafted antibodies) are antibody molecules having one or more complementarity determining regions (CDRs) from a non-human species and a framework region from a human immunoglobulin molecule (see, *e.g.* US 5,585,089; WO91/09967). It will be appreciated that it may only be necessary to transfer the specificity determining residues of the CDRs rather than the entire CDR (see for example, Kashmiri *et al.*, 2005, Methods, 36, 25-34). Humanised antibodies may optionally further comprise one or more framework residues derived from the non-human species from which the CDRs were derived.

The present invention provides agonistic humanised antibodies having specificity for human PD-1.

An agonistic murine anti-PD-1 antibody (Clone 10) was described in PCT/IB2009/06946 (unpublished) and the sequences of the variable regions and CDRs of this antibody are provided in Figures 1 and 2. In particular the CDRs of this antibody are provided in Figure 1, SEQ ID NOs 1-6.

5 As used herein, the term 'humanised antibody molecule' refers to an antibody molecule wherein the heavy and/or light chain contains one or more CDRs (including, if desired, one or more modified CDRs) from a donor antibody (e.g. a murine monoclonal antibody) grafted into a heavy and/or light chain variable region framework of an acceptor antibody (e.g. a human antibody). For a review, see Vaughan *et al.*, Nature Biotechnology, 16, 535-539, 1998. In one
10 embodiment rather than the entire CDR being transferred, only one or more of the specificity determining residues from any one of the CDRs described herein above are transferred to the human antibody framework (see for example, Kashmiri *et al.*, 2005, Methods, 36, 25-34). In one embodiment only the specificity determining residues from one or more of the CDRs described herein above are transferred to the human antibody framework. In another
15 embodiment only the specificity determining residues from each of the CDRs described herein above are transferred to the human antibody framework.

When the CDRs or specificity determining residues are grafted, any appropriate acceptor variable region framework sequence may be used having regard to the class/type of the donor antibody from which the CDRs are derived, including mouse, primate and human
20 framework regions. Suitably, the humanised antibody according to the present invention has a variable domain comprising human acceptor framework regions as well as one or more of the CDRs provided in Figure 1 (SEQ ID Nos 1-6). Thus, provided in one embodiment is an agonistic humanised antibody which binds human PD-1 wherein the variable domain comprises human acceptor framework regions and non-human donor CDRs.

25 Examples of human frameworks which can be used in the present invention are KOL, NEWM, REI, EU, TUR, TEI, LAY and POM (Kabat *et al.*, *supra*). For example, KOL and NEWM can be used for the heavy chain, REI can be used for the light chain and EU, LAY and POM can be used for both the heavy chain and the light chain. Alternatively, human germline sequences may be used; these are available at: <http://vbase.mrc-cpe.cam.ac.uk/>

30 In a humanised antibody of the present invention, the acceptor heavy and light chains do not necessarily need to be derived from the same antibody and may, if desired, comprise composite chains having framework regions derived from different chains.

Once such suitable framework region for the heavy chain of the humanised antibody of the present invention is derived from the human sub-group VH4 sequence 3-1 4-30.4 together

with JH4 (SEQ ID NO:33). Accordingly, in one example there is provided an agonistic humanised antibody comprising the sequence given in SEQ ID NO:1 for CDR-H1, the sequence given in SEQ ID NO:2 for CDR-H2 and the sequence given in SEQ ID NO:3 for CDRH3 wherein the heavy chain framework region is derived from the human subgroup VH4 sequence 3-1 4-30.4 together with JH4. The sequence of human JH4 is as follows:
5 (YFDY)WGQGTLVTVS (Seq ID No: 35). The YFDY motif is part of CDR-H3 and is not part of framework 4 (Ravetch, JV. *et al.*, 1981, *Cell*, 27, 583-591).

A suitable framework region for the light chain of the humanised antibody of the present invention is derived from the human germline sub-group VK2 sequence 4-1-1 A18 together
10 with JK2 (SEQ ID NO:31). Accordingly, in one example there is provided an agonistic humanised antibody comprising the sequence given in SEQ ID NO:4 for CDR-L1, the sequence given in SEQ ID NO:5 for CDR-L2 and the sequence given in SEQ ID NO:6 for CDRL3 wherein the light chain framework region is derived from the human subgroup sequence VK2 4-1-1 A18 together with JK2. The JK2 sequence is as follows: **(YT)FGQGKLEIK (Seq ID**
15 **No: 36)**. The YT motif is part of CDR-L3 and is not part of framework 4 (Hieter, PA., *et al.*, 1982, *J. Biol. Chem.*, 257, 1516-1522).

Also, in a humanised antibody of the present invention, the framework regions need not have exactly the same sequence as those of the acceptor antibody. For instance, unusual residues may be changed to more frequently-occurring residues for that acceptor chain class or
20 type. Alternatively, selected residues in the acceptor framework regions may be changed so that they correspond to the residue found at the same position in the donor antibody (see Reichmann *et al.*, 1998, *Nature*, 332, 323-324). Such changes should be kept to the minimum necessary to recover the affinity of the donor antibody. A protocol for selecting residues in the acceptor framework regions which may need to be changed is set forth in WO 91/09967.

Suitably, in a humanised antibody molecule of the present invention, if the acceptor heavy chain has the human VH4 sequence 3-1 4-30.4 together with JH4, then the acceptor framework regions of the heavy chain comprise, in addition to the three donor CDRs (SEQ ID
25 NOs:1, 2 and 3), a donor residue at at least one of positions 25, 44, 48 and 71 (according to Kabat *et al.*, (*supra*)). Accordingly, in one example there is provided a humanised antibody,
30 wherein at least the residues at each of positions 25, 44, 48 and 71 of the variable domain of the heavy chain are donor residues, see for example the sequence given in SEQ ID NO:23.

Suitably, in a humanised antibody molecule according to the present invention, if the acceptor light chain has the human sub-group VK2 sequence 4-1-1 A18 together with JK2, then the acceptor framework regions of the light chain comprise, in addition to three donor CDRs

(SEQ ID NOs:4, 5 and 6), a donor residue at at least one of positions 2, 3, 45, 62 and 87. Accordingly, in one example there is provided a humanised antibody, wherein at least the residues at each of positions 2, 3, 45, 62 and 87 of the variable domain of the light chain are donor residues, see for example SEQ ID NO:15.

5 Donor residues are residues from the donor antibody, i.e. the antibody from which the CDRs were originally derived. Donor residues may be replaced by a suitable residue derived from a human receptor framework (acceptor residues).

Suitable human acceptor residues to replace donor residues for each framework are listed below:

10 **Light chain**

<u>Kabat position</u>	<u>Human residue to replace donor</u>
-----------------------	---------------------------------------

2	Isoleucine
15 3	Valine
45	Glutamine
62	Phenylalanine
87	Tyrosine

20 **Heavy chain**

<u>Kabat position</u>	<u>Human residue to replace donor</u>
-----------------------	---------------------------------------

25	Serine
25 44	Glycine
48	Isoleucine
71	Valine

30 The antibody molecules of the present invention suitably comprise a complementary light chain or a complementary heavy chain, respectively. Accordingly, in one embodiment the present invention provides a humanised agonistic antibody which binds human PD-1 having a heavy chain comprising the sequence given in SEQ ID NO:23 and a light chain comprising the sequence given in SEQ ID NO: 15.

35 It will be appreciated that one or more amino acid substitutions, additions and/or deletions may be made to the CDRs or other sequences (e.g variable domains) provided by the present invention without significantly altering the ability of the antibody to bind to PD-1 and

to agonise PD-1 activity. The effect of any amino acid substitutions, additions and/or deletions can be readily tested by one skilled in the art, for example by using the methods described herein, in particular in the Examples, to determine PD-1 binding and PD-1 agonism.

In another embodiment, an antibody of the present invention comprises a heavy chain, wherein the variable domain of the heavy chain comprises a sequence having at least 60% identity or similarity to the sequence given in SEQ ID NO:23. In one embodiment, an antibody of the present invention comprises a heavy chain, wherein the variable domain of the heavy chain comprises a sequence having at least 70%, 80%, 90%, 95% or 98% identity or similarity to the sequence given in SEQ ID NO:23.

"Identity", as used herein, indicates that at any particular position in the aligned sequences, the amino acid residue is identical between the sequences. "Similarity", as used herein, indicates that, at any particular position in the aligned sequences, the amino acid residue is of a similar type between the sequences. For example, leucine may be substituted for isoleucine or valine. Other amino acids which can often be substituted for one another include but are not limited to:

- phenylalanine, tyrosine and tryptophan (amino acids having aromatic side chains);
- lysine, arginine and histidine (amino acids having basic side chains);
- aspartate and glutamate (amino acids having acidic side chains);
- asparagine and glutamine (amino acids having amide side chains); and

- cysteine and methionine (amino acids having sulphur-containing side chains). Degrees of identity and similarity can be readily calculated (Computational Molecular Biology, Lesk, A.M., ed., Oxford University Press, New York, 1988; Biocomputing. Informatics and Genome Projects, Smith, D.W., ed., Academic Press, New York, 1993; Computer Analysis of Sequence Data, Part 1, Griffin, A.M., and Griffin, H.G., eds., Humana Press, New Jersey, 1994; Sequence Analysis in Molecular Biology, von Heinje, G., Academic Press, 1987, Sequence Analysis Primer, Gribskov, M. and Devereux, J., eds., M Stockton Press, New York, 1991, the BLAST™ software available from NCBI (Altschul, S.F. *et al.*, 1990, J. Mol. Biol. 215:403-410; Gish, W. & States, D.J. 1993, Nature Genet. 3:266-272. Madden, T.L. *et al.*, 1996, Meth. Enzymol. 266:131-141; Altschul, S.F. *et al.*, 1997, Nucleic Acids Res. 25:3389-3402; Zhang, J. & Madden, T.L. 1997, Genome Res. 7:649-656,).

In another embodiment, an antibody of the present invention comprises a light chain, wherein the variable domain of the light chain comprises a sequence having at least 60% identity or similarity to the sequence given in SEQ ID NO: 15.

In one embodiment the antibody of the present invention comprises a light chain, wherein the variable domain of the light chain comprises a sequence having at least 70%, 80%, 90%, 95% or 98% identity or similarity to the sequence given in SEQ ID NO: 15.

In another embodiment of the invention, the antibody comprises a heavy chain and a
5 light chain, wherein the variable domain of the heavy chain comprises a sequence having at least 60% identity or similarity to the sequence given in SEQ ID NO:23 and the variable domain of the light chain comprises a sequence having at least 60% identity or similarity to the sequence given in SEQ ID NO: 15.

Suitably, the antibody comprises a heavy chain, wherein the variable domain of the
10 heavy chain comprises a sequence having at least 70%, 80%, 90%, 95% or 98% identity or similarity to the sequence given in SEQ ID NO:23 and a light chain, wherein the variable domain of the light chain comprises a sequence having at least 70%, 80%, 90%, 95% or 98% identity or similarity to the sequence given in SEQ ID NO: 15.

The antibody molecules of the present invention may comprise a complete antibody
15 molecule having full length heavy and light chains or a fragment thereof and may be, but are not limited to Fab, modified Fab, Fab', modified Fab', F(ab')₂, Fv, single domain antibodies (e.g. VH or VL or VHH), scFv, bi, tri or tetra-valent antibodies, Bis-scFv, diabodies, triabodies, tetrabodies and epitope-binding fragments of any of the above (see for example Holliger and Hudson, 2005, Nature Biotech. 23(9):1126-1136; Adair and Lawson, 2005, Drug Design
20 Reviews - Online 2(3), 209-217). The methods for creating and manufacturing these antibody fragments are well known in the art (see for example Verma et al., 1998, Journal of Immunological Methods, 216, 165-181). Other antibody fragments for use in the present invention include the Fab and Fab' fragments described in International patent applications WO2005/003169, WO2005/003170 and WO2005/003171. Multi-valent antibodies may
25 comprise multiple specificities e.g bispecific or may be monospecific (see for example WO 92/22853 and WO05/113605).

In one embodiment the antibody according to the present disclosure is provided as PD-1
binding antibody fusion protein which comprises an immunoglobulin moiety, for example a Fab or Fab' fragment, and one or two single domain antibodies (dAb) linked directly or
30 indirectly thereto, for example as described in WO2009/040562.

In one embodiment the fusion protein comprises two domain antibodies, for example as a variable heavy (VH) and variable light (VL) pairing, optionally linked by a disulphide bond.

In one embodiment the Fab or Fab' element of the fusion protein has the same or similar specificity to the single domain antibody or antibodies. In one embodiment the Fab or Fab' has

a different specificity to the single domain antibody or antibodies, that is to say the fusion protein is multivalent. In one embodiment a multivalent fusion protein according to the present invention has an albumin binding site, for example a VH/VL pair therein provides an albumin binding site.

5 The constant region domains of the antibody molecule of the present invention, if present, may be selected having regard to the proposed function of the antibody molecule, and in particular the effector functions which may be required. For example, the constant region domains may be human IgA, IgD, IgE, IgG or IgM domains. In particular, human IgG constant region domains may be used, especially of the IgG1 and IgG3 isotypes when the antibody
10 molecule is intended for therapeutic uses and antibody effector functions are required. Alternatively, IgG2 and IgG4 isotypes may be used when the antibody molecule is intended for therapeutic purposes and antibody effector functions are not required, e.g. for simply agonising PD-1 activity. It will be appreciated that sequence variants of these constant region domains may also be used. For example IgG4 molecules in which the serine at position 241 has been
15 changed to proline as described in Angal *et al.*, *Molecular Immunology*, 1993, 30 (1), 105-108 may be used. It will also be understood by one skilled in the art that antibodies may undergo a variety of posttranslational modifications. The type and extent of these modifications often depends on the host cell line used to express the antibody as well as the culture conditions. Such modifications may include variations in glycosylation, methionine oxidation,
20 diketopiperazine formation, aspartate isomerization and asparagine deamidation. A frequent modification is the loss of a carboxy-terminal basic residue (such as lysine or arginine) due to the action of carboxypeptidases (as described in Harris, R.J. *Journal of Chromatography* 705:129-134, 1995). Accordingly, the C-terminal lysine of the antibody heavy chain given in Figure 7, SEQ ID NO: 27 may be absent.

25 In one embodiment the antibody heavy chain comprises a CH1 domain and the antibody light chain comprises a CL domain, either kappa or lambda.

 Examples of suitable sequences comprising constant domains are provided in SEQ ID NOs 19 and 27.

30 Biological molecules, such as antibodies or fragments, contain acidic and/or basic functional groups, thereby giving the molecule a net positive or negative charge. The amount of overall "observed" charge will depend on the absolute amino acid sequence of the entity, the local environment of the charged groups in the 3D structure and the environmental conditions of the molecule. The isoelectric point (pI) is the pH at which a particular molecule or solvent accessible surface thereof carries no net electrical charge. In one example, the PD-1 antibody

and fragments of the invention may be engineered to have an appropriate isoelectric point. This may lead to antibodies and/or fragments with more robust properties, in particular suitable solubility and/or stability profiles and/or improved purification characteristics.

Thus in one aspect the invention provides a humanised PD-1 antibody engineered to
5 have an isoelectric point different to that of the originally identified antibody 948. The antibody may, for example be engineered by replacing an amino acid residue such as replacing an acidic amino acid residue with one or more basic amino acid residues. Alternatively, basic amino acid residues may be introduced or acidic amino acid residues can be removed. Alternatively, if the molecule has an unacceptably high pI value acidic residues may be
10 introduced to lower the pI, as required. It is important that when manipulating the pI care must be taken to retain the desirable activity of the antibody or fragment. Thus in one embodiment the engineered antibody or fragment has the same or substantially the same activity as the “unmodified” antibody or fragment.

Programs such as ** ExPASy http://www.expasy.ch/tools/pi_tool.html, and
15 http://www.iut-arles.up.univ-mrs.fr/w3bb/d_abim/compo-p.html, may be used to predict the isoelectric point of the antibody or fragment.

It will be appreciated that the affinity of antibodies provided by the present invention may be altered using any suitable method known in the art. The affinity of the antibodies or variants thereof may be measured using any suitable method known in the art, including
20 BIAcore, using isolated natural or recombinant PD-1 or a suitable fusion protein/polypeptide. In one example affinity is measured using recombinant human PD-1 extracellular domain. In one example the recombinant human PD-1 extracellular domain used is a monomer. The present invention therefore also relates to variants of the antibody molecules of the present invention, which have an improved affinity for PD-1. Such variants can be obtained by a
25 number of affinity maturation protocols including mutating the CDRs (Yang *et al.*, J. Mol. Biol., 254, 392-403, 1995), chain shuffling (Marks *et al.*, Bio/Technology, 10, 779-783, 1992), use of mutator strains of *E. coli* (Low *et al.*, J. Mol. Biol., 250, 359-368, 1996), DNA shuffling (Patten *et al.*, Curr. Opin. Biotechnol., 8, 724-733, 1997), phage display (Thompson *et al.*, J. Mol. Biol., 256, 77-88, 1996) and sexual PCR (Cramer *et al.*, Nature, 391, 288-291, 1998).
30 Vaughan *et al.* (*supra*) discusses these methods of affinity maturation.

In one embodiment the antibody molecules of the present invention agonise human PD-1 activity. Assays suitable for determining the ability of an antibody to agonise PD-1 are known in the art.

If desired an antibody for use in the present invention may be conjugated to one or more effector molecule(s). It will be appreciated that the effector molecule may comprise a single effector molecule or two or more such molecules so linked as to form a single moiety that can be attached to the antibodies of the present invention. Where it is desired to obtain an antibody
5 fragment linked to an effector molecule, this may be prepared by standard chemical or recombinant DNA procedures in which the antibody fragment is linked either directly or via a coupling agent to the effector molecule. Techniques for conjugating such effector molecules to antibodies are well known in the art (see, Hellstrom *et al.*, Controlled Drug Delivery, 2nd Ed., Robinson *et al.*, eds., 1987, pp. 623-53; Thorpe *et al.*, 1982, Immunol. Rev., 62:119-58 and
10 Dubowchik *et al.*, 1999, Pharmacology and Therapeutics, 83, 67-123). Particular chemical procedures include, for example, those described in WO 93/06231, WO 92/22583, WO 89/00195, WO 89/01476 and WO03031581. Alternatively, where the effector molecule is a protein or polypeptide the linkage may be achieved using recombinant DNA procedures, for example as described in WO 86/01533 and EP0392745.

15 The term effector molecule as used herein includes, for example, antineoplastic agents, drugs, toxins, biologically active proteins, for example enzymes, other antibody or antibody fragments, synthetic or naturally occurring polymers, nucleic acids and fragments thereof e.g. DNA, RNA and fragments thereof, radionuclides, particularly radioiodide, radioisotopes, chelated metals, nanoparticles and reporter groups such as fluorescent compounds or
20 compounds which may be detected by NMR or ESR spectroscopy.

Examples of effector molecules may include cytotoxins or cytotoxic agents including any agent that is detrimental to (*e.g.* kills) cells. Examples include combrestatins, dolastatins, epothilones, staurosporin, maytansinoids, spongistatins, rhizoxin, halichondrins, roridins, hemiasterlins, taxol, cytochalasin B, gramicidin D, ethidium bromide, emetine, mitomycin,
25 etoposide, tenoposide, vincristine, vinblastine, colchicin, doxorubicin, daunorubicin, dihydroxy anthracin dione, mitoxantrone, mithramycin, actinomycin D, 1-dehydrotestosterone, glucocorticoids, procaine, tetracaine, lidocaine, propranolol, and puromycin and analogs or homologs thereof.

Effector molecules also include, but are not limited to, antimetabolites (*e.g.*
30 methotrexate, 6-mercaptopurine, 6-thioguanine, cytarabine, 5-fluorouracil decarbazine), alkylating agents (*e.g.* mechlorethamine, thioepa chlorambucil, melphalan, carmustine (BSNU) and lomustine (CCNU), cyclophosphamide, busulfan, dibromomannitol, streptozotocin, mitomycin C, and cis-dichlorodiamine platinum (II) (DDP) cisplatin), anthracyclines (*e.g.* daunorubicin (formerly daunomycin) and doxorubicin), antibiotics (*e.g.* dactinomycin (formerly

actinomycin), bleomycin, mithramycin, anthramycin (AMC), calicheamicins or duocarmycins), and anti-mitotic agents (e.g. vincristine and vinblastine).

Other effector molecules may include chelated radionuclides such as ^{111}In and ^{90}Y , Lu^{177} , Bismuth 213 , Californium 252 , Iridium 192 and Tungsten 188 /Rhenium 188 ; or drugs such as but not

5 limited to, alkylphosphocholines, topoisomerase I inhibitors, taxoids and suramin.

Other effector molecules include proteins, peptides and enzymes. Enzymes of interest include, but are not limited to, proteolytic enzymes, hydrolases, lyases, isomerases, transferases.

Proteins, polypeptides and peptides of interest include, but are not limited to, immunoglobulins, toxins such as abrin, ricin A, pseudomonas exotoxin, or diphtheria toxin, a protein such as

10 insulin, tumour necrosis factor, α -interferon, β -interferon, nerve growth factor, platelet derived growth factor or tissue plasminogen activator, a thrombotic agent or an anti-angiogenic agent,

e.g. angiostatin or endostatin, or, a biological response modifier such as a lymphokine,

interleukin-1 (IL-1), interleukin-2 (IL-2), granulocyte macrophage colony stimulating factor

(GM-CSF), granulocyte colony stimulating factor (G-CSF), nerve growth factor (NGF) or other

15 growth factor and immunoglobulins.

Other effector molecules may include detectable substances useful for example in diagnosis. Examples of detectable substances include various enzymes, prosthetic groups,

fluorescent materials, luminescent materials, bioluminescent materials, radioactive nuclides, positron emitting metals (for use in positron emission tomography), and nonradioactive

20 paramagnetic metal ions. See generally U.S. Patent No. 4,741,900 for metal ions which can be conjugated to antibodies for use as diagnostics. Suitable enzymes include horseradish

peroxidase, alkaline phosphatase, beta-galactosidase, or acetylcholinesterase; suitable prosthetic

groups include streptavidin, avidin and biotin; suitable fluorescent materials include

umbelliferone, fluorescein, fluorescein isothiocyanate, rhodamine, dichlorotriazinylamine

25 fluorescein, dansyl chloride and phycoerythrin; suitable luminescent materials include luminol;

suitable bioluminescent materials include luciferase, luciferin, and aequorin; and suitable

radioactive nuclides include ^{125}I , ^{131}I , ^{111}In and ^{99}Tc .

In another example the effector molecule may increase the half-life of the antibody *in vivo*, and/or reduce immunogenicity of the antibody and/or enhance the delivery of an antibody

30 across an epithelial barrier to the immune system. Examples of suitable effector molecules of this type include polymers, albumin, albumin binding proteins or albumin binding compounds such as those described in WO05/117984.

Where the effector molecule is a polymer it may, in general, be a synthetic or a naturally occurring polymer, for example an optionally substituted straight or branched chain

polyalkylene, polyalkenylene or polyoxyalkylene polymer or a branched or unbranched polysaccharide, e.g. a homo- or hetero- polysaccharide.

Specific optional substituents which may be present on the above-mentioned synthetic polymers include one or more hydroxy, methyl or methoxy groups.

5 Specific examples of synthetic polymers include optionally substituted straight or branched chain poly(ethyleneglycol), poly(propyleneglycol) poly(vinylalcohol) or derivatives thereof, especially optionally substituted poly(ethyleneglycol) such as methoxypoly(ethyleneglycol) or derivatives thereof.

10 Specific naturally occurring polymers include lactose, amylose, dextran, glycogen or derivatives thereof.

“Derivatives” as used herein is intended to include reactive derivatives, for example thiol-selective reactive groups such as maleimides and the like. The reactive group may be linked directly or through a linker segment to the polymer. It will be appreciated that the residue of such a group will in some instances form part of the product as the linking group
15 between the antibody fragment and the polymer.

The size of the polymer may be varied as desired, but will generally be in an average molecular weight range from 500Da to 50000Da, for example from 5000 to 40000Da such as from 20000 to 40000Da. The polymer size may in particular be selected on the basis of the intended use of the product for example ability to localize to certain tissues such as tumors or
20 extend circulating half-life (for review see Chapman, 2002, Advanced Drug Delivery Reviews, 54, 531-545). Thus, for example, where the product is intended to leave the circulation and penetrate tissue, for example for use in the treatment of a tumour, it may be advantageous to use a small molecular weight polymer, for example with a molecular weight of around 5000Da. For applications where the product remains in the circulation, it may be advantageous to use a
25 higher molecular weight polymer, for example having a molecular weight in the range from 20000Da to 40000Da.

Suitable polymers include a polyalkylene polymer, such as a poly(ethyleneglycol) or, especially, a methoxypoly(ethyleneglycol) or a derivative thereof, and especially with a molecular weight in the range from about 15000Da to about 40000Da.

30 In one example antibodies for use in the present invention are attached to poly(ethyleneglycol) (PEG) moieties. In one particular example the antibody is an antibody fragment and the PEG molecules may be attached through any available amino acid side-chain or terminal amino acid functional group located in the antibody fragment, for example any free amino, imino, thiol, hydroxyl or carboxyl group. Such amino acids may occur naturally in the

antibody fragment or may be engineered into the fragment using recombinant DNA methods (see for example US 5,219,996; US 5,667,425; WO98/25971, WO2008/038024). In one example the antibody molecule of the present invention is a modified Fab fragment wherein the modification is the addition to the C-terminal end of its heavy chain one or more amino acids to
5 allow the attachment of an effector molecule. Suitably, the additional amino acids form a modified hinge region containing one or more cysteine residues to which the effector molecule may be attached. Multiple sites can be used to attach two or more PEG molecules.

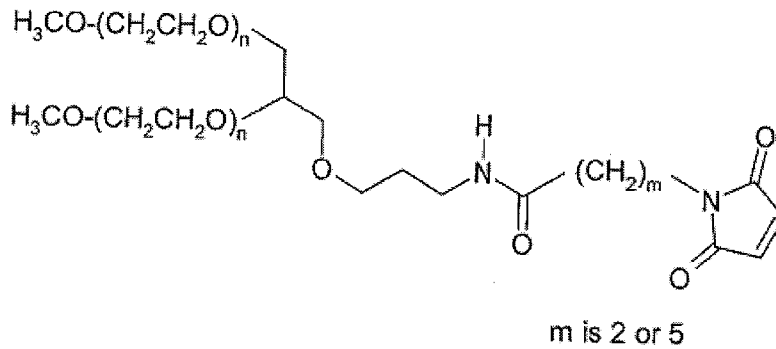
Suitably PEG molecules are covalently linked through a thiol group of at least one cysteine residue located in the antibody fragment. Each polymer molecule attached to the
10 modified antibody fragment may be covalently linked to the sulphur atom of a cysteine residue located in the fragment. The covalent linkage will generally be a disulphide bond or, in particular, a sulphur-carbon bond. Where a thiol group is used as the point of attachment appropriately activated effector molecules, for example thiol selective derivatives such as maleimides and cysteine derivatives may be used. An activated polymer may be used as the
15 starting material in the preparation of polymer-modified antibody fragments as described above. The activated polymer may be any polymer containing a thiol reactive group such as an α -halocarboxylic acid or ester, e.g. iodoacetamide, an imide, e.g. maleimide, a vinyl sulphone or a disulphide. Such starting materials may be obtained commercially (for example from Nektar, formerly Shearwater Polymers Inc., Huntsville, AL, USA) or may be prepared from
20 commercially available starting materials using conventional chemical procedures. Particular PEG molecules include 20K methoxy-PEG-amine (obtainable from Nektar, formerly Shearwater; Rapp Polymere; and SunBio) and M-PEG-SPA (obtainable from Nektar, formerly Shearwater).

In one embodiment, the antibody is a modified Fab fragment or diFab which is
25 PEGylated, *i.e.* has PEG (poly(ethyleneglycol)) covalently attached thereto, *e.g.* according to the method disclosed in EP 0948544 or EP1090037 [see also "Poly(ethyleneglycol) Chemistry, Biotechnical and Biomedical Applications", 1992, J. Milton Harris (ed), Plenum Press, New York, "Poly(ethyleneglycol) Chemistry and Biological Applications", 1997, J. Milton Harris and S. Zalipsky (eds), American Chemical Society, Washington DC and "Bioconjugation
30 Protein Coupling Techniques for the Biomedical Sciences", 1998, M. Aslam and A. Dent, Grove Publishers, New York; Chapman, A. 2002, Advanced Drug Delivery Reviews 2002, 54:531-545]. In one example PEG is attached to a cysteine in the hinge region. In one example, a PEG modified Fab fragment has a maleimide group covalently linked to a single thiol group in a modified hinge region. A lysine residue may be covalently linked to the

maleimide group and to each of the amine groups on the lysine residue may be attached a methoxypoly(ethyleneglycol) polymer having a molecular weight of approximately 20,000Da. The total molecular weight of the PEG attached to the Fab fragment may therefore be approximately 40,000Da.

5 Particular PEG molecules include 2-[3-(N-maleimido)propionamido]ethyl amide of N,N'-bis(methoxypoly(ethylene glycol) MW 20,000) modified lysine, also known as PEG2MAL40K (obtainable from Nektar, formerly Shearwater).

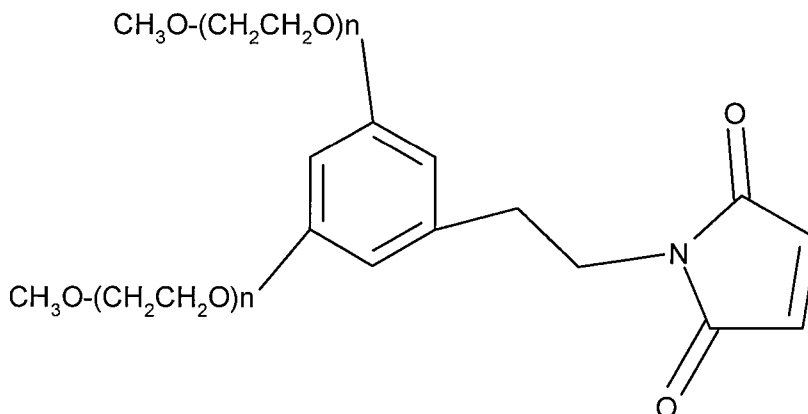
Alternative sources of PEG linkers include NOF who supply GL2-400MA2 (wherein m in the structure below is 5) and GL2-400MA (where m is 2) and n is approximately 450:



10

That is to say each PEG is about 20,000Da.

Further alternative PEG effector molecules of the following type:



15

20

25

are available from Dr Reddy, NOF and Jenkem.

In one embodiment there is provided an antibody which is PEGylated (for example with a PEG described herein), attached through a cysteine amino acid residue at or about amino acid 226 in the chain, for example amino acid 226 of the heavy chain (by sequential numbering).

The present invention also provides an isolated DNA sequence encoding the heavy and/or light chain(s) of an antibody molecule of the present invention. Suitably, the DNA sequence encodes the heavy or the light chain of an antibody molecule of the present invention.

The DNA sequence of the present invention may comprise synthetic DNA, for instance
5 produced by chemical processing, cDNA, genomic DNA or any combination thereof.
DNA sequences which encode an antibody molecule of the present invention can be obtained by methods well known to those skilled in the art. For example, DNA sequences coding for part or all of the antibody heavy and light chains may be synthesised as desired from the determined DNA sequences or on the basis of the corresponding amino acid sequences.

10 DNA coding for acceptor framework sequences is widely available to those skilled in the art and can be readily synthesised on the basis of their known amino acid sequences.

Standard techniques of molecular biology may be used to prepare DNA sequences coding for the antibody molecule of the present invention. Desired DNA sequences may be synthesised completely or in part using oligonucleotide synthesis techniques. Site-directed
15 mutagenesis and polymerase chain reaction (PCR) techniques may be used as appropriate.

Examples of suitable DNA sequences are provided in Figures 3-12, in particular SEQ ID NOs 16, 18, 20, 22, 24, 26, 28 and 30.

The present invention also relates to a cloning or expression vector comprising one or more DNA sequences of the present invention. Accordingly, provided is a cloning or
20 expression vector comprising one or more DNA sequences encoding an antibody of the present invention. Suitably, the cloning or expression vector comprises two DNA sequences, encoding the light chain and the heavy chain of the antibody molecule of the present invention, respectively and suitable signal sequences. In one example the vector comprises an intergenic sequence between the heavy and the light chains (see WO03/048208).

25 General methods by which the vectors may be constructed, transfection methods and culture methods are well known to those skilled in the art. In this respect, reference is made to "Current Protocols in Molecular Biology", 1999, F. M. Ausubel (ed), Wiley Interscience, New York and the Maniatis Manual produced by Cold Spring Harbor Publishing.

Also provided is a host cell comprising one or more cloning or expression vectors
30 comprising one or more DNA sequences encoding an antibody of the present invention. Any suitable host cell/vector system may be used for expression of the DNA sequences encoding the antibody molecule of the present invention. Bacterial, for example *E. coli*, and other microbial systems may be used or eukaryotic, for example mammalian, host cell expression systems may also be used. Suitable mammalian host cells include CHO, myeloma or hybridoma cells.

The present invention also provides a process for the production of an antibody molecule according to the present invention comprising culturing a host cell containing a vector of the present invention under conditions suitable for leading to expression of protein from DNA encoding the antibody molecule of the present invention, and isolating the antibody molecule.

The antibody molecule may comprise only a heavy or light chain polypeptide, in which case only a heavy chain or light chain polypeptide coding sequence needs to be used to transfect the host cells. For production of products comprising both heavy and light chains, the cell line may be transfected with two vectors, a first vector encoding a light chain polypeptide and a second vector encoding a heavy chain polypeptide. Alternatively, a single vector may be used, the vector including sequences encoding light chain and heavy chain polypeptides.

The antibodies and fragments according to the present disclosure are expressed at good levels from host cells. Thus the properties of the antibodies and/or fragments are optimised and conducive to commercial processing.

As the antibodies of the present invention are useful in the treatment and/or prophylaxis of a pathological condition, the present invention also provides a pharmaceutical or diagnostic composition comprising an antibody molecule of the present invention in combination with one or more of a pharmaceutically acceptable excipient, diluent or carrier. Accordingly, provided is the use of an antibody of the invention for the manufacture of a medicament. The composition will usually be supplied as part of a sterile, pharmaceutical composition that will normally include a pharmaceutically acceptable carrier. A pharmaceutical composition of the present invention may additionally comprise a pharmaceutically-acceptable adjuvant.

The present invention also provides a process for preparation of a pharmaceutical or diagnostic composition comprising adding and mixing the antibody molecule of the present invention together with one or more of a pharmaceutically acceptable excipient, diluent or carrier.

The antibody molecule may be the sole active ingredient in the pharmaceutical or diagnostic composition or may be accompanied by other active ingredients including other antibody ingredients, for example anti-TNF, anti-IL-1 β , anti-T cell, anti-IFN γ or anti-LPS antibodies, or non-antibody ingredients such as xanthines.

In a further embodiment the antibody, fragment or composition according to the disclosure is employed in combination with a further pharmaceutically active agent, for example a corticosteroid (such as fluticasone propionate) and/or a beta-2-agonist (such as salbutamol, salmeterol or formoterol) or inhibitors of cell growth and proliferation (such as

rapamycin, cyclophosphamide, methotrexate) or alternative a CD28 and /or CD40 inhibitor. In one embodiment the inhibitor is a small molecule. In another embodiment the inhibitor is an antibody specific to the target.

The pharmaceutical compositions suitably comprise a therapeutically effective amount of the antibody of the invention. The term “therapeutically effective amount” as used herein refers to an amount of a therapeutic agent needed to treat, ameliorate or prevent a targeted disease or condition, or to exhibit a detectable therapeutic or preventative effect. For any antibody, the therapeutically effective amount can be estimated initially either in cell culture assays or in animal models, usually in rodents, rabbits, dogs, pigs or primates. The animal model may also be used to determine the appropriate concentration range and route of administration. Such information can then be used to determine useful doses and routes for administration in humans.

The precise therapeutically effective amount for a human subject will depend upon the severity of the disease state, the general health of the subject, the age, weight and gender of the subject, diet, time and frequency of administration, drug combination(s), reaction sensitivities and tolerance/response to therapy. This amount can be determined by routine experimentation and is within the judgement of the clinician. Generally, a therapeutically effective amount will be from 0.01 mg/kg to 50 mg/kg, for example 0.1 mg/kg to 20 mg/kg. Pharmaceutical compositions may be conveniently presented in unit dose forms containing a predetermined amount of an active agent of the invention per dose.

Compositions may be administered individually to a patient or may be administered in combination (*e.g.* simultaneously, sequentially or separately) with other agents, drugs or hormones.

The dose at which the antibody molecule of the present invention is administered depends on the nature of the condition to be treated, the extent of the inflammation present and on whether the antibody molecule is being used prophylactically or to treat an existing condition.

The frequency of dose will depend on the half-life of the antibody molecule and the duration of its effect. If the antibody molecule has a short half-life (*e.g.* 2 to 10 hours) it may be necessary to give one or more doses per day. Alternatively, if the antibody molecule has a long half life (*e.g.* 2 to 15 days) it may only be necessary to give a dosage once per day, once per week or even once every 1 or 2 months.

The pharmaceutically acceptable carrier should not itself induce the production of antibodies harmful to the individual receiving the composition and should not be toxic. Suitable

carriers may be large, slowly metabolised macromolecules such as proteins, polypeptides, liposomes, polysaccharides, polylactic acids, polyglycolic acids, polymeric amino acids, amino acid copolymers and inactive virus particles.

Pharmaceutically acceptable salts can be used, for example mineral acid salts, such as hydrochlorides, hydrobromides, phosphates and sulphates, or salts of organic acids, such as acetates, propionates, malonates and benzoates.

Pharmaceutically acceptable carriers in therapeutic compositions may additionally contain liquids such as water, saline, glycerol and ethanol. Additionally, auxiliary substances, such as wetting or emulsifying agents or pH buffering substances, may be present in such compositions. Such carriers enable the pharmaceutical compositions to be formulated as tablets, pills, dragees, capsules, liquids, gels, syrups, slurries and suspensions, for ingestion by the patient.

Suitable forms for administration include forms suitable for parenteral administration, e.g. by injection or infusion, for example by bolus injection or continuous infusion. Where the product is for injection or infusion, it may take the form of a suspension, solution or emulsion in an oily or aqueous vehicle and it may contain formulatory agents, such as suspending, preservative, stabilising and/or dispersing agents. Alternatively, the antibody molecule may be in dry form, for reconstitution before use with an appropriate sterile liquid.

Once formulated, the compositions of the invention can be administered directly to the subject. The subjects to be treated can be animals. However, in one or more embodiments the compositions are adapted for administration to human subjects.

Suitably in formulations according to the present disclosure, the pH of the final formulation is not similar to the value of the isoelectric point of the antibody or fragment, for example if the pH of the formulation is 7 then a pI of from 8-9 or above may be appropriate. Whilst not wishing to be bound by theory it is thought that this may ultimately provide a final formulation with improved stability, for example the antibody or fragment remains in solution.

In one embodiment the pharmaceutical formulation at a pH in the range of 4.0 to 7.0 comprises: 1 to 200mg/mL of an antibody according to the present disclosure, 1 to 100mM of a buffer, 0.001 to 1% of a surfactant, a) 10 to 500mM of a stabiliser, b) 10 to 500mM of a stabiliser and 5 to 500 mM of a tonicity agent, or c) 5 to 500 mM of a tonicity agent.

For example the formulation at approximately pH6 may comprise 1 to 50mg/mL of antibody, 20mM L-histadine HCl, 240 mM trehalose and 0.02% polysorbate 20. Alternatively a formulation at approximately pH 5.5 may comprise 1 to 50mg/mL of antibody, 20mM citrate buffer, 240mM sucrose, 20mM arginine, and 0.02% polysorbate 20.

The pharmaceutical compositions of this invention may be administered by any number of routes including, but not limited to, oral, intravenous, intramuscular, intra-arterial, intramedullary, intrathecal, intraventricular, transdermal, transcutaneous (for example, see WO98/20734), subcutaneous, intraperitoneal, intranasal, enteral, topical, sublingual, 5 intravaginal or rectal routes. Hyposprays may also be used to administer the pharmaceutical compositions of the invention. Typically, the therapeutic compositions may be prepared as injectables, either as liquid solutions or suspensions. Solid forms suitable for solution in, or suspension in, liquid vehicles prior to injection may also be prepared.

Direct delivery of the compositions will generally be accomplished by injection, 10 subcutaneously, intraperitoneally, intravenously or intramuscularly, or delivered to the interstitial space of a tissue. The compositions can also be administered into a lesion. Dosage treatment may be a single dose schedule or a multiple dose schedule.

It will be appreciated that the active ingredient in the composition will be an antibody molecule. As such, it will be susceptible to degradation in the gastrointestinal tract. Thus, if 15 the composition is to be administered by a route using the gastrointestinal tract, the composition will need to contain agents which protect the antibody from degradation but which release the antibody once it has been absorbed from the gastrointestinal tract.

A thorough discussion of pharmaceutically acceptable carriers is available in Remington's Pharmaceutical Sciences (Mack Publishing Company, N.J. 1991).

20 In one embodiment the formulation is provided as a formulation for topical administrations including inhalation.

Suitable inhalable preparations include inhalable powders, metering aerosols containing propellant gases or inhalable solutions free from propellant gases. Inhalable powders according to the disclosure containing the active substance may consist solely of the abovementioned 25 active substances or of a mixture of the abovementioned active substances with physiologically acceptable excipient.

These inhalable powders may include monosaccharides (e.g. glucose or arabinose), disaccharides (e.g. lactose, saccharose, maltose), oligo- and polysaccharides (e.g. dextrans), polyalcohols (e.g. sorbitol, mannitol, xylitol), salts (e.g. sodium chloride, calcium carbonate) or 30 mixtures of these with one another. Mono- or disaccharides are suitably used, the use of lactose or glucose, particularly but not exclusively in the form of their hydrates.

Particles for deposition in the lung require a particle size less than 10 microns, such as 1-9 microns for example from 0.1 to 5 μm , in particular from 1 to 5 μm . The particle size of the active ingredient (such as the antibody or fragment) is of primary importance.

The propellant gases which can be used to prepare the inhalable aerosols are known in the art. Suitable propellant gases are selected from among hydrocarbons such as n-propane, n-butane or isobutane and halohydrocarbons such as chlorinated and/or fluorinated derivatives of methane, ethane, propane, butane, cyclopropane or cyclobutane. The abovementioned
5 propellant gases may be used on their own or in mixtures thereof.

Particularly suitable propellant gases are halogenated alkane derivatives selected from among TG 11, TG 12, TG 134a and TG227. Of the abovementioned halogenated hydrocarbons, TG134a (1,1,1,2-tetrafluoroethane) and TG227 (1,1,1,2,3,3,3-heptafluoropropane) and mixtures thereof are particularly suitable.

10 The propellant-gas-containing inhalable aerosols may also contain other ingredients such as cosolvents, stabilisers, surface-active agents (surfactants), antioxidants, lubricants and means for adjusting the pH. All these ingredients are known in the art.

The propellant-gas-containing inhalable aerosols according to the invention may contain up to 5 % by weight of active substance. Aerosols according to the invention contain, for
15 example, 0.002 to 5 % by weight, 0.01 to 3 % by weight, 0.015 to 2 % by weight, 0.1 to 2 % by weight, 0.5 to 2 % by weight or 0.5 to 1 % by weight of active ingredient.

Alternatively topical administrations to the lung may also be by administration of a liquid solution or suspension formulation, for example employing a device such as a nebulizer, for example, a nebulizer connected to a compressor (e.g., the Pari LC-Jet Plus(R) nebulizer
20 connected to a Pari Master(R) compressor manufactured by Pari Respiratory Equipment, Inc., Richmond, Va.).

The antibody of the invention can be delivered dispersed in a solvent, e.g., in the form of a solution or a suspension. It can be suspended in an appropriate physiological solution, e.g., saline or other pharmacologically acceptable solvent or a buffered solution. Buffered solutions
25 known in the art may contain 0.05 mg to 0.15 mg disodium edetate, 8.0 mg to 9.0 mg NaCl, 0.15 mg to 0.25 mg polysorbate, 0.25 mg to 0.30 mg anhydrous citric acid, and 0.45 mg to 0.55 mg sodium citrate per 1 ml of water so as to achieve a pH of about 4.0 to 5.0. A suspension can employ, for example, lyophilised antibody.

The therapeutic suspensions or solution formulations can also contain one or more
30 excipients. Excipients are well known in the art and include buffers (e.g., citrate buffer, phosphate buffer, acetate buffer and bicarbonate buffer), amino acids, urea, alcohols, ascorbic acid, phospholipids, proteins (e.g., serum albumin), EDTA, sodium chloride, liposomes, mannitol, sorbitol, and glycerol. Solutions or suspensions can be encapsulated in liposomes or

biodegradable microspheres. The formulation will generally be provided in a substantially sterile form employing sterile manufacture processes.

This may include production and sterilization by filtration of the buffered solvent/solution used for the formulation, aseptic suspension of the antibody in the sterile buffered solvent solution, and dispensing of the formulation into sterile receptacles by methods familiar to those of ordinary skill in the art.

Nebulizable formulation according to the present disclosure may be provided, for example, as single dose units (e.g., sealed plastic containers or vials) packed in foil envelopes. Each vial contains a unit dose in a volume, e.g., 2 mL, of solvent/solutionbuffer.

10 The antibodies disclosed herein may be suitable for delivery via nebulisation.

It is also envisaged that the antibody of the present invention may be administered by use of gene therapy. In order to achieve this, DNA sequences encoding the heavy and light chains of the antibody molecule under the control of appropriate DNA components are introduced into a patient such that the antibody chains are expressed from the DNA sequences and assembled *in situ*.

The present invention also provides an antibody molecule (or compositions comprising same) for use in the control of inflammatory diseases, for example acute or chronic inflammatory disease. Suitably, the antibody molecule (or compositions comprising same) can be used to reduce the inflammatory process or to prevent the inflammatory process. In one embodiment there is provided an *in vivo* reduction of activated T cells, in particular those involved in inappropriate inflammatory immune responses, for example recruited to the vicinity/location of such a response.

Reduction of activated T cells, as employed herein, may be a reduction, 10, 20, 30, 40, 50, 60, 70, 80, 90 or more percent in comparison to before treatment or without treatment. Advantageously, treatment with an antibody, fragment or composition according to the present invention, may allow the reduction in the level of activated T cells, without reducing the patients general level of T cells (unactivated T cells). This may result in fewer side effects, and possibly prevent T cell depletion in the patient.

30 The present invention also provides the antibody molecule of the present invention for use in the treatment or prophylaxis of an immune disorder. The immune disorder, may, for example be selected from the group consisting of infections (viral, bacterial, fungal and parasitic), endotoxic shock associated with infection, arthritis, rheumatoid arthritis, asthma, COPD, pelvic inflammatory disease, Alzheimer's Disease, inflammatory bowel disease, Crohn's disease, ulcerative colitis, Peyronie's Disease, coeliac disease, gallbladder disease,

Pilonidal disease, peritonitis, psoriasis, vasculitis, surgical adhesions, stroke, Type I Diabetes, lyme disease, arthritis, meningoen­cephalitis, autoimmune uveitis, immune mediated inflammatory disorders of the central and peripheral nervous system such as multiple sclerosis, lupus (such as systemic lupus erythematosus) and Guillain-Barr syndrome, Atopic dermatitis, 5 autoimmune hepatitis, fibrosing alveolitis, Grave's disease, IgA nephropathy, idiopathic thrombocytopenic purpura, Meniere's disease, pemphigus, primary biliary cirrhosis, sarcoidosis, scleroderma, Wegener's granulomatosis, other autoimmune disorders, pancreatitis, trauma (surgery), graft-versus-host disease, transplant rejection, heart disease including ischaemic diseases such as myocardial infarction as well as atherosclerosis, intravascular 10 coagulation, bone resorption, osteoporosis, osteoarthritis, periodontitis and hypochlorhydia or infertility related to loss of fetal-maternal tolerance.

In one embodiment the antibody according to the invention is employed in the treatment of allergy, COPD, autoimmune disease or rheumatoid arthritis.

The present invention also provides an antibody molecule according to the present 15 invention for use in the treatment or prophylaxis of pain, particularly pain associated with inflammation.

The present invention further provides the use of an antibody molecule, fragment or composition according to the present invention in the manufacture of a medicament for the treatment or prophylaxis of an immune disorder, in particular the immune disorder is 20 rheumatoid arthritis, asthma or COPD.

The present invention further provides the use of an antibody molecule, fragment or composition according to the present invention in the manufacture of a medicament for the treatment or prophylaxis of one or more medical indications described herein.

An antibody molecule, fragment or composition of the present invention may be utilised 25 in any therapy where it is desired to increase the effects of PD-1 in the human or animal body.

In one embodiment the antibody molecule of the present invention or a composition comprising the same is used for the control of inflammatory disease, e.g. as described herein.

The present invention also provides a method of treating human or animal subjects suffering from or at risk of an immune disorder, the method comprising administering to the 30 subject an effective amount of the antibody molecule of the present invention, or a composition comprising the same.

In one embodiment there is provided a process for purifying an antibody (in particular an antibody or fragment according to the invention) comprising the steps:

performing anion exchange chromatography in non-binding mode such that the impurities are retained on the column and the antibody is eluted.

Suitable ion exchange resins for use in the process include Q.FF resin (supplied by GE-Healthcare). The step may, for example be performed at a pH about 8.

5 The process may further comprise an initial capture step employing cation exchange chromatography, performed for example at a pH of about 4 to 5, such as 4.5. The cation exchange chromatography may, for example employ a resin such as CaptoS resin or SP sepharose FF (supplied by GE-Healthcare). The antibody or fragment can then be eluted from the resin employing an ionic salt solution such as sodium chloride, for example at a
10 concentration of 200mM.

Thus the chromatograph step or steps may include one or more washing steps, as appropriate.

The purification process may also comprise one or more filtration steps, such as a diafiltration step.

15 Thus in one embodiment there is provided a purified anti-PD-1 antibody or fragment, for example a humanised antibody or fragment, in particular an antibody or fragment according to the invention, in substantially purified form, in particular free or substantially free of endotoxin and/or host cell protein or DNA.

Purified form as used *supra* is intended to refer to at least 90% purity, such as 91, 92,
20 93, 94, 95, 96, 97, 98, 99% w/w or more pure.

Substantially free of endotoxin is generally intended to refer to an endotoxin content of 1 EU per mg antibody product or less such as 0.5 or 0.1 EU per mg product.

Substantially free of host cell protein or DNA is generally intended to refer to host cell protein and/or DNA content 400µg per mg of antibody product or less such as 100µg per mg or
25 less, in particular 20µg per mg, as appropriate.

The antibody molecule of the present invention may also be used in diagnosis, for example in the *in vivo* diagnosis and imaging of disease states involving PD-1.

Comprising in the context of the present specification is intended to meaning including.

Where technically appropriate embodiments of the invention may be combined.

30 Embodiments are described herein as comprising certain features/elements. The disclosure also extends to separate embodiments consisting or consisting essentially of said features/elements.

The present invention is further described by way of illustration only in the following examples, which refer to the accompanying Figures, in which:

Figure 1 in detail:

CDRH1 (SEQ ID NO:1), CDRH2 (SEQ ID NO:2), CDRH3 (SEQ ID NO:3), CDRL1 (SEQ ID NO:4), CDRL2 (SEQ ID NO:5), CDRL3 (SEQ ID NO:6) of antibody 948

Light chain V region of antibody 948 (SEQ ID NO:7)

5 Light chain V region DNA of antibody 948 (SEQ ID NO:8)

Light chain V region with signal sequence of antibody 948 (SEQ ID NO:9)

Figure 2

Light chain V region DNA with signal sequence of antibody 948 (SEQ ID NO:10)

10 Mouse Ab948 VH region (SEQ ID NO:11)

Mouse Ab948 VH region DNA (SEQ ID NO:12)

Mouse Ab948 VH region with signal sequence (SEQ ID NO:13)

Figure 3

15 Mouse Ab948 VH region DNA with signal sequence (SEQ ID NO:14)

948 VL gL1 V region (SEQ ID NO:15)

948 VL gL1 V region DNA (SEQ ID NO:16)

948 VL gL1 V region with signal sequence (SEQ ID NO:17)

20 Figure 4

948 VL gL1 V region DNA with signal sequence (SEQ ID NO:18)

948 VL gL1 light chain V + constant (SEQ ID NO:19)

Figure 5

25 948 VL gL1 light chain V + constant DNA (SEQ ID NO:20)

948 VL gL1 light chain V + constant with signal sequence (SEQ ID NO:21)

Figure 6

948 VL gL1 light chain V + constant with signal sequence (SEQ ID NO:22)

30 948 VH g1 (SEQ ID NO:23)

948 VH g1 DNA (SEQ ID NO:24)

Figure 7

35 948 VH g1 with signal sequence (SEQ ID NO:25)

948 VH g1 with signal sequence DNA (SEQ ID NO:26)

948 VH g1 and constant domain (SEQ ID NO:27)

Figure 8

40 948 VH g1 and constant domain DNA (SEQ ID NO:28)

Figure 9

948 VH g1 and constant domain and signal sequence (SEQ ID NO:29)

Figure 10

5 948 VH g1 and constant domain and signal sequence DNA (SEQ ID NO:30)

Figure 11

Human VK2 4-1-(1) A18 JK2 acceptor framework (SEQ ID NO:31)

Human VK2 4-1-(1) A18 JK2 acceptor framework DNA (SEQ ID NO:32)

10 Human VH4 3-1 4-30.4 JH4 acceptor framework (SEQ ID NO:33)

Human VH4 3-1 4-30.4 JH4 acceptor framework (SEQ ID NO:34)

Figure 12 Comparison of 948 chimeric and humanised grafts binding to cell expressed human PD-1. Binding of the indicated concentrations of 948 grafts to HEK293 cells transfected with human full-length PD-1 was measured by flow cytometry. Data is presented as geomean of PD-1 antibody associated fluorescence.

Figure 13 shows an alignment of the light chains for the murine, acceptor frameworks and humanised light chains and an alignment of the heavy chains for the murine, acceptor frameworks and humanised heavy chains. CDRs are in bold and underlined. Donor residues are in bold, italic and are highlighted.

EXAMPLES

25

EXAMPLE 1—METHODS FOR GENERATION OF ANTI-PD-1 ANTIBODY CLONE 10

The generation of antibody clone 10 has already been described in international application PCT/IB2009/006946 (unpublished).

30

1.1 Myeloma cell line

For fusion the myeloma cell line SP2/0-Ag14 from the German Collection of Microorganisms and Cell Cultures (DSMZ GmbH, Braunschweig) was used. This cell line is a hybrid between BALB/c spleen cells and the myeloma cell line P3x63Ag8. The cells have been described as not synthesizing or secreting immunoglobulin chains, being resistant to 8-azaguanine at 20 µg/ml, and not growing in HAT (Hypoxanthine, Aminopterin, Thymidine) medium. The SP2/0 cells are routinely maintained in tissue culture flasks in standard growth

medium (with 10% FCS). A new aliquot of frozen SP2/0 cells was used after a period of 2 weeks in order to avoid the implementation of HGPRT-positive revertants. The myeloma cells were shown to be negative in all mycoplasma tests.

5 1.2 Antigen for immunization and screening

The recombinant protein PD-1Fc was prepared using the methods described for the production of CD28Fc (Evans *et al. Nat Immunol.* 6, 271-9 (2005)) and concentrated to 5.1 mg/ml in 0.01 M HEPES, 150 mM NaCl, pH 7.4. SDS-PAGE analysis of the antigen run under reducing and non-reducing conditions established the purity of the protein to be >95%.

10

1.3 Immunization

Five mice (about 8 weeks old) were immunized *via* the intraperitoneal cavity using an immunization protocol over 60 days. For immunization an alum precipitate of the immunogen was prepared. The alum precipitate was freshly prepared for each boost. The mice were
15 immunized with 50 µg protein and boosted with 25 µg protein. Three mice were used for fusion.

1.4 General handling of cells

Cells were handled under sterile conditions using a laminar air-flow system, sterile
20 materials and sterile solutions. Cells were incubated at 37°C in a humid atmosphere containing 5% carbon dioxide. For cultivation of the hybridoma cells a complete growth medium (CGM) containing DMEM with supplements 2-mercaptoethanol, L-Glutamine, GlutaMax, HT, non essential amino acids, sodium pyruvate, antibiotics/antimycotic solution (in concentrations recommended by the supplier) and FCS at different concentrations (10%, 15% or 20%) was
25 used.

1.5 Preparation of spleen cells and cell fusions

After asphyxiation of the three immunized mice in CO₂ spleens were aseptically removed. A single cell suspension of pooled spleens was prepared. The spleen cells and the
30 myeloma cells were washed several times with DMEM and fused twice in the presence of 1 ml 50% (w/v) PEG 3550 (ratio spleen cells to SP2/0 2.5:1 and 2.4:1). The hybridomas produced were resuspended in CGM containing 20% FCS and aminopterin (HAT medium). The cell suspension (140 Cl/well) of each fusion was plated out into eight 96-well tissue culture flat-bottom plates (Corning-Costar) containing 140 Cl/well peritoneal exudate cells as feeder cells

in CGM with 20% FCS. The plates were incubated for 10 days. During this period cells were fed two times with HAT medium. An aliquot of the spleen cell preparation (about 8×10^6 spleen cells) was cultivated 10 days in a well of a 24-well plate and the cell culture supernatant served as positive control in ELISA.

5

1.6 Screening assay

An ELISA was used for screening of IgG in cell culture supernatants. 96 well flat-bottom polystyrene microtiter plates (Greiner, Cat. No 655061) were coated with 50 μ l/well PD-1Fc antigen (5 μ g/ml) in 0.5 M carbonate/bicarbonate buffer, pH 9.6. After incubation overnight in a moist chamber at 4°C the plates were washed with tris-buffered saline (TBS, 50 mM Tris, pH 7.8, 500 mM sodium chloride) containing 0.01% Triton X-100 (washing buffer) and blocked with 200 μ l/well 2% FCS in TBS (blocking buffer) for 1 hour at room temperature (RT) on a shaker. The wells were washed with washing buffer and 100 μ l cell culture supernatant was added in the appropriate well. Cell culture supernatant from SP 2/0 myeloma cells was used as a negative control. As positive control cell culture supernatant from spleen cell culture was used. The plates were incubated on a shaker for 1 h at RT, followed by several washes. For detection of bound antibodies plates were incubated with 50 μ l/well goat anti-mouse IgG (Fab specific) conjugated to alkaline phosphatase (1:5000) in blocking buffer for 1 h at RT on a shaker, followed by several washes and addition of 150 μ l/well substrate buffer (2 mM 4-nitrophenyl phosphate in 5% diethanolamine + 0.5 mM $MgCl_2$, pH 9.8). The optical density (OD) was estimated in a 12-channel Dynex Opsys MR microplate reader at 405 nm. Wells with OD_{405nm} 2-fold higher than the OD_{405nm} of the average plate value were selected as positive.

25 1.7 Selection of stable antibody producers

Cells from positive IgG producing cultures were transferred into wells of a 48-well plate and cultivated for several days (depending on the growth characteristics of the cells). An ELISA on PD-1Fc and without precoated antigen in order to select the specific binders was carried out. The cells from ELISA-positive wells were frozen in freezing medium (90 % FCS, 10 % DMSO). An aliquot of the cells was further cultivated for production of cell culture supernatants for further characterization.

30

1.8 Limiting dilution cloning

As soon as positive wells were identified, hybridoma cells were cloned to reduce the risk of overgrowth by non-producing cells (first cloning). To ensure that the antibodies are truly monoclonal the hybridomas were cloned again (second cloning). The method of limiting dilution was used for both cloning procedures. IgG producing cells were distributed into one 96 well plate containing feeder cells at a density of 1-3 cells per well. After 8-10 days (depending on growth characteristics) all plates were visually inspected under the microscope for detection of monoclonal growth. Culture supernatants from such wells were screened for specific immunoglobulin content using the above-described screening assay. The appropriate clones concerning growth characteristic and ELISA signal were selected, transferred into wells of a 24- well plate and cultivated for some days. A screening assay was performed. This procedure was repeated two to three times. The appropriate subclone was selected respectively for the second cloning procedure or cultivation for cryopreservation. This procedure resulted in the production of an anti-PD-1 antibody known as Clone 10.

1.9 Preparation and isotyping of antibodies

Hybridoma supernatant was prepared and diluted into sterile, azide-free PBS. Purified stocks of monoclonal antibodies were isotyped at 1 µg/ml in PBS using the IsoStrip Mouse Monoclonal Antibody Isotyping Kit (Santa Cruz; sc-24958). Clone 10 was found to be isotype IgG_{1K}.

1.10 Sequencing of Clone 10

The genes encoding clone 10 were cloned and sequenced and are provided in Figure 1. This antibody was named antibody CA051_00948 (often abbreviated to 948).

EXAMPLE 2: Humanisation of antibody CA051_00948

Antibody CA051_00948 was humanised by grafting the complementarity determining regions (CDRs) from the mouse antibody V-regions onto human germline antibody V-region frameworks. In order to recover the activity of the antibody, a number of framework residues from the mouse V-regions were also retained in the humanised sequence. These residues were selected using the protocol outlined by Adair et al. (1991) (Humanised antibodies. WO91/09967). Alignments of the mouse antibody (donor) V-region sequences with the human germline antibody (acceptor) V-region sequences are shown in Figure 13, together with the designed humanised sequence.

The CDRs grafted from the donor to the acceptor sequence are as defined by Kabat (Kabat *et al.* Sequence of proteins of immunological interest (1987). Bethesda MD, National Institutes of Health, US), with the exception of CDR-H1 where the combined Chothia/Kabat definition is used (see Adair *et al.* (1991) Humanised antibodies. WO91/09967).

5 Human V-region VH4 3-1 4-30.4 plus JH4 J-region (V BASE, <http://vbase.mrc-cpe.cam.ac.uk/>) was chosen as the acceptor for the heavy chain CDRs. The heavy chain framework residues are all from the human germline gene, with the exception of residues 25, 44, 48 and 71 (Kabat numbering), where the donor residues Threonine (T25), Lysine (K44), Methionine (M48) and Arginine (R71) were retained, respectively. The Glutamine residue at position 1 of the human
10 framework was replaced with Glutamic acid (E1) to afford the expression and purification of a homogeneous product: the conversion of Glutamine to pyroGlutamate at the N-terminus of antibodies and antibody fragments is widely reported.

Human V-region VK2 4-1-(1) A18 plus JK2 J-region (V BASE, <http://vbase.mrc-cpe.cam.ac.uk/>) was chosen as the acceptor for the light chain CDRs. The light chain
15 framework residues are all from the human germline gene, with the exception of residues 2, 3, 45, 62 and 87 (Kabat numbering), where the donor residues Valine (V2), Leucine (L3), Lysine (K44), Isoleucine (I62) and Phenylalanine (F87) were retained, respectively.

Genes encoding the 948.g1 light and heavy chain V-region sequences were designed and constructed by an automated synthesis approach by Entelechon GmbH. The 948.g1 light chain
20 V-region gene sequence was cloned into the UCB-Celltech human light chain expression vector pKH10.1, which contains DNA encoding the human Kappa chain constant region (Km3 allotype). The 948.g1 heavy chain V-region gene sequence was cloned into the UCB-Celltech human gamma-4 heavy chain expression vector pVhγ4P FL, which contains DNA encoding the human gamma-4 heavy chain constant region with the hinge stabilising mutation S241P (Angal
25 *et al.*, Mol Immunol. 1993, 30(1):105-8). Transient co-transfection of light and heavy chain vectors into HEK293 suspension cells was achieved using 293 Fectin (12347-019 Invitrogen), and gave expression of the recombinant antibody, 948.g1.

The sequences are provided in figures 3-11 and in Figure 13.

Summary of Ab948 residues for humanization**Light chain**

	<u>Kabat position</u>	<u>Human residue to replace donor</u>
5		
	4	Isoleucine
	5	Valine
	46	Glutamine
	63	Phenylalanine
10	88	Tyrosine

Heavy chain

	<u>Kabat position</u>	<u>Human residue to replace donor</u>
15	26	Serine
	45	Glycine
	49	Isoleucine
	71	Valine

20 OR

Light chain

	<u>Kabat position</u>	<u>Human residue to replace donor</u>
25	2	Isoleucine
	3	Valine
	45	Glutamine
	62	Phenylalanine
	87	Tyrosine

30 **Heavy chain**

	<u>Kabat position</u>	<u>Human residue to replace donor</u>
35	25	Serine
	44	Glycine
	48	Isoleucine
	71	Valine

Example 3

40 Characterisation of the Humanised antibodies generated in Example 2

3.1 Flow cytometry analysis of antibody 948 chimeric and 948 humanised graft binding to cell-expressed human PD-1

In order to determine if humanising antibody 948 had changed its ability to bind PD-1, a binding comparison was performed of 948 (murine parental), 948 chimeric and the 948 humanised graft on HEK293 cells expressing human PD-1.

Method

HEK293 cells were transiently transfected by culturing at 5×10^6 /well with 5 μ g human PD-1 DNA and 293fectin (Invitrogen) overnight in 6 well plates. The following day PD-1 expressing HEK293 cells were incubated for 1hr at 4°C with the stated concentrations of 948 chimeric, 948 humanised graft, 948 chimeric (purified) or 948 murine parental (purified) antibodies. Cells were washed with PBS and incubated with an appropriate secondary antibody, either FITC Mouse anti Human IgG (05-4211 Zymed, 1:20 dilution) or rat anti Mouse IgG (04-6111 Zymed, 1:20 dilution) for 1hr at 4°C. Flow cytometry analysis was performed on a FACSCalibur (Becton Dickinson).

Results

The flow cytometry binding curves shown in Figure 12 demonstrate that all versions of antibody 948 bound specifically to cell-expressed PD-1 and that the humanised graft of 948 bound human PD-1 with equal or greater efficiency to the parental and chimeric versions of the antibody.

It will of course be understood that the present invention has been described by way of example only, is in no way meant to be limiting, and that modifications of detail can be made within the scope of the claims hereinafter. Preferred features of each embodiment of the invention are as for each of the other embodiments *mutatis mutandis*. All publications, including but not limited to patents and patent applications, cited in this specification are herein incorporated by reference as if each individual publication were specifically and individually indicated to be incorporated by reference herein as though fully set forth.

CLAIMS

1. A humanised agonistic antibody which binds human PD-1 comprising a heavy chain wherein the variable domain of the heavy chain comprises the sequence given in SEQ ID NO:1 for CDR-H1, the sequence given in SEQ ID NO:2 for CDR-H2 and the sequence given in SEQ
5 ID NO:3 for CDR-H3 and the heavy chain framework region is derived from human sub-group sequence VH4 3-1 4-30.4 + JH4 (SEQ ID NO: 33)
2. A humanised antibody according to claim 1 wherein the residue at at least one of positions 25, 44, 48 and 71 of the variable domain of the heavy chain is a donor residue.
3. A humanised antibody according to claim 2 having the heavy chain variable domain
10 sequence given in SEQ ID NO:23.
4. A humanised agonistic antibody which binds human PD-1 comprising a light chain wherein the variable domain of the light chain comprises the sequence given in SEQ ID NO:4 for CDR-L1, the sequence given in SEQ ID NO:5 for CDR-L2 and the sequence given in SEQ
15 ID NO:6 for CDR-L3 and the light chain framework region is derived from human sub-group sequence VK2 4-1-1 A18 + JK2 (SEQ ID NO:31)
5. A humanised antibody according to claim 4 wherein the residue at at least one of positions 2, 3, 45, 62, and 87 of the variable domain of the light chain is a donor residue.
6. A humanised antibody according to claim 5 having the light chain variable domain sequence given in SEQ ID NO:15.
- 20 7. A humanised agonistic antibody which binds human PD-1 having a heavy chain comprising a sequence given in SEQ ID NO:23 and a light chain comprising a sequence given in SEQ ID NO:15.
8. An agonistic antibody molecule according to any one of claims 1 to 7, wherein the antibody molecule is selected from the group consisting of: a complete antibody molecule
25 having full length heavy and light chains or a fragment thereof, such as a Fab, modified Fab', Fab', F(ab')₂, Fv, VH, VL or scFv fragment.
9. A humanised agonistic antibody which binds human PD-1, wherein the variable domain of the light chain comprises a sequence having at least 80% identity or similarity to the light chain variable domain of the antibody of claim 7 and wherein the variable domain of the heavy chain
30 comprises a sequence having at least 80% identity or similarity to the heavy chain variable domain of the antibody of claim 7.
10. An isolated DNA sequence encoding the heavy and/or light chain(s) of an antibody according to any one of claims 1 to 9.

11. A cloning or expression vector comprising one or more DNA sequences according to claim 10.
12. A host cell comprising one or more cloning or expression vectors according to claim 11.
13. A process for the production of the antibody of any one of claims 1 to 9, comprising
5 culturing the host cell of claim 12 and isolating the antibody.
14. A pharmaceutical composition comprising an antibody according to any one of claims 1 to 9, in combination with one or more of a pharmaceutically acceptable excipient, diluent or carrier.
15. A pharmaceutical composition according to claim 14, additionally comprising other active
10 ingredients.
16. An antibody according to any one of claims 1 to 9 or a pharmaceutical composition according to claim 14 or claim 15, for use in the treatment or prophylaxis of an immune disorder.
17. The use of an antibody according to any one of claims 1 to 9 in the manufacture of a
15 medicament for the treatment or prophylaxis of an immune disorder.

Figure 1

CDRH1 GYSITSDYAWN (SEQ ID NO:1)

CDRH2 YINYSGSTSYNPSLKS (SEQ ID NO:2)

CDRH3 WIGSSAWYFDV (SEQ ID NO:3)

CDRL1 RSGQNIVHSNGNTYLE (SEQ ID NO:4)

CDRL2 KVSNRFF (SEQ ID NO:5)

CDRL3 FQGSHVPFT (SEQ ID NO:6)

Mouse Ab 948 VL region (SEQ ID NO:7)

DVLMTQTPLS LPVSLGDQAS ISCRSGQNIV HSNNGNTYLEW YLQKPGQSPK
LLIYKVSNRF FGVDPDRISGS GSGTDFTLKI SRVEAEDLGV YFCFQGSHVP
FTFGSGTKLE IK

Mouse Ab 948 VL region ((SEQ ID NO:8)

gatgttttga tgacccaaac tccactctcc ctgcctgtca gtcttggaga
tcaagcctcc atctcttgca gatctgggtca gaacattgta catagtaatg
gaaacaccta tttagaatgg tacctacaga aaccaggcca gtctccaaag
ctcctgatct acaaagtctc caaccgattt tttgggggtcc cagacaggat
cagtggcagt ggatcagga cagatttcac actcaagatc agcagagtgg
aggctgagga tctgggagtt tatttctgct ttcaagggtc acatgttcca
ttcacgttcg gctcggggac aaagctggaa ataaaa

Mouse Ab 948 VL region with signal sequence underlined and italicised (SEQ ID NO:9)

MKLPVRLLVL *MFWIPASSSD* VLMTQTPLSL PVSLGDQASI SCRSGQNIVH
SNGNTYLEWY LQKPGQSPKL LIYKVSNRFF GVPDRISGS GSGTDFTLKIS
RVEAEDLGVY FCFQGSHVPF TFGSGTKLEI K

Figure 2

Mouse Ab 948 VL region with signal sequence underlined and italicised (SEQ ID NO:10)

atgaagttgc ctgtaggct gttggtgctg atgttctgga ttcctgcttc
cagcagtgat gttttgatga cccaaactcc actctccctg cctgtcagtc
 ttggagatca agcctccatc tcttgcagat ctggtcagaa cattgtacat
 agtaatggaa acacctattht agaatggtac ctacagaaac caggccagtc
 tccaaagctc ctgatctaca aagtctccaa ccgatttttt ggggtcccag
 acaggatcag tggcagtgga tcaggacag atttcacact caagatcagc
 agagtggagg ctgaggatct gggagtttat ttctgctttc aaggttcaca
 tgttccattc acgttcggct cggggacaaa gctggaaata aaa

Mouse Ab 948 VH region (SEQ ID NO:11)

DVQLQESGPG LVKPSQSLSL TCTVTGYSIT SDYAWNWIRO FPGNKLEWVG
 YINYSGSTSY NPSLKSRSI TRDTSKNQFF LQLNSVTTED TATYYCARWI
 GSSAWYFDVW GAGTTVTVS

Mouse Ab 948 VH region (SEQ ID NO:12)

gatgtgcagc ttcaggagtc gggacctggc ctggtgaaac cttctcagtc
 tctgtccctc acctgcactg tcaactggta ctcaatcacc agtgattatg
 cctggaactg gatccggcag tttccaggaa acaaactgga gtggatgggc
 tacataaact acagtggtag cactagctac aaccatctc tcaaaagtcg
 aatctctatc acccgagaca catccaagaa ccagttcttc ctgcagttga
 attctgtgac tactgaggac acagccacat attactgtgc aagatggatc
 ggtagtagcg cctggactt cgatgtctgg ggcgcaggga ccacggtcac agtctcg

Mouse Ab 948 VH region with signal sequence underlined and italicised (SEQ ID NO:13)

MRVLILLWLF TAFPGILSDV QLQESGGLV KPSQSLSLTC TVTGYSITSD
 YAWNWIROFP GNKLEWVGVI NYSGSTSYNP SLKSRSITR DTSKNQFFLQ
 LNSVTTEDTA TYYCARWIGS SAWYFDVWGA GTTVTVS

Figure 3

Mouse Ab 948 VH region with signal sequence underlined and italicised (SEQ ID NO:14)

atgagagtgc tgattctttt gtggctgttc acagcctttc ctggtatcct
gtctgatgtg cagcttcagg agtcgggacc tggcctgggtg aaaccttctc
 agtctctgtc cctcacctgc actgtcactg gctactcaat caccagtgat
 tatgcctgga actggatccg gcagtttcca ggaaacaaac tggagtggat
 gggctacata aactacagtg gtagcactag ctacaacca tctctcaaaa
 gtcgaatctc taccaccga gacacatcca agaaccagtt cttcctgcag
 ttgaattctg tgactactga ggacacagcc acatattact gtgcaagatg
 gatcggtagt agcgcctggg acttcgatgt ctggggcgca gggaccacgg
 tcacagtctc g

948.g1 VL (SEQ ID NO:15)

DVLMTQTPLS LSVTPGQPAS ISCRSGQNIV HSNNGNTYLEW YLQKPGQSPK
 LLIYKVS NRF FGVPDRISGS GSGTDFTLKI SRVEAEDVGV YFCFQGSHPV
 FTFGQGTKLE IK

948.g1 VL (SEQ ID NO:16)

gacgtgctga tgaccagac acccctgtca cttagcgtga ctccctggcca
 acctgcctca atttcctgtc gctccggtea gaatatcgtg cactctaacg
 ggaacaccta cttggagtgg tatctcaaaa agcctggcca gagcccaaag
 ctgctgatct acaaggctct caatcggttc tttggcgtgc ctgacagaat
 tagtggtagc ggatccggaa ctgacttcac cctgaaaatc tcacgggtgg
 aagctgaaga tgtcggcgtg tatttctgct tccaaggctc ccacgttccc
 tttacgtttg gacagggcac caaactggag ataaag

948.g1 VL with signal sequence underlined and italicised (SEQ ID NO:17)

MSVPTQVLGL LLLWLT DARC DVLMTQTPLS LSVTPGQPAS ISCRSGQNIV
 HSNNGNTYLEW YLQKPGQSPK LLIYKVS NRF FGVPDRISGS GSGTDFTLKI
 SRVEAEDVGV YFCFQGSHPV FTFGQGTKLE IK

Figure 4

948.g1 VL with signal sequence underlined and italicised (SEQ ID NO:18)

atgagcgtcc caacacaagt tcttgggctc cttctgctct ggcttactga
tgcaagatgc gacgtgctga tgacccagac acccctgtca cttagcgtga
ctcctggcca acctgcctca atttcctgtc gctccgggtca gaatcctgtg
cactctaacg ggaacaccta cttggagtgg tatctccaaa agcctggcca
gagcccaaag ctgctgatct acaaggtctc caatcgggtc tttggcgtgc
ctgacagaat tagtggtagc ggatccggaa ctgacttcac cctgaaaatc
tcacgggtgg aagctgaaga tgcggcgtg tatttctgct tccaaggctc
ccacgttccc tttacgtttg gacagggcac caaactggag ataaag

948.g1 light chain (V + constant) (SEQ ID NO:19)

DVLMQTPLS LSVTPGQPAS ISCRSGQNIV HSNNGNTYLEW YLQKPGQSPK
LLIYKVS NRF FGVPDRISGS GSGTDFTLKI SRVEAEDVGV YFCFQGSHPV
FTFGQGTKLE IKRTVAAPSV FIFPPSDEQL KSGTASVVCL LNNFYPREAK
VQWKVDNALQ SGNSQESVTE QDSKDYSTYSL SSTLTLSKAD YEKHKVYACE
VTHQGLSSPV TKSFNRGEC

Figure 5

948.g1 light chain (V + constant) (SEQ ID NO:20)

gacgtgctga tgacccagac acccctgtca cttagecgtga ctccctggcca
acctgcctca atttcctgtc gctccgggtca gaatatcgtg cactctaacg
ggaacaccta cttggagtgg tatctccaaa agcctggcca gagcccaaag
ctgctgatct acaaggtctc caatcgggtc tttggcgtgc ctgacagaat
tagtggtagc ggatccggaa ctgacttcac cctgaaaatc tcacgggtgg
aagctgaaga tgtcggcgtg tatttctgct tocaaggctc ccacgttccc
tttacgtttg gacagggcac caaactggag ataaagcgta cggtagcggc
cccatctgtc ttcattctcc cgccatctga tgagcagttg aaatctggaa
ctgcctctgt tgtgtgcctg ctgaataact tctatcccag agaggccaaa
gtacagtgga aggtggataa cgccctccaa tcgggtaact cccaggagag
tgtcacagag caggacagca aggacagcac ctacagcctc agcagcacc
tgacgctgag caaagcagac tacgagaaac acaaagtcta cgccctgcgaa
gtcacccatc agggcctgag ctcgcccgtc acaaagagct tcaacagggg agagtgt

948.g1 light chain with signal sequence underlined and italicised (SEQ ID NO:21)

*MSVPTQVLGL LLLWLT**DARC* DVLMTQTPLS LSVTPGQPAS ISCRSGQNIV
HNSGNTYLEW YLQKPGQSPK LLIYKVSNRF FGVDPDRISGS GSGTDFTLKI
SRVEAEDVGV YFCFQGSHPV FTFGQGTKLE IKRTVAAPSV FIFPPSDEQL
KSGTASVVCL LNNFYPREAK VQWKVDNALQ SGNSQESVTE QDSKDSTYSL
SSTLTLSKAD YEKHKVYACE VTHQGLSSPV TKSFNREGC

Figure 6

948.g1 light chain with signal sequence underlined and italicised (SEQ ID NO:22)

atgagcgtcc caacacaagt tcttgggctc cttctgctct ggcttactga
tgcaagatgc gacgtgctga tgaccagac acccctgtca cttagecgtga
ctcctggcca acctgcctca atttcctgtc gctccgggtca gaataticgtg
cactctaacg ggaacaccta cttggagtgg tatctccaaa agcctggcca
gagcccaaag ctgctgatct acaaggctct caatcgggtc tttggcgtgc
ctgacagaat tagtggtagc ggatccggaa ctgacttcac cctgaaaatc
tcacgggtgg aagctgaaga tgtcggcgtg tatttctgct tccaaggctc
ccacgttccc tttacgtttg gacagggcac caaactggag ataaagcgtg
cggtagcggc cccatctgct ttcattctcc cgccatctga tgagcagttg
aaatctggaa ctgcctctgt tgtgtgctg ctgaataact tctatcccag
agaggccaaa gtacagtgga aggtggataa cgccctccaa tcgggtaact
cccaggagag tgtcacagag caggacagca aggacagcac ctacagcctc
agcagcacc tgacgctgag caaagcagac tacgagaaac acaaagtcta
cgctgcgaa gtcaccatc agggcctgag ctcgcccgtc acaaagagct
tcaacagggg agagtgt

948.g1 VH (SEQ ID NO:23)

EVQLQESGPG LVKPSQTLST TCTVTGYSIT SDYAWNWIRO PPGKKLEWVG
YINYSGSTSY NPSLKSRTVI SRDTSKNQFS LKLSSVTAAD TAVYYCARWI
GSSAWYFDVW GQGTLVTVS

948.g1 VH (SEQ ID NO:24)

gaagttcagc tgcaagaatc cggccctgga ctcgtgaaac caagccagac
actgagcctg acttgcaccg tcaactggcta tagcatcacc agcgattacg
cctggaactg gataaggcag ccacctggaa agaagctgga gtggatgggc
tacatcaact actccggaag cagtcctac aatccctcac ttaagagcag
agtcacaatc tcacgagaca cctccaagaa ccagttctcc ctgaaactga
gctccgttac tgccgctgat actgccgtgt actattgtgc aagggtggatt
gggagctcag cttggtatth cgacgtttgg ggacaaggca cacttgtgac cgtctcg

Figure 7

948.g1 VH with signal sequence underlined and italicised (SEQ ID NO:25)

MEWSWVFLFF LSVTTGVHSE VQLQESGPGL VKPSQTLSLT CTVTGYSITS
DYAWNWIROP PGKKLEWNGY INYSGSTSYN PSLKSRVTIS RDTSKNQFSL
KLSSVTAADT AVYYCARWIG SSAWYFDVWG QGTLVTVS

948.g1 VH with signal sequence underlined and italicised (SEQ ID NO:26)

atggagtgga gctgggtctt tctcttcttt ctctccgtga ctaccggtgt
gcactccgaa gttcagctgc aagaatccgg ccttgactc gtgaaaccaa
gccagacact gagcctgact tgcaccgtca ctggctatag catcaccagc
gattacgcct ggaactggat aaggcagcca cctggaaaga agctggagtg
gatgggctac atcaactact ccggaagcac gtctacaat ccctcactta
agagcagagt cacaatctca cgagacacct ccaagaacca gttctccctg
aaactgagct ccgttactgc cgctgatact gccgtgtact attgtgcaag
gtggattggg agctcagctt ggtatttcga cgtttgggga caaggcacac
ttgtgaccgt ctcg

948.g1 heavy chain (V + constant - hu IgG4P) (SEQ ID NO:27)

EVQLQESGPG LVKPSQTLSL TCTVTGYSIT SDYAWNWIROP PPGKKLEWNG
YINYSGSTSY NPSLKSRVTI SRDTSKNQFS LKLSSVTAAD TAVYYCARWI
GSSAWYFDVW GQGTTLVTVSS ASTKGPSVFP LAPCSRSTSE STAALGCLVK
DYFPEPVTVS WNSGALTSGV HTFPAVLQSS GLYSLSSVVT VPSSSLGTKT
YTCNVDHKPS NTKVDKRVES KYGPPCPPCP APEFLGGPSV FLFPPKPKDT
LMISRTPEVT CVVVDVSQED PEVQFNWYVD GVEVHNAKTK PREEQFNSTY
RVVSVLTVLH QDWLNGKEYK CKVSNKGLPS SIEKTIKAK GQPREPQVYT
LPPSQEEMTK NQVSLTCLVK GFYPSDIAVE WESNGQPENN YKTTTPVLDS
DGSFFLYSRL TVDKSRWQEG NVFSCSVME ALHNHYTQKS LSLSLGK

Figure 8

948.g1 heavy chain (V + constant – hu IgG4P, exons underlined) (SEQ ID NO:28)

gaagttcagc tgcaagaatc cggccctgga ctcgtgaaac caagccagac actgagcctg
acttgcaccg tcaactggcta tagcatcacc agcgattacg cctggaactg gataaggcag
ccacctggaa agaagctgga gtggatgggc tacatcaact actccggaag cacgtcctac
aatccctcac ttaagagcag agtcacaatc tcacgagaca cctccaagaa ccagttctcc
ctgaaactga gctccgttac tgccgctgat actgccgtgt actattgtgc aaggtggatt
gggagctcag cttggatttt cgacgtttgg ggacaaggca cacttgtgac cgtctcgagc
gcttctacaa agggcccatc cgtcttccc ctggcgccct gctccaggag cacctccgag
agcacagccg cctgggctg cctggtcaag gactacttcc ccgaaccggt gacgggtgctg
tggaactcag gcgccctgac cagcggcgtg cacaccttcc cggctgtcct acagtcctca
ggactctact cctcagcag cgtggtgacc gtgccctcca gcagcttggg cacgaagacc
tacacctgca acgtagatca caagcccagc aacaccaagg tggacaagag agttggtgag
aggccagcac agggaggag ggtgtctgct ggaagccagg ctacgccctc ctgacctggac
gcaccccggc tgtgcagccc cagcccaggg cagcaaggca tgccccatct gtctcctcac
ccggaggcct ctgaccacc cactcatgcc cagggagagg gtctttctgga tttttccacc
aggctccggg cagccacagg ctggatgcc ctaccccagg cctgcccct acaggggag
gtgctgcgct cagacctgcc aagagccata tccgggagga cctgccccct gacctaagcc
caccccaaag gccaaactct ccactccctc agctcagaca ctttctctcc tcccagatct
gagtaactcc caatcttctc tctgcagagt ccaaatatgg tccccatgc ccaccatgcc
caghtaagcc aaccagggc tcgccctcca gctcaaggcg ggacaggtgc cctagagtag
cctgcatcca gggacaggcc ccagccgggt gctgacgcat ccacctccat ctcttctca
gcacctgagt tcttgggggg accatcagtc ttctgttcc ccccaaaacc caaggacact
ctcatgatct cccggacccc tgaggtaacg tgcgtggtgg tggacgtgag ccaggaagac
cccgaggtcc agttcaactg gtacgtggat ggcgtggagg tgcataatgc caagacaaag
ccgcgggagg agcagttcaa cagcacgtac cgtgtggtca gcgtcctcac cgtcctgcac
caggactggc tgaacggcaa ggagtacaag tgcaaggctc ccaacaaagg cctcccgtcc
tccatcgaga aaaccatctc caaagccaaa ggtgggacc acgggggtgc agggccacat
ggacagaggt cagctcggcc caccctctgc cctgggagtg accgctgtgc caacctctgt
ccctacaggg cagccccgag agccacaggt gtacacctg ccccatccc aggaggagat
gaccaagaac caggtcagcc tgacctgct ggtcaaaggc ttctacccca gcgacatcgc
cgtggagtgg gagagcaatg ggcagccgga gaacaactac aagaccacgc ctcccgtgct
ggactccgac ggctccttct tctctacag caggctaacc gtggacaaga gcaggtggca
ggaggggaat gtcttctcat gctccgtgat gcatgaggct ctgcacaacc actacacaca
gaagagcctc tcctgtctc tgggtaaa

Figure 9

948.g1 heavy chain (V + constant – hu IgG4P) with signal sequence underlined and italicised
(SEQ ID NO:29)

MEWSWVFLFF LSVTTGVHSE VQLQESGPGL VKPSQTLSLT CTVTGYSITS
DYAWNWIRQP PGKKLEWMGY INYSGSTSYN PSLKSRVTIS RDTSKNQFSL
KLSSVTAADT AVYYCARWIG SSAWYFDVWG QGTLVTVSSA STKGPSVFPL
APCSRSTSES TAALGCLVKD YFPEPVTVSW NSGALTSGVH TFPAVLQSSG
LYSLSSVTV PSSSLGTKTY TCNVDHKPSN TKVDKRVESK YGPPCPPCPA
PEFLGGPSVF LFPPKPKDTL MISRTPEVTC VVVDVSQEDP EVQFNWYVDG
VEVHNAKTKP REEQFNSTYR VVSVLTVLHQ DWLNGKEYKC KVSNGKLPSS
IEKTISKAKG QPREPQVYTL PPSQEEMTKN QVSLTCLVKG FYPSDIAVEW
ESNGQPENNY KTTTPVLDSG GSFFLYSRLT VDKSRWQEGN VFSCSVMHEA
LHNHYTQKSL SLSLGK

10/13

Figure 10

948.g1 heavy chain (V + constant – hu IgG4P, exons underlined) with signal sequence underlined and italicised (SEQ ID NO:30)

atggagtgga gctgggtctt tctcttcttt ctctccgtga ctaccggtgt gcaactccgaa
gttcagctgc aagaatccgg ccttgactc gtgaaaccaa gccagacact gagcctgact
tgcaccgtca ctggctatag catcaccage gattacgcct ggaactggat aaggcagcca
cctggaaaga agctggagtg gatgggctac atcaactact ccggaagcac gtcctacaat
ccctcactta agagcagagt cacaatctca cgagacacct ccaagaacca gttctccctg
aaactgagct ccgttactgc cgctgatact gccgtgtact attgtgcaag gtggattggg
agctcagctt ggtatttcga cgtttgggga caaggcacac ttgtgaccgt ctcgagcgt
tctacaaagg gcccatccgt cttcccctg gcgccctgct ccaggagcac ctccgagagc
acagccgcc tgggctgcct ggtcaaggac tacttccccg aaccgggtgac ggtgtcgtgg
aactcaggcg cctgaccag cggcgtgcac accttccccg ctgtcctaca gtcctcagga
ctctactccc tcagcagcgt ggtgaccgtg ccctccagca gcttgggacac gaagacctac
acctgcaacg tagatcacia gccagcaac accaagggtg acaagagagt tggtgagagg
ccagcacagg gagggagggt gtctgctgga agccaggctc agccctcctg cctggacgca
ccccggctgt gcagccccag ccaggggcag caaggcatgc cccatctgtc tctcacccg
gaggcctctg accaccccac tcatgccag ggagagggtc ttctggattt ttccaccagg
ctccgggcag ccacaggctg gatgcccta cccaggccc tgcgcataca ggggcagggtg
ctgcgctcag acctgccaag agccatatec gggaggacc tgcacctgac ctaagcccc
cccaaaggcc aaactctcca ctcccctcagc tcagacacct tctctcctcc cagatctgag
taactcccaa tcttctctct gcagagtcca aatatggtcc cccatgccca ccatgcccag
gtaagccaac ccaggcctcg ccctccagct caaggcggga cagggtgcct agagtagcct
gcatccaggg acaggccca gccgggtgct gacgcataca cctccatctc ttctcagca
cctgagttcc tggggggacc atcagtcttc ctgttcccc caaaacccaa ggacactctc
atgatctccc ggaccctga ggtcacgtgc gtggtggtgg acgtgagcca ggaagacccc
gagggtccagt tcaactggta cgtggatggc gtggagggtgc ataatgccaa gacaaagccg
cgggaggagc agttcaacag cacgtaccgt gtggtcagcg tctcaccgt cctgcaccag
gactggctga acggcaagga gtacaagtgc aaggctctca acaaaggcct cccgtcctcc
atcgagaaaa ccatctcaa agccaaagggt gggaccacg gggtgcgagg gccacatgga
cagaggtcag ctcgcccac cctctgcct gggagtgacc gctgtgcaa cctctgtccc
tacagggcag ccccgagagc cacagggtgta caccctgccc ccatcccagg aggagatgac
caagaaccag gtcagcctga cctgcctggc caaaggcttc taccacagcg acatcgccgt
ggagtgggag agcaatggc agccggagaa caactacaag accacgcctc ccgtgctgga
ctccgacggc tcttcttcc tctacagcag gtaaccgtg gacaagagca ggtggcagga
ggggaatgtc ttctcatgct ccgtgatgca tgaggctctg cacaaccact acacacagaa
gagcctctcc ctgtctctgg gtaaa

Figure 11

Human VK2 4-1-(1) A18 JK2 acceptor framework (SEQ ID NO:31)

DIVMTQTPLS LSVTPGQPAS ISCKSSQSLI HSDGKTYLYW YLQKPGQSPQ
LLIYEVSSRF SGVPDRFSGS GSGTDFTLKI SRVEAEDVGV YYCMQGIHLP
YTFGQGTKLE IK

Human VK2 4-1-(1) A18 JK2 acceptor framework (SEQ ID NO:32)

gatattgtga tgaccagac tccactctct ctgtccgtca cccctggaca
gccggcctcc atctcctgca agtctagtca gagcctcctg catagtgatg
gaaagaccta tttgtattgg tacctgcaga agccaggcca gtctccacag
ctcctaactct atgaagtttc cagccggttc tctggagtgc cagataggtt
cagtggcagc gggtcagga cagatttcac actgaaaatc agccgggtgg
aggctgagga tgttgggggt tattactgca tgcaaggtat acaccttct
tacacttttg gccaggggac caagctggag atcaaa

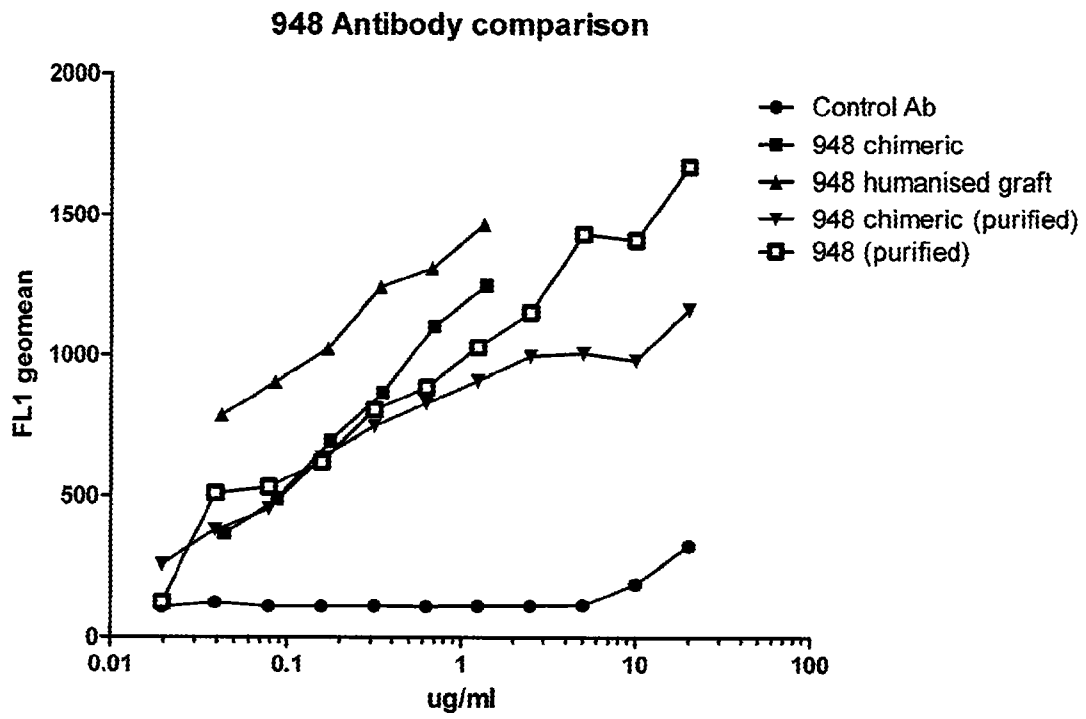
Human VH4 3-1 4-30.4 JH4 acceptor framework (SEQ ID NO:33)

QVQLQESGPG LVKPSQTLISL TCTVSGGSIS SGDYYWSWIR QPPGKGLEWI
GYIYYSGSTY YNPSLKSRVT ISVDTSKNQF SLKLSSVTAA DTAVYYCARY
FDYWGQGTLLV TVS

Human VH4 3-1 4-30.4 JH4 acceptor framework (SEQ ID NO:34)

cagggtgcagc tgcaggagtc gggcccagga ctgggtgaagc cttcacagac
cctgtccctc acctgcactg tctctgggtg ctccatcagc agtggtgatt
actactggag ttggatccgc cagccccag ggaagggcct ggagtggatt
gggtacatct attacagtgg gagcacctac tacaaccctg ccctcaagag
tcgagttacc atatcagtag acacgtccaa gaaccagttc tccctgaagc
tgagctctgt gactgccgca gacacggccg tgtattactg tgccagatac
tttgactact ggggcccagg aaccctggtc accgtctcc

Figure 12



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/053559

A. CLASSIFICATION OF SUBJECT MATTER INV. C07K16/28 C07K16/46 C12N15/13 C07K14/705 ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) C07K C12N		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, BIOSIS, EMBASE, WPI Data, Sequence Search		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2004/056875 A1 (WYETH CORP [US]; CAMBRIDGE ANTIBODY TECH [GB]; COLLINS MARY [US]; WOOD) 8 July 2004 (2004-07-08) cited in the application figures 3, 5; examples; table 6 -----	1-17
X	SEKO ET AL: "Roles of programmed death-1 (PD-1)/PD-1 ligands pathway in the development of murine acute myocarditis caused by coxsackievirus B3", CARDIOVASCULAR RESEARCH, OXFORD UNIVERSITY PRESS, GB, vol. 75, no. 1, 7 June 2007 (2007-06-07), pages 158-167, XP022124955, ISSN: 0008-6363, DOI: DOI:10.1016/J.CARDIORES.2007.03.012 whole document, especially the Abstract, paragraphs 2.5 & 3.7, and Figure 6B ----- -/--	1-17
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents :		
"A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed	"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art. "&" document member of the same patent family	
Date of the actual completion of the international search	Date of mailing of the international search report	
5 August 2011	17/08/2011	
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Authorized officer Luyten, Kattie	

INTERNATIONAL SEARCH REPORT

International application No

PCT/EP2011/053559

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	<p>WANG LIQING ET AL: "Programmed cell death 1 (PD-1) and its ligand PD-L1 are required for allograft tolerance", EUROPEAN JOURNAL OF IMMUNOLOGY, WILEY - V C H VERLAG GMBH & CO. KGAA, DE, vol. 37, no. 10, 1 October 2007 (2007-10-01), pages 2983-2990, XP009126366, ISSN: 0014-2980 page 2988, left-hand column -----</p>	1-17
X	<p>KEIR MARY E ET AL: "Programmed death-1 (PD-1):PD-ligand 1 interactions inhibit TCR-mediated positive selection of thymocytes.", JOURNAL OF IMMUNOLOGY (BALTIMORE, MD. : 1950) 1 DEC 2005 LNKD- PUBMED:16301644, vol. 175, no. 11, 1 December 2005 (2005-12-01), pages 7372-7379, XP002636167, ISSN: 0022-1767 page 7373, left-hand column, last paragraph; page 7374, right-hand column, last paragraph; page 7374, left-hand column; discussion, first paragraph -----</p>	1-17
X,P	<p>WO 2010/029434 A1 (ISIS INNOVATION [GB]; DAVIS SIMON [GB]) 18 March 2010 (2010-03-18) the whole document -----</p>	1-17
X,P	<p>WO 2010/029435 A1 (ISIS INNOVATION [GB]; DAVIS SIMON [GB]; TYSON KERRY LOUISE [GB]) 18 March 2010 (2010-03-18) the whole document -----</p>	1-17

INTERNATIONAL SEARCH REPORT

International application No.

PCT/EP2011/053559

Box No. I Nucleotide and/or amino acid sequence(s) (Continuation of item 1.c of the first sheet)

1. With regard to any nucleotide and/or amino acid sequence disclosed in the international application and necessary to the claimed invention, the international search was carried out on the basis of:
 - a. (means)
 - on paper
 - in electronic form
 - b. (time)
 - in the international application as filed
 - together with the international application in electronic form
 - subsequently to this Authority for the purpose of search
2. In addition, in the case that more than one version or copy of a sequence listing and/or table relating thereto has been filed or furnished, the required statements that the information in the subsequent or additional copies is identical to that in the application as filed or does not go beyond the application as filed, as appropriate, were furnished.
3. Additional comments:

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2011/053559

Patent document cited in search report	Publication date	Patent family member(s)	Publication date	
WO 2004056875	A1	08-07-2004	AT 514713 T	15-07-2011
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			EP 2342228 A1	13-07-2011
			US 2011171220 A1	14-07-2011

WO 2010029435	A1	18-03-2010	AU 2009290544 A1	18-03-2010
			CA 2736829 A1	18-03-2010
			EP 2342229 A1	13-07-2011
			US 2011171215 A1	14-07-2011
