(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
17 December 2009 (17.12.2009)

PCT

(10) International Publication Number
WO 2009/149486 A2

(51) International Patent Classification:
A61K 38/08 (2006.01) *A61P 25/28* (2006.01)
A61P 27/16 (2006.01)

(21) International Application Number:
PCT/AT2009/000236

(22) International Filing Date:
12 June 2009 (12.06.2009)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
A 951/2008 12 June 2008 (12.06.2008) AT

(71) Applicant *(for all designated States except US)*: **AFFIRIS AG** [AT/AT]; Viehmarktgasse 2A, A-1030 Vienna (AT).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **MANDLER, Markus** [AT/AT]; Dieselgasse 5/115, A-1100 Vienna (AT). **GIEFFERS, Christian** [DE/DE]; Blütenweg 12, 69221 Dossenheim (DE). **MATTNER, Frank** [DE/AT]; Sieveringerstrasse 190, A-1190 Vienna (AT). **DOLISCHKA, Andrea** [AT/AT]; Richtergasse 8/9, A-1070 Vienna (AT). **OTAVA, Oleksandr** [UA/AT]; Kleistgasse 3/8, A-1030 Vienna (AT).

(74) Agent: **SONN & PARTNER**; Riemergasse 14, A-1010 Vienna (AT).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PE, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

— *of inventorship (Rule 4.17(iv))*

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

WO 2009/149486 A2

(54) **Title**: COMPOUNDS FOR TREATING DISEASES

(57) **Abstract**: The present invention relates to the use of mimotopes in the treatment of diseases associated with β-amyloid formation and/or aggregation (β-Amyloidoses) including Alzheimer's disease, whereby said mimotopes are able to induce the in vivo formation of antibodies directed to Aβl-40/42, AβpE3-40/42, Aβ3-40/42 and Aβll-40/42.

Compounds for treating diseases

The present invention relates to the use of mimotopes for the prevention, treatment and diagnosis of diseases associated with ß-amyloid formation and/or aggregation (ß-Amyloidoses).

Various degenerative diseases are characterized by the aberrant polymerization and accumulation of specific proteins. These so called proteopathies include neurological disorders such as Alzheimer's disease, Parkinson's disease and Huntington's disease as well as diverse systemic disorders including the amyloidoses. The present invention relates to the prevention, treatment and diagnosis of proteopathies associated with ß-amyloid proteins summarised under the term ß-Amyloidoses. The most prominent form of ß-Amyloidoses is Alzheimer`s disease (AD). Other examples include but are not limited to Dementia with Lewy bodies and Dementia in Down syndrome.

AD is characterized by the abnormal accumulation of extracellular amyloid plaques - closely associated with extensive astrocytosis and microgliosis as well as dystrophic neurones and neuronal loss. These amyloid plaques mainly consist of the Amyloid-β (Aβ) peptides Aβ40 and Aβ42 derived from the Amyloid Precursor Protein (APP), which is expressed on various cell types in the nervous system. Aβ peptides are considered to be directly involved in the pathogenesis and progression of AD.

APP is normally processed by two cleavage steps to form the currently known forms of Abeta x-40/42/43. The first cleavage is performed by the so called beta-site APP-cleaving enzymes 1 and 2 (BACE1 and BACE2); the second proteolytic step is performed by the gamma-Secretase Complex (reviewed in De Strooper et al. J Cell Sci 113 (2000): 1857-1870).

BACE enzymes recognise two sites in the N-terminal portion of the presumptive Aß peptide: the first interaction of BACE with APP leads to a cut at the sequence DAEFR (pos. 1 in Aß) and formation of Abeta 1-X. Alternatively BACE can also cut at future position 11 within Aß resulting in the fragment 11-X. Thus BACE mediated APP processing creates a variety of different Aß species with full length Abeta 1-40/42 as major contribuent. Gamma-Secretase activity leads to production of 3 main fragments: Aß 1-40/42/43. Once these peptides are produced they are further processed by Amino-peptidases resulting in their subse-

quent stepwise degradation. These further steps lead to formation of other forms like for example Aß3-40/42 respectively.In humans on average 60 - 85% of amyloid plaque material is formed by Aβ40/42 derivatives which are N-terminally truncated and frequently modified. The relative amounts of N-terminally truncated Aß species are variable in respect of Aß levels, mutations and BACE activity.

The most abundant truncated forms of Aβ are: Aβ3-40/42 and Aβ11-40/42. Both peptides contain an N-terminal glutamate residue, which is frequently modified enzymatically to pyroglutamate, resulting in the formation of Aβ3(pE)-40/42 and Aβ11(pE)-40/42, respectively. Because the amino terminus of the Abeta 3(pE) and 11(pE) peptides is blocked by internal lactam, it is protected from the proteolytic action of aminopeptidases other than pyroglutamate-specific ones and can thus remain stable in tissues.

The most prominent form of N-terminally truncated modified amyloid is formed by the peptide 3(pE)-40/42, which is thought to constitute up to 50% of all truncated forms. This means that this isoforms constitute 25-40 % of all amyloid peptides in AD brains. Another prominent form of truncated Aß peptides is Aß11-40/42: Naslund et al. and Huse et al. could demonstrate that there is a significant level of these truncated species detectable in human brains of AD patients as well as in infra-clinical patients for AD. Furthermore these peptides undergo intramolecular dehydration and form stable (pE) forms with similar consequences as described for 3(pE)-40/42.

It has been shown previously that truncated and modified peptides are more stable in neural tissue than full length Aβ. Additionally, N-terminally truncated forms of Aβ are more amyloidogenic than unmodified Aβ peptides, thus enhancing the rate of plaque formation, and also show neurotoxic activity when applied to neurons in culture as well as in in vivo experiments. Truncated forms of Aβ can already be detected in diffuse aggregations of Aβ in early stages of AD and might be involved in early plaque formation, acting as individual seeds *in vivo*.

There is compelling evidence that the occurrence of N-terminally truncated Aβ species is correlated with increasing severity and early onset of neurodegeneration in sporadic and familial Alzheimer disease as well as Down Syndrome patients.

The aggregatory effects in conjunction with the increased stability of these peptides make them a potentially dangerous player in AD development. Analysis in infraclinical patients suffering from familial AD or Down-Syndrome have unequivocally shown that Aß 3(pE)-42 can be detected during the earliest stages of disease, also called the "seed" stages. At this time no or only minor neurological symptoms can be detected although plaques are starting to accumulate which bear the Aß 3(pE)-42 peptide species. Thus, data from such patients are implying a link between early formation of truncated Aß species and disease onset as well as progression.

In light of these findings it seems to be important to decrease the amount of these peptide species in AD patients to modify disease progression and reduce toxicity and accompanying cognitive decline. An optimal AD-vaccine should thus elicit an immune response which is able to target the most prominent forms of Aß peptides present in the brain of AD patients.

Indeed, immunotherapeutic treatment using active and passive immunisation strategies to target full length Aβ, led to reduction of Aβ plaques and had beneficial impact on disease progression in animal models of AD. Passive vaccination experiments in mouse models of AD clearly showed, that antibodies specifically directed against the N- and C-termini of Aβ40/42 are able to reduce plaque burden in the brain and also improve cognitive functions in treated animals as judged from behavioural analyses. Similar observations have been made in active vaccination experiments, using different approaches to induce immune responses directed against Aβ40/42 in mice. All of these approaches used full length Aβ40/42 or fragments containing the native sequence of Aβ and most reduced the amyloid burden in transgenic mouse models. Importantly, these animals also showed improved cognitive functions. Strikingly, Lemere et al. (Am J Pathol 165 (2004): 283-297) could reproduce these results in non-human primates which showed clear reduction of plaque deposition and associated pathology in response to active vaccination with full length Aβ. However, the first phase IIa clinical vaccination trial in AD patients using full length Aβ42 as antigen had to be discontinued due to severe neuroinflammatory side effects including brain infiltration of autoreactive T-cells. Nevertheless, studies investigating the clinical effects in patients

treated with AN-1792 revealed that patients who developed an antibody response against Aβ42 but did not suffer from meningoencephalitis performed better in cognitive tests than non-responding patients, indicating that immunotherapy might be a very useful treatment approach in AD.

Most importantly, recent results obtained from autopsy cases analysing patients which underwent AN1792 vaccination showed a clearance of full length Aß species from the brain but a persistence of N-terminally truncated forms of Aß. This underscores the necessity of the invention of novel vaccines which are targeting full length Aß as well as N-terminaly truncated and modified forms of this molecule.

Inducing an immune response against Aβ40/42 peptides in humans can interfere with cognitive decline in AD patients, but a safe Alzheimer vaccine has to avoid the formation of autoreactive T cells. Vaccination using native Aβ40/42 peptides or fragments thereof suffers from the intrinsic risk of inducing autoimmune disease in patients, as the immune response cannot exclusively be targeted to Aβ.

It is an object of the present invention to provide compounds and medicaments which can be used to treat and/or prevent ß-Amyloidoses including Alzheimer's disease. These compounds should show no or a significantly reduced risk of inducing autoimmune diseases when administered to an individual. According to another object of the present invention said compound may be able to induce the *in vivo* formation of antibodies in an individual which are directed to truncated and/or stabilised forms of Aβ, which usually are the major components of amyloid deposits.

Therefore the present invention relates to the use of at least one compound comprising the amino acid sequence

$$X_1RX_2DX_3(X_4)_n(X_5)_m(X_6)_o \qquad \text{(Formula I)},$$

wherein

X_1 is isoleucine (I) or valine (V),
X_2 is tryptophan (W) or tyrosine (Y),
X_3 is threonine (T), valine (V), alanine (A), methionine (M), glutamine (Q) or glycine (G),

X_4 is proline (P), alanine (A), tyrosine (Y), serine (S), cysteine (C) or glycine (G),
X_5 is proline (P), leucine (L), glycine (G) or cysteine (C),
X_6 is cysteine (C),
n, m and o are, independently, 0 or 1,

said compound having a binding capacity to an antibody which is specific for an epitope of the amyloid-beta-peptide (Aβ) comprising the amino acid sequence EFRHDSGY and/or pEFRHDSGY

for producing a medicament for preventing and/or treating β-amyloidoses.

It surprisingly turned out, that a compound comprising an amino acid sequence of the formula I is able to induce the *in vivo* formation of antibodies which are directed to the truncated Aβ forms AßpE3-40/42 and Aß3-40/42. The antibodies formed are able to bind to said Aβ fragments resulting in the disintegration of Aβ plaques.

Formula I and II and all other peptidic molecules disclosed herein mimic the natural occurring Aß peptides and variants Aß1-40/42, AßpE3-40/42, Aß3-40/42 and Aß11-40/42, so that compounds comprising the amino acid sequences disclosed herein are able to induce the formation of respective antibodies.

The invention presented herein refers to antigens which do not contain sequences of the native Aβ peptide and mimic the structure of neo-epitopes not detectable by mimotopes such as described in WO 2004/062556. Such a mimotope-based AD vaccine would therefore induce antibody responses exclusively reacting with the pathological Aβ molecules mentioned herein but not with parental structures like APP. Furthermore, mimotopes do not contain potential T-cell self-epitopes and avoid induction of detrimental autoreactive T-cells.

"ß-Amyloidoses", as used herein, refers to various degenerative diseases which are characterized by the aberrant polymerization and accumulation of specific proteins so called proteopathies. The present invention relates to the prevention, treatment and diagnosis of proteopathies associated with ß-amyloid proteins summarized under the term ß-Amyloidoses. The most prominent form of ß-Amyloidoses is Alzheimer`s disease (AD). Other

examples include but are not limited to Dementia with Lewy bodies and Dementia in Down syndrome. Further examples are Lewy body dementia, myositis, sporadic inclusion body myositis, hereditary cerebral hemorrhage with amyloidosis (dutch type), cerebral amyloid angiopathy, Aß related angiitis.

According to a particularly preferred embodiment of the present invention "ß-Amyloidoses" is Alzheimer's disease.

According to a preferred embodiment of the present invention the compound comprises a peptide having an amino acid sequence selected from the group consisting of IRWDTP(C), VRWDVYP(C), IRYDAPL(C), IRYDMAG(C), IRWDTSL(C), IRWDQP(C), IRWDG(C) and IRWDGG(C).

Particularly preferred compounds of the present invention comprise or consist of the above identified amino acid sequences, whereby the C-terminus of said peptide may or may not comprise a cysteine residue (indicated by the use of brackets) so that the compound obtained may be coupled, e.g., to a carrier molecule. However, it is of course also possible to link to the N-terminus of said peptide a cysteine residue.

According to a particularly preferred embodiment of the present invention the amino acid sequence is IRWDTP(C), VRWDVYP(C), IRYDAPL(C) or IRYDMAG(C).

Another aspect of the present invention relates to the use of at least one compound comprising the amino acid sequence

$$EX_1WHX_2X_3(X_4)_n(X_5)_m \qquad \text{(Formula II)},$$

wherein

X_1 is valine (V), arginine (R) or leucine (L),
X_2 is arginine (R) or glutamic acid (E),
X_3 is alanine (A), histidine (H), lysine (K), leucine (L), tyrosine (Y) or glycine (G),
X_4 is proline (P), histidine (H), phenylalanine (F), glutamine (Q) or cysteine (C)
X_5 is cysteine (C),
n and m are, independently, 0 or 1,

said compound having a binding capacity to an antibody which is specific for an epitope of the amyloid-beta-peptide (Aβ) com-

prising the amino acid sequence EVHHQKL

for producing a medicament for preventing and/or treating β-amyloidoses.

The administration of a compound comprising an amino acid sequence of formula II provokes an immune response against the truncated Aß form Aß11-40/42.

According to a preferred embodiment of the present invention the compound comprises a peptide having an amino acid sequence selected from the group consisting of EVWHRHQ(C), ERWHEKH(C), EVWHRLQ(C), ELWHRYP(C), ELWHRAF(C), ELWHRA(C), EVWHRG(C), EVWHRH(C) and ERWHEK(C), preferably EVWHRHQ(C), ERWHEKH(C), EVWHRLQ(C), ELWHRYP(C) and ELWHRAF(C).

Another aspect of the present invention relates to the use of at least one compound comprising an amino acid sequence selected from the group consisting of QDFRHY(C), SEFKHG(C), TSFRHG(C), TSVFRH(C), TPFRHT(C), SQFRHY(C), LMFRHN(C), SAFRHH(C), LPFRHG(C), SHFRHG(C), ILFRHG(C), QFKHDL(C), NWFPHP(C), EEFKYS(C), NELRHST(C), GEMRHQP(C), DTYFPRS(C), VELRHSR(C), YSMRHDA(C), AANYFPR(C), SPNQFRH(C), SSSFFPR(C), EDWFFWH(C), SAGSFRH(C), QVMRHHA(C), SEFSHSS(C), QPNLFYH(C), ELFKHHL(C), TLHEFRH(C), ATFRHSP(C), APMYFPH(C), TYFSHSL(C), HEPLFSH(C), SLMRHSS(C), EFLRHTL(C), ATPLFRH(C), QELKRYY(C), THTDFRH(C), LHIPFRH(C), NELFKHF(C), SQYFPRP(C), DEHPFRH(C), MLPFRHG(C), SAMRHSL(C), TPLMFWH(C), LQFKHST(C), ATFRHST(C), TGLMFKH(C), AEFSHWH(C), QSEFKHW(C), AEFMHSV(C), ADHDFRH(C), DGLLFKH(C), IGFRHDS(C), SNSEFRR(C), SELRHST(C), THMEFRR(C), EELRHSV(C), QLFKHSP(C), YEFRHAQ(C), SNFRHSV(C), APIQFRH(C), AYFPHTS(C), NSSELRH(C), TEFRHKA(C), TSTEMWH(C), SQSYFKH(C), (C)SEFKH, SEFKH(C), (C)HEFRH and HEFRH(C) for producing a medicament for preventing and/or treating β-amyloidoses.

Each of these compounds is able to induce the in vivo formation of antibodies directed to Aß1-40/42, AßpE3-40/42 and Aß3-40/42. Therefore these compounds are particularly well suited to treat and/or prevent β-amyloidoses, such as AD, because the administration of one compound results in the formation of antibodies which are capable to recognize the three major Aß forms Aß1-40/42, AßpE3-40/42 and Aß3-40/42.

According to a preferred embodiment of the present invention the compound comprises or consists of a peptide having an amino

acid sequence selected from the group consisting of QDFRHY(C), SEFKHG(C), TSFRHG(C), TSVFRH(C), TPFRHT(C), SQFRHY(C), LMFRHN(C), SAFRHH(C), LPFRHG(C), SHFRHG(C), ILFRHG(C), QFKHDL(C), NWFPHP(C), EEFKYS(C), SPNQFRH(C), TLHEFRH(C), THTDFRH(C), DEHPFRH(C), QSEFKHW(C), ADHDFRH(C), DGLLFKH(C), EELRHSV(C), TEFRHKA(C), (C)SEFKH, SEFKH(C), (C)HEFRH and HEFRH(C) preferably SEFKHG(C), TSVFRH(C), SQFRHY(C), LMFRHN(C), ILFRHG(C), SPNQFRH(C), ELFKHHL(C), TLHEFRH(C), THTDFRH(C), DEHPFRH(C), QSEFKHW(C), ADHDFRH(C), YEFRHAQ(C), TEFRHKA(C).

The amino acid sequences disclosed herein are considered to be mimotopes of the epitopes of Aβ comprising the amino acid sequence EFRHDSGY, pEFRHDSGY or EVHHQKL. According to the present invention the term "mimotope" refers to a molecule which has a conformation that has a topology equivalent to the epitope of which it is a mimic. The mimotope binds to the same antigen-binding region of an antibody which binds immunospecifically to a desired antigen. The mimotope will elicit an immunological response in a host that is reactive to the antigen to which it is a mimic. The mimotope may also act as a competitor for the epitope of which it is a mimic in in vitro inhibition assays (e.g. ELISA inhibition assays) which involve the epitope and an antibody binding to said epitope. However, a mimotope of the present invention may not necessarily prevent or compete with the binding of the epitope of which it is a mimic in an in vitro inhibition assay although it is capable to induce a specific immune response when administered to a mammal.

As used herein, the term "epitope" refers to an immunogenic region of an antigen which is recognized by a particular antibody molecule. In general, an antigen will possess one or more epitopes, each capable of binding an antibody that recognizes the particular epitope.

The mimotopes of the present invention can be synthetically produced by chemical synthesis methods which are well known in the art, either as an isolated peptide or as a part of another peptide or polypeptide. Alternatively, the peptide mimotope can be produced in a microorganism which produces the peptide mimotope which is then isolated and if desired, further purified. The peptide mimotope can be produced in microorganisms such as bacteria, yeast or fungi, in eukaryote cells such as a mammalian or an insect cell, or in a recombinant virus vector such as ade-

novirus, poxvirus, herpesvirus, Simliki forest virus, baculovirus, bacteriophage, sindbis virus or sendai virus. Suitable bacteria for producing the peptide mimotope include E.coli, B.subtilis or any other bacterium that is capable of expressing peptides such as the peptide mimotope. Suitable yeast types for expressing the peptide mimotope include Saccharomyces cerevisiae, Schizosaccharomyces pombe, Candida, Pichia pastoris or any other yeast capable of expressing peptides. Corresponding methods are well known in the art. Also methods for isolating and purifying recombinantly produced peptides are well known in the art and include e.g. as gel filtration, affinity chromatography, ion exchange chromatography etc..

To facilitate isolation of the peptide mimotope, a fusion polypeptide may be made wherein the peptide mimotope is translationally fused (covalently linked) to a heterologous polypeptide which enables isolation by affinity chromatography. Typical heterologous polypeptides are His-Tag (e.g. His_6; 6 histidine residues), GST-Tag (Glutathione-S-transferase) etc.. The fusion polypeptide facilitates not only the purification of the mimotopes but can also prevent the mimotope polypeptide from being degraded during purification. If it is desired to remove the heterologous polypeptide after purification the fusion polypeptide may comprise a cleavage site at the junction between the peptide mimotope and the heterologous polypeptide. The cleavage site consists of an amino acid sequence that is cleaved with an enzyme specific for the amino acid sequence at the site (e.g. proteases).

The mimotopes of the present invention may also be modified at or nearby their N- and/or C-termini so that at said positions a cysteine residue is bound thereto. In a preferred embodiment terminally positioned (located at the N- and C-termini of the peptide) cysteine residues are used to cyclize the peptides through a disulfide bond. The cysteine residue may also serve to bind to said peptide/compound a further molecule (e.g. a carrier).

The mimotopes of the present invention may also be used in various assays and kits, in particular in immunological assays and kits. Therefore, it is particularly preferred that the mimotope may be part of another peptide or polypeptide, particularly an enzyme which is used as a reporter in immunological assays.

Such reporter enzymes include e.g. alkaline phosphatase or horseradish peroxidase.

The mimotopes according to the present invention preferably are antigenic polypeptides which in their amino acid sequence vary from the amino acid sequence of Aβ or of fragments of Aβ. In this respect, the inventive mimotopes may not only comprise amino acid substitutions of one or more naturally occurring amino acid residues but also of one or more non-natural amino acids (i.e. not from the 20 "classical" amino acids) or they may be completely assembled of such non-natural amino acids. Moreover, the inventive antigens which induce antibodies directed and binding to Aß1-40/42, AßpE3-40/42, Aß3-40/42 and Aß11-40/42 may be assembled of D- or L- amino acids or of combinations of DL- amino acids and, optionally, they may have been changed by further modifications, ring closures or derivatizations. Suitable antibody-inducing antigens may be provided from commercially available peptide libraries. Preferably, these peptides are at least 7 amino acids, and preferred lengths may be up to 16, preferably up to 14 or 20 amino acids (e.g. 5 to 16 amino acid residues). According to the invention, however, also longer peptides may very well be employed as antibody-inducing antigens. Furthermore the mimotopes of the present invention may also be part of a polypeptide and consequently comprising at their N- and/or C-terminus at least one further amino acid residue.

For preparing the mimotopes of the present invention (i.e. the antibody-inducing antigens disclosed herein), of course also phage libraries, peptide libraries are suitable, for instance produced by means of combinatorial chemistry or obtained by means of high throughput screening techniques for the most varying structures (Display: A Laboratory Manual by Carlos F. Barbas (Editor), et al.; Willats WG Phage display: practicalities and prospects. Plant Mol. Biol. 2002 Dec.; 50(6):837-54).

Furthermore, according to the invention also anti-Aß1-40/42-, -AßpE3-40/42-, -Aß3-40/42- and -Aß11-40/42-antibody-inducing antigens based on nucleic acids ("aptamers") may be employed, and these, too, may be found with the most varying (oligonucleotide) libraries (e.g. with 2-180 nucleic acid residues) (e.g. Burgstaller et al., Curr. Opin. Drug Discov. Dev. 5(5) (2002), 690-700; Famulok et al., Acc. Chem. Res. 33 (2000), 591-599;

Mayer et al., PNAS 98 (2001), 4961-4965, etc.). In antibody-inducing antigens based on nucleic acids, the nucleic acid backbone can be provided e.g. by the natural phosphor-diester compounds, or also by phosphorotioates or combinations or chemical variations (e.g. as PNA), wherein as bases, according to the invention primarily U, T, A, C, G, H and mC can be employed. The 2'-residues of the nucleotides which can be used according to the present invention preferably are H, OH, F, Cl, NH_2, O-methyl, O-ethyl, O-propyl or O-butyl, wherein the nucleic acids may also be differently modified, i.e. for instance with protective groups, as they are commonly employed in oligonucleotide synthesis. Thus, aptamer-based antibody-inducing antigens are also preferred antibody-inducing antigens within the scope of the present invention.

According to a preferred embodiment of the present invention the compound is coupled to a pharmaceutically acceptable carrier, preferably KLH (Keyhole Limpet Hemocyanin), tetanus toxoid, albumin-binding protein, bovine serum albumin, a dendrimer (MAP; Biol. Chem. 358: 581), peptide linkers (or flanking regions) as well as the adjuvant substances described in Singh et al., Nat. Biotech. 17 (1999), 1075-1081 (in particular those in Table 1 of that document), and O'Hagan et al., Nature Reviews, Drug Discovery 2 (9) (2003), 727-735 (in particular the endogenous immuno-potentiating compounds and delivery systems described therein), or mixtures thereof. The conjugation chemistry (e.g. via heterobifunctional compounds such as GMBS and of course also others as described in "Bioconjugate Techniques", Greg T. Hermanson) in this context can be selected from reactions known to the skilled man in the art. Moreover, the vaccine composition may be formulated with an adjuvant, preferably a low soluble aluminium composition, in particular aluminium hydroxide. Of course, also adjuvants like MF59 aluminium phosphate, calcium phosphate, cytokines (e.g., IL-2, IL-12, GM-CSF), saponins (e.g., QS21), MDP derivatives, CpG oligos, LPS, MPL, polyphosphazenes, emulsions (e.g., Freund's, SAF), liposomes, virosomes, iscoms, cochleates, PLG microparticles, poloxamer particles, virus-like particles, heat-labile enterotoxin (LT), cholera toxin (CT), mutant toxins (e.g., LTK63 and LTR72), microparticles and/or polymerized liposomes may be used.

The compound of the present invention is preferably bound to

the carrier or adjuvant via a linker, which is selected from the group consisting of NHS-poly (ethylene oxide) (PEO) (e.g. NHS-PEO_4-maleimide).

A vaccine which comprises the present compound (mimotope) and the pharmaceutically acceptable carrier may be administered by any suitable mode of application, e.g. i.d., i.v., i.p., i.m., intranasally, orally, subcutaneously, etc. and in any suitable delivery device (O'Hagan et al., Nature Reviews, Drug Discovery 2 (9), (2003), 727-735). The compound of the present invention is preferably formulated for intravenous, subcutaneous, intradermal or intramuscular administration (see e.g. "Handbook of Pharmaceutical Manufacturing Formulations", Sarfaraz Niazi, CRC Press Inc, 2004).

The medicament (vaccine) according to the present invention contains the compound according to the invention in an amount of from 0.1 ng to 10 mg, preferably 10 ng to 1 mg, in particular 100 ng to 100 µg, or, alternatively, e.g. 100 fmol to 10 µmol, preferably 10 pmol to 1 µmol, in particular 100 pmol to 100 nmol. Typically, the vaccine may also contain auxiliary substances, e.g. buffers, stabilizers etc.

Another aspect of the present invention relates to the use of a compound as defined above for treating and/or ameliorating symptoms of synucleopathy.

It surprisingly turned out that the compounds of the present invention can also be used to treat and ameliorate symptoms associated with synucleopathies.

Amyloidoses and synucleopathies are associated with the cerebral accumulation of β-amyloid and α-synuclein, respectively. Some patients show clinical and pathological features of both diseases, raising the possibility of overlapping pathogenic pathways. These patients are also classified as suffering from a newly identified syndrome described as Dementia with Lewy Bodies or Parkinson´s disease with dementia (DLB/PDD). In a recent transgenic animal model for DLB/PDD it has been shown that overexpression of both, □synuclein and Amyloid Precursor Protein (hAPP), in mice leads to the development of cognitive and motor alterations accompanied by loss of cholinergic neurons and reduction in synaptic vesicles, formation of extensive amyloid plaques, and haSYN-immunoreactive intraneuronal fibrillar inclusions. All of these features are also found in the DLB/PDD syn-

drome. It has been described recently that both molecules are potentially able to interact and to form hybrid oligomers in vitro. It has also been shown that overexpression of the APP can exacerbate some of the pathologic effects of α-synuclein overexpression. In contrast, α-synuclein is able to enhance secretion and toxicity of amyloid beta peptides and could thus also increase the effects of β-amyloid supporting the notion of overlapping pathogenic pathways in neurodegenerative processes.

In both proteopathies progressive accumulation of peptide oligomers has been identified as one of the central toxic events leading to the various alterations typical for either synucleopathies or amyloidoses. Despite this mechanistic similarity, it is hypothesized that α-synuclein and Aß have distinct, as well as convergent, pathogenic effects on the integrity and function of the brain. Synucleins are believed to affect motoric function more severely than cognitive function, whereas amyloid ß peptides are described to have opposite effects. The reason for this discrepancy is currently unknown but it precludes a clear description of the interdependencies and effects of both molecules.

The treatment approach presented in the current invention is describing an immunotherapy targeting Aß which will lead to the removal of mainly extracellular amyloid. It is thus believed to relieve the amyloid associated alterations ranging from plaque deposition to neuronal death as well as to memory problems and cognitive decline. The subcellular localization of synucleins however indicates that these intracellular proteins are mainly active at the synapse, especially confined to synaptic vesicles. Interestingly, also synuclein accumulations, which are the unifying pathologic hallmark of synucleopathies, are mainly detectable intracellularly. Additionally, the pathogenic mechanism underlying synucleopathies is believed to be attributable to intraneuronal changes ranging from mitochondrial dysfunction, accumulation of abnormally folded, ubiquitinated or phosphorylated proteins as well as accumulation of alpha synuclein. These alterations are consequently resulting in changes in synaptic functions, synaptic failure, and loss of dopaminergic neurons and classical clinical signs of synucleopathies. In contrast Aß is mainly detectable extraneuronally and amyloid plaques as well as fibrils, protofibrils and oligomers of beta amyloid can exert

neurotoxic functions when applied extracellularly or intracerebrally. Thus it is a surprising finding to the expert that an approach mainly targeting extracellular amyloid would reduce the symptoms of synucleopathies like PD, which are affecting mainly intracellular processes leading to the typical symptoms described below. It is even more surprising as it is currently believed that the overlapping effects of both molecules are caused by direct interactions of the two proteins which should mainly occur intracellularly. According to the present invention the term "synucleinopathy" includes all neurodegenerative disorders characterized by pathological synuclein aggregations. Several neurodegenerative disorders including Parkinson's Disease (PD), Lewy Body Disease (LBD), Diffuse Lewy Body Disease (DLBD), Dementia with Lewy Bodies (DLB), Parkinsonism with Dementia (PDD), Multiple System Atrophy (MSA) and Neurodegeneration with Brain Iron Accumulation type I (NBIA Type I) are collectively grouped as synucleinopathies.

"Symptoms of synucleopathy", as used herein, refers to those symptoms of the synucleopathies, in particular Parkinson's disease, which affect the motor and non-motor behaviour of a patient suffering from said disease. "Motor symptoms" include resting tremor, Bradykinesia, rigidity, postural instability, stooped posture, dystonia, fatigue, impaired fine motor dexterity and motor coordination, impaired gross motor coordination, poverty of movement (decreased arm swing), akathisia, speech problems, such as softness of voice or slurred speech caused by lack of muscle control, loss of facial expression, or "masking", micrographia, difficulty swallowing, sexual dysfunction, drooling etc.. "Non-motor" symptoms include pain, dementia or confusion, sleep disturbances, constipation, skin problems, depression, fear or anxiety, memory difficulties and slowed thinking, urinary problems, fatigue and aching, loss of energy, compulsive behaviour, cramping etc..

According to a preferred embodiment of the present invention the synucleopathy is selected from the group of Parkinson's Disease, Dementia with Lewy Bodies, multiple system atrophy and neurodegeneration with brain iron accumulation. Particularly preferred is Parkinson's disease.

Another aspect of the present invention relates to a peptide having or consisting of an amino acid sequence selected from the

group consisting of IRWDTP(C), VRWDVYP(C), IRYDAPL(C), IRYDMAG(C), IRWDTSL(C), IRWDQP(C), IRWDG(C), IRWDGG(C), EVWHRHQ(C), ERWHEKH(C), EVWHRLQ(C), ELWHRYP(C), ELWHRAF(C), ELWHRA(C), EVWHRG(C), EVWHRH(C), ERWHEK(C), QDFRHY(C), SEFKHG(C), TSFRHG(C), TSVFRH(C), TPFRHT(C), SQFRHY(C), LMFRHN(C), SAFRHH(C), LPFRHG(C), SHFRHG(C), ILFRHG(C), QFKHDL(C), NWFPHP(C), EEFKYS(C), NELRHST(C), GEMRHQP(C), DTYFPRS(C), VELRHSR(C), YSMRHDA(C), AANYFPR(C), SPNQFRH(C), SSSFFPR(C), EDWFFWH(C), SAGSFRH(C), QVMRHHA(C), SEFSHSS(C), QPNLFYH(C), ELFKHHL(C), TLHEFRH(C), ATFRHSP(C), APMYFPH(C), TYFSHSL(C), HEPLFSH(C), SLMRHSS(C), EFLRHTL(C), ATPLFRH(C), QELKRYY(C), THTDFRH(C), LHIPFRH(C), NELFKHF(C), SQYFPRP(C), DEHPFRH(C), MLPFRHG(C), SAMRHSL(C), TPLMFWH(C), LQFKHST(C), ATFRHST(C), TGLMFKH(C), AEFSHWH(C), QSEFKHW(C), AEFMHSV(C), ADHDFRH(C), DGLLFKH(C), IGFRHDS(C), SNSEFRR(C), SELRHST(C), THMEFRR(C), EELRHSV(C), QLFKHSP(C), YEFRHAQ(C), SNFRHSV(C), APIQFRH(C), AYFPHTS(C), NSSELRH(C), TEFRHKA(C), TSTEMWH(C), SQSYFKH(C), (C)SEFKH, SEFKH(C), (C)HEFRH and HEFRH(C). As indicated by the use of the parenthesis the peptides of the present invention may or may not comprise the cysteine residue at the C- or N-terminus. Consequently the present invention encompasses also the following amino acid sequences: IRWDTP, VRWDVYP, IRYDAPL, IRYDMAG, IRWDTSL, IRWDQP, IRWDG, IRWDGG, EVWHRHQ, ERWHEKH, EVWHRLQ, ELWHRYP, ELWHRAF, ELWHRA, EVWHRG, EVWHRH, ERWHEK, QDFRHY, SEFKHG, TSFRHG, TSVFRH, TPFRHT, SQFRHY, LMFRHN, SAFRHH, LPFRHG, SHFRHG, ILFRHG, QFKHDL, NWFPHP, EEFKYS, NELRHST, GEMRHQP, DTYFPRS, VELRHSR, YSMRHDA, AANYFPR, SPNQFRH, SSSFFPR, EDWFFWH, SAGSFRH, QVMRHHA, SEFSHSS, QPNLFYH, ELFKHHL, TLHEFRH, ATFRHSP, APMYFPH, TYFSHSL, HEPLFSH, SLMRHSS, EFLRHTL, ATPLFRH, QELKRYY, THTDFRH, LHIPFRH, NELFKHF, SQYFPRP, DEHPFRH, MLPFRHG, SAMRHSL, TPLMFWH, LQFKHST, ATFRHST, TGLMFKH, AEFSHWH, QSEFKHW, AEFMHSV, ADHDFRH, DGLLFKH, IGFRHDS, SNSEFRR, SELRHST, THMEFRR, EELRHSV, QLFKHSP, YEFRHAQ, SNFRHSV, APIQFRH, AYFPHTS, NSSELRH, TEFRHKA, TSTEMWH, SQSYFKH, (C)SEFKH, SEFKH, HEFRH and HEFRH.

According to a preferred embodiment the peptide is coupled to a pharmaceutically acceptable carrier, preferably KLH (Key-hole Limpet Hemocyanin).

Yet another aspect of the present invention relates to a pharmaceutical formulation, preferably a vaccine, comprising at least one peptide according to the present invention. Said phar-

maceutical formulation may be employed to treat individuals suffering from ß-Amyloidoses including Alzheimer's disease or prevent the formation of Aß-plaques in an individual to impede the formation of ß-Amyloidoses including Alzheimer's disease.

The present invention is further illustrated by the following figures and examples, however without being restricted thereto.

Fig.1 shows binding of monoclonal antibody MV-001 to specific peptides and recombinant proteins;

Fig. 2 shows binding of monoclonal antibody MV-003 to specific peptides and recombinant proteins;

Fig. 3 shows binding of monoclonal antibody MV-004 to specific peptides and recombinant proteins;

Fig. 4 shows typical binding assays with mimotopes for ß-amyloid and N-terminally truncated and/or posttranslationally modified ß-amyloid fragments;

Fig. 5 shows typical inhibition assays with mimotopes for ß-amyloid and N-terminally truncated and/or posttranslationally modified ß-amyloid fragments;

Fig. 6 shows examples for in vivo characterisations of the immune response elicited by mimotope vaccination (injected peptide/irrelevant peptide);

Fig. 7 shows examples for in vivo characterisation of the immune response elicited by mimotope vaccination against Amyloid Beta fragments;

Fig. 8 shows examples for in vivo characterisation of the immune response elicited by mimotope vaccination against full length Aß40/42.

Fig. 9 shows areas occupied by amyloid plaques. Tg2576 were injected 6 times with mimotope vaccines adjuvanted with aluminium hydroxide (ALUM) by s.c. inoculation at monthly intervals. Con-

trol mice received PBS-ALUM only. Area occupied by amyloid plaques shown as percent of the control group. Gr1...control group; Gr2... received p4381; Gr3... received p4390; Gr4... received p4715

Fig. 10 shows areas occupied by amyloid plaques. Tg2576 were injected 6 times with AFFITOPE vaccines adjuvanted with aluminium hydroxide (ALUM) by s.c. inoculation at monthly intervals. Control mice received PBS-ALUM only. Area occupied by amyloid plaques shown as percent of the control group. Gr1...control group; Gr2... received p4395.

E X A M P L E S :

Methods

The antibodies used for the mimotope identification according to the present invention detect amino acid sequences derived from human Aß but do not bind to full length human APP. The sequences detected include EFRHDS (= original epitope aa3-8 of Aß), p(E)FRHDS(= original epitope of the modified aa3-8 of Aß), EVHHQK(= original epitope aa11-16 of Aß). The antibody may be a monoclonal or polyclonal antibody preparation or any antibody part or derivative thereof, the only prerequisite is that the antibody molecule specifically recognises at least one of the epitopes mentioned above (derived from human Aß), but does not bind to full length human APP.

The mimotopes are identified and further characterised with such monoclonal antibodies and peptide libraries.

Example 1: Generation of monoclonal antibodies to specifically detect ß-amyloid and N-terminally truncated and/or posttranslationally modified ß-amyloid fragments.

Example 1a: ***Generation of monoclonal antibody MV-001***

A monoclonal antibody derived from the fusion of experiment Alz-5 was generated: In experiment Alz-5 C57/Bl6 mice were immunized repeatedly with original Aß epitope DAEFRHDSGYC coupled to KLH (Keyhole Limpet Hemocyanin) and Alum (Aluiminium Hydroxide) as adjuvant. p4371-peptide-specific, antibody-producing hybrido-

mas were detected by ELISA (p1253- and p4371-peptide-coated ELISA plates). Human Aß40/42 (recombinant protein) was used as positive control peptide: hybridomas recognizing the recombinant protein immobilised on ELISA plates were included because they are binding both peptide and full length Aß specifically. P1454 (Human Aß 33-40) was used as negative control peptide. Furthermore hybridomas were tested against p4373. Only hybridomas with no or limited p4373 binding were used for further antibody development.
The Hybridoma clone (MV-001 (internal name 824; IgG1) was purified and analysed for specific detection of p1253, p4371, p4373, p1454 and Aß respectively. MV-001 recognized the injected epitope (p1253) as well as the specific epitope (p4371) and full length Aß protein (recombinant protein; obtained from Bachem AG, Bubendorf, Switzerland) in ELISA. It however did not detect p1454 in ELISA. Furthermore, the MV-001 antibodies basically failed to detect the peptide p4373 encoding the pyroglutamate version of Aß3-10 (30 times lower titer than the original epitopes).

Example 1b: *Generation of monoclonal antibody MV-003*
A monoclonal antibody derived from the fusion of experiment Alz-16 was generated: In experiment Alz-16 BalbC mice were immunized repeatedly with the epitope p(E)FRHDSC (p4373) coupled to KLH (Keyhole Limpet Hemocyanin) and Alum (Aluiminium Hydroxide) as adjuvant. p4373-peptide-specific, antibody-producing hybridomas were detected by ELISA (p4373-peptide-coated ELISA plates). p1253, p1454 and Aß40/42 were used as negative control peptides. Furthermore, hybridomas were tested against p4371. Only hybridomas with no or limited p4371 binding were used for further antibody development in order to guarantee for pyroglutamate-specificity.

The Hybridoma clone (MV-003 (internal name D129; IgG1) was purified and analysed for specific detection of p1253, p4371, p4373, p1454 and Aß respectively. MV-003 recognized the injected epitope (p4373) but failed to detect p1454, p1253 or full length Aß protein (recombinant protein; obtained from Bachem AG, Bubendorf, Switzerland) in ELISA. Furthermore, the MV-003 antibodies failed to detect the peptide p4371 encoding the normal version

of Aß3-10 (15 times lower titer than the original epitope).

Example 1c: ***Generation of monoclonal antibody MV-004***

A monoclonal antibody derived from the fusion of experiment Alz-15 was generated: In experiment Alz-15 BalbC mice were immunized repeatedly with the epitope EVHHQKC (p4372) coupled to KLH (Key-hole Limpet Hemocyanin) and Alum (Aluiminium Hydroxide) as adjuvant. p4372-peptide-specific, antibody-producing hybridomas were detected by ELISA (p4372-peptide-coated ELISA plates). P4376, p4378, p1454 and Aß40/42 were used as negative control peptides. Only hybridomas with no or limited p4376 and p4378 binding were used for further antibody development in order to guarantee for specificity against the free N-Terminus at position aa11.

The Hybridoma clone (MV-004 (internal name B204; IgG1) was purified and analysed for specific detection of p4372, p4376, p4378, p1454 and Aß respectively. MV-004 recognized the injected epitope (p4372) but failed to detect p1454, p4376 and p4378 as well as full length Aß protein (recombinant protein; obtained from Bachem AG, Bubendorf, Switzerland) in ELISA. The failure to detect p4376, p4378 demonstrates specificity for the free N-terminus at position aa11 in truncated Aß.

Example 2: Phage Display, in vitro binding and inhibition ELISA

Phage Display libraries used in this example were: Ph.D. 7: New England BioLabs E8102L (linear 7mer library). Phage Display was done according to manufacturer's protocol (www.neb.com).

After 2 or 3 subsequent rounds of panning, single phage clones were picked and phage supernatants were subjected to ELISA on plates coated with the antibody that was used for the panning procedure. Phage clones that were positive in this ELISA (strong signal for the target, but no signal for unspecific control) were sequenced. From DNA sequences, peptide sequences were deduced. These peptides were synthesized and characterised in binding and inhibition ELISA. Additionally, some novel mimotopes were created by combining sequence information from mimotopes identified in the screen to support the identification of a consensus sequence for a mimotope vaccination.

1. In vitro binding assay (ELISA)
Peptides derived from Phage Display as well as variants thereof were coupled to BSA and bound to ELISA plates (1µM; as indicated in the respective figures) and subsequently incubated with the monoclonal antibody that was used for the screening procedure to analyse binding capacity of identified peptides.

2. In vitro inhibition assay (ELISA)
Different amounts of peptides (concentrations ranging from 10 µg to 0,08µg; serial dilutions), derived from Phage Display were incubated with the monoclonal antibody that was used for the screening procedure. Peptides diminishing subsequent binding of the antibody to the original epitope coated on ELISA plates were considered as inhibiting in this assay.

Example 3: in vivo testing of mimotopes: analysis of immunogenicity and crossreactivity

1. In vivo testing of mimotopes

Inhibiting as well as non-inhibiting peptides were coupled to KLH and injected into mice (wildtype C57/Bl6 mice; subcutaneous injection into the flank) together with an appropriate adjuvant (aluminium hydroxide). Animals were vaccinated 3-6 times in biweekly intervals and sera were taken biweekly as well. Titers to injected peptides, as well as to an irrelevant peptide were determined with every serum. Furthermore, titers against the recombinant human Aß protein, and against original peptides were determined respectively. In general sera were analysed by reaction against peptides coupled to Bovine Serum Albumin (BSA) and recombinant full length proteins which were immobilised on ELISA plates. Titers were determined using anti mouse IgG specific antibodies. For detailed results see Figures 6, 7 and 8 respectively.

2. Results
2.1. Identification of specific monoclonal antibodies (mAB) directed against n-terminally truncated and modified forms of Aß:

Figure 1 depicts the characterisation of the monoclonal antibody MV-001 (internal name 824; IgG1) derived from experiment Alz-5 demonstrating specificity for full length Aß and Aß truncated at position E3.

Figure 2 depicts the characterisation of the monoclonal antibody MV-003 (internal name D129; IgG1) derived from experiment Alz-16 demonstrating specificity for Aß truncated and posttranslationally modified at position p(E)3.

Figure 3 depicts the characterisation of the monoclonal antibody MV-004 (internal name B204; IgG1) derived from experiment Alz-15 demonstrating specificity for Aß truncated at position E11.

2.2. Screening with specific mABs directed against n-terminally truncated and modified forms of Aß:

2.2.1. Phage Display Library Ph.D. 7
2.2.1.1. Screening with monoclonal antibody directed against p4373

8 Sequences were identified by screening PhD 7 phage display libraries in this screen: Table 1A summarises the peptides identified and their binding capacity as compared to the original epitope.

2.2.1.2. Screening with monoclonal antibody directed against p4372

9 Sequences were identified by screening PhD 7 phage display libraries in this screen: Table 1B summarises the peptides identified and their binding capacity as compared to the original epitope.

2.2.1.3. Screening with monoclonal antibody directed against p4371

71 Sequences were identified by screening PhD 7 and PhD12 phage display libraries in this screen: Table 1C summarises the peptides identified and their binding capacity as compared to the

original epitope.

Table 1A: mimotopes binding to the parental antibody MV-003

Internal Peptide number	SEQ ID No.	Sequence	Binding Capacity
p4395	1	IRWDTPC	2
p4396	2	VRWDVYPC	1
p4397	3	IRYDAPLC	1
p4399	4	IRYDMAGC	1
p4728	5	IRWDTSLC	3
p4756	6	IRWDQPC	3
p4792	7	IRWDGC	1
p4793	8	IRWDGGC	2

Legend to Table 1A: the binding capacity is coded by the following binding code: 1:X describes the dilution factor of the parental AB.

binding code		**OD halfmax 1:X**
0	no binding	:0
1	weak binding	:<16000
2	medium binding	:16-60000
3	strong binding	:>60000

Table 1B: mimotopes binding to the parental antibody MV-004

Internal Peptide number	SEQ ID No.	Sequence	Binding Capacity
p4417	9	EVWHRHQC	2
p4418	10	ERWHEKHC	3
p4419	11	EVWHRLQC	3
p4420	12	ELWHRYPC	2
p4665	13	ELWHRAFC	2
p4786	14	ELWHRAC	1
p4788	15	EVWHRGC	1
p4789	16	EVWHRHC	1
p4790	17	ERWHEKC	1

Legend to Table 1B: the binding capacity is coded by the following binding

code: 1:X describes the dilution factor of the parental AB.

binding code		OD halfmax 1:X
0	no binding	:0
1	weak binding	:<24000
2	medium binding	:24-96000
3	strong binding	:>96000

Table 1C: mimotopes binding to the parental antibody MV-001

Internal Peptide number	SEQ ID No.	Sequence	Binding Capacity
p4380	18	QDFRHYC	2
p4381	19	SEFKHGC	3
p4382	20	TSFRHGC	2
p4383	21	TSVFRHC	3
p4384	22	TPFRHTC	2
p4385	23	SQFRHYC	2
p4386	24	LMFRHNC	3
p4387	25	SAFRHHC	2
p4388	26	LPFRHGC	2
p4389	27	SHFRHGC	2
p4390	28	ILFRHGC	3
p4391	29	QFKHDLC	2
p4392	30	NWFPHPC	1
p4393	31	EEFKYSC	2
p4701	32	NELRHSTC	3
p4702	33	GEMRHQPC	3
p4703	34	DTYFPRSC	2
p4704	35	VELRHSRC	2
p4705	36	YSMRHDAC	2
p4706	37	AANYFPRC	2
p4707	38	SPNQFRHC	3
p4708	39	SSSFFPRC	2
p4709	40	EDWFFWHC	1
p4710	41	SAGSFRHC	3
p4711	42	QVMRHHAC	2

p4712	43	SEFSHSSC	3
p4713	44	QPNLFYHC	1
p4714	45	ELFKHHLC	3
p4715	46	TLHEFRHC	3
p4716	47	ATFRHSPC	2
p4717	48	APMYFPHC	2
p4718	49	TYFSHSLC	2
p4719	50	HEPLFSHC	1
p4721	51	SLMRHSSC	2
p4722	52	EFLRHTLC	3
p4723	53	ATPLFRHC	3
p4724	54	QELKRYYC	1
p4725	55	THTDFRHC	3
p4726	56	LHIPFRHC	3
p4727	57	NELFKHFC	2
p4729	58	SQYFPRPC	2
p4730	59	DEHPFRHC	3
p4731	60	MLPFRHGC	2
p4732	61	SAMRHSLC	2
p4733	62	TPLMFWHC	1
p4734	63	LQFKHSTC	2
p4735	64	ATFRHSTC	2
p4736	65	TGLMFKHC	2
p4737	66	AEFSHWHC	2
p4738	67	QSEFKHWC	3
p4739	68	AEFMHSVC	2
p4740	69	ADHDFRHC	3
p4741	70	DGLLFKHC	3
p4742	71	IGFRHDSC	2
p4743	72	SNSEFRRC	3
p4744	73	SELRHSTC	3
p4745	74	THMEFRRC	3
p4746	75	EELRHSVC	3
p4747	76	QLFKHSPC	3
p4748	77	YEFRHAQC	3
p4749	78	SNFRHSVC	3
p4750	79	APIQFRHC	3
p4751	80	AYFPHTSC	2

p4752	81	NSSELRHC	3
p4753	82	TEFRHKAC	3
p4754	83	TSTEMWHC	1
p4755	84	SQSYFKHC	3
p4800	85	CSEFKH	3
p4801	86	SEFKHC	3
p4802	87	CHEFRH	3
p4803	88	HEFRHC	3

Legend to Table 1C: the binding capacity is coded by the following binding code: 1:X describes the dilution factor of the parental AB

binding code		OD halfmax 1:X
0	no binding	:0
1	weak binding	:<4000
2	medium binding	:4000-20000
3	strong binding	:>20000

2.3. In vitro characterisation of mimotopes identified in screening Phage Display Libraries with monoclonal antibodies directed against n-terminally truncated and modified forms of Aß:

Figures 4 and 5 show representative examples for binding and inhibition assays used to characterise mimotopes in vitro. Data obtained are summarised in Tables 1 and 2 respectively.

MV-003 Mimotopes: From the 8 sequences presented 6 sequences inhibit binding of the p(E)3-7Aß specific monoclonal antibody in in vitro competition experiments: Additional 2 sequences were identified that do not inhibit binding of monoclonal antibody in in vitro competition experiments but still retain binding capacity to the parental antibody (Table 2A).

MV-004 Mimotopes: All the 9 sequences presented inhibit binding of the monoclonal antibody specifically binding the free N-terminus of Aß truncated at position E11 in in vitro competition

experiments: (Table 2B).

MV-001 Mimotopes: From the 71 sequences presented 27 sequences inhibit binding of the monoclonal antibody specifically directed against Aß truncated at position E3 in in vitro competition experiments: Additional 44 sequences were identified that do not inhibit binding of monoclonal antibody in in vitro competition experiments but still retain binding capacity to the parental antibody (Table 2C).

Table 2: mimotopes identified in this invention giving positive results in inhibiting assays

Table 2A: MV-003 Mimotopes

Internal Peptide number	SEQ ID No.	Sequence	Inhibition Capacity
p4395	1	IRWDTPC	1
p4397	3	IRYDAPLC	1
p4728	5	IRWDTSLC	2
p4756	6	IRWDQPC	1
p4792	7	IRWDGC	1
p4793	8	IRWDGGC	1

Legend to Table 2A: the inhibition capacity is coded by the following code: Weak inhibition means more peptide is required to lower AB binding than with the original epitope; strong inhibition means similar peptide amounts are required for mimotope and original epitope for lowering AB binding. Mimotopes are compared to the original peptide as standard. OD at 10ug peptide used in the assay is used to calculate the competition capacity compared to original peptide.

competition code	
0	no inhibition (OD of 10ug peptide above 12 times of original peptide)
1	Weaker than original epitope (OD of 10ug peptide below 12 times of original peptide)
2	strong inhibition (as original epitope; OD of 10ug peptide below 5 times of original peptide)

Table 2B: MV-004 Mimotopes

Internal Peptide number	SEQ ID No.	Sequence	Inhibition Capacity
p4417	9	EVWHRHQC	1
p4418	10	ERWHEKHC	2
p4419	11	EVWHRLQC	2
p4420	12	ELWHRYPC	1
p4665	13	ELWHRAFC	2
p4786	14	ELWHRAC	1
p4788	15	EVWHRGC	1
p4789	16	EVWHRHC	1
p4790	17	ERWHEKC	2

Legend to Table 2B: the inhibition capacity is coded by the following code: Weak inhibition means more peptide is required to lower AB binding than with the original epitope; strong inhibition means similar peptide amounts are required for mimotope and original epitope for lowering AB binding. Mimotopes are compared to the original peptide as standard. OD at 10ug peptide used in the assay is used to calculate the competition capacity compared to original peptide.

competition code	
0	no inhibition (OD of 10ug peptide above 5 times of original peptide)
1	Weaker than original epitope (OD of 10ug peptide below 5 times of original peptide)
2	strong inhibition (as original epitope; OD of 10ug peptide below 2 times of original peptide)

Table 2C: MV-001 Mimotopes

Internal Peptide number	SEQ ID No.	Sequence	Inhibition Capacity
p4380	18	QDFRHYC	1
p4381	19	SEFKHGC	1
p4382	20	TSFRHGC	1
p4383	21	TSVFRHC	1
p4384	22	TPFRHTC	1
p4385	23	SQFRHYC	1

p4386	24	LMFRHNC	1
p4387	25	SAFRHHC	1
p4388	26	LPFRHGC	1
p4389	27	SHFRHGC	1
p4390	28	ILFRHGC	1
p4391	29	QFKHDLC	1
p4392	30	NWFPHPC	1
p4393	31	EEFKYSC	1
p4707	38	SPNQFRHC	1
p4715	46	TLHEFRHC	2
p4725	55	THTDFRHC	1
p4730	59	DEHPFRHC	1
p4738	67	QSEFKHWC	1
p4740	69	ADHDFRHC	1
p4741	70	DGLLFKHC	1
p4746	75	EELRHSVC	1
p4753	82	TEFRHKAC	2
p4800	85	CSEFKH	2
p4801	86	SEFKHC	1
p4802	87	CHEFRH	2
p4803	88	HEFRHC	2

Legend to Table 2C: the inhibition capacity is coded by the following code: Weak inhibition means more peptide is required to lower AB binding than with the original epitope; strong inhibition means similar peptide amounts are required for mimotope and original epitope for lowering AB binding. Mimotopes are compared to the original peptide as standard. OD at 10ug peptide used in the assay is used to calculate the competition capacity compared to original peptide.

competition code	
0	no inhibition (OD of 10ug peptide above 3 times of original peptide)
1	Weaker than original epitope (OD of 10ug peptide below 3 times of original peptide)
2	strong inhibition (as original epitope; OD of 10ug peptide below 2 times of original peptide)

Table 3: Non-mimotope peptides

Internal Peptide number	SEQ ID No.	Sequence
p1253	89	DAEFRHDSGYC
p4371	90	EFRHDS-C
p4372	91	EVHHQK-C
p4373	92	p(E)FRHDS-C
p4374	93	p(E)VHHQKLVFC
p4376	94	GYEVHHQKC
p4377	95	EVHHQKLVFC
p4378	96	C-EVHHQKLVFF
p1454	97	CGLMVGGVV
Aß1-40	98	DAEFRHDSGYEVHHQKLVFFAEDVGSNKGAI-IGLMVGGVV
Aß1-42	99	DAEFRHDSGYEVHHQKLVFFAEDVGSNKGAI-IGLMVGGVVIA
sAPPalpha	100	alpha-Secretase induced cleavage product derived from human APP (gi:112927)

2.4. In vivo characterisation of mimotopes identified in screening Phage Display Libraries with a monoclonal antibody directed against against n-terminally truncated and modified forms of Aß:

Female C57/bl6 mice, 5-6 mice per group, were subcutaneously immunized with 30 µg peptide coupled to KLH. Control groups were administered original epitope-KLH conjugates respectively. As adjuvant alum was used (always 1 mg per mouse). The peptides administered were all able to bind to monoclonal antibodies specifically although some of the peptides did not inhibit the binding of the original epitope to its parental antibody in vitro (in an in vitro inhibition assay). The in vitro ELISA assay to determine the antibody titer was performed with sera of single mice after each vaccination in a two week interval (see Fig. 6 and 7 respectively). The wells of the ELISA plate were coated

with mimotope-BSA conjugate and an irrelevant peptide-BSA conjugate (negative control). The positive control was performed by reaction of the parental antibody with the respective mimotope-BSA conjugate. The detection was performed with anti-mouse IgG. Additionally, recombinant proteins were immobilised on ELISA plates and sera reacted accordingly. Figures 6 to 8 show representative examples for assays used to characterise mimotopes in vivo.

Figure 6 shows examples for in vivo characterisations of the immune response elicited by mimotope vaccination by analysing the immune response against injected peptide and an irrelevant peptide, containing an unrelated sequence. In all three examples shown, the original epitopes and the mimotopes, elicit immune responses against the injected peptides but fail to induce a relevant immune response against an unrelated sequence (p1454).

As example for MV-003-mimotopes, original epitope p4373 and the mimotopes p4395, p4396, p4397, and p4399 are depicted in Figure 6A. All vaccines are mounting similar immune responses against their respective mimotopes. Neither original epitope p4373-vaccine treated nor the animals treated with mimotope p4395, p4396, p4397 or p4399- vaccines mount relevant titers against irrelevant peptide p1454 (11x -25x less than injected peptides).

As example for MV-004-mimotopes original epitope p4372 and the mimotopes p4417, p4418, p4419, and p4420 are depicted in Figure 6B. All vaccines are mounting similar immune responses against their respective mimotopes. Neither original epitope p4372-vaccine treated nor the animals treated with mimotope p4417, p4418, p4419, and p4420- vaccines mount relevant titers against irrelevant peptide p1454 (20-80x less than injected peptides).

As example for MV-001-mimotopes original epitope p4371 and the mimotopes p4381, p4382, and p4390 are depicted in Figure 6C. All vaccines are mounting similar immune responses against their respective mimotopes. Neither original epitope p4371-vaccine treated nor the animals treated with mimotope p4381, p4382, and p4390 - vaccines mount relevant titers against irrelevant peptide p1454 (>10x less than injected peptides).

Figure 7 shows examples for in vivo characterisations of the immune response elicited by mimotope vaccination against the respective original epitope of the parental antibody as well as against peptides derived of other forms of truncated species of Aß.

As example for MV-003-mimotopes, original epitope p4373 and the mimotopes p4395, p4396, p4397, and p4399 are depicted in Figure 7A. 3/4 Mimotope vaccines indicated mount detectable immune responses against the original epitope p4373. A similar phenomenon can be detected analysing cross reactivity against the non-modified form as displayed by p4371. The original epitope p4373-vaccine and 2/4 Mimotope vaccines mount relevant titers against p4371. Surprisingly, the mimotopes selected by MV-003, which is specifically binding to p4373 are also inducing a immune reaction cross reacting with the unmodified form of the original epitope.

As example for MV-004-mimotopes, original epitope p4372 and the mimotopes p4417, p4418, p4419, and p4420 are depicted in Figure 7B. 3/4 Mimotope vaccines shown mount detectable immune responses against the original epitope p4372.

As example for MV-001-mimotopes, original epitope p4371 and the mimotopes p4381, p4382, and p4390 are depicted in Figure 7C. All Mimotope vaccines depicted mount detectable immune responses against the original epitope p4371. A similar phenomenon as described for MV-003 derived mimotopes can be detected analysing cross reactivity against the pyroglutamate-modified form as displayed by p4373. The original epitope p4371-vaccine and all Mimotope vaccines mount relevant titers against p4373. Surprisingly, the mimotopes selected by MV-001, which is specifically binding to p4371 are inducing a immune reaction cross reacting better with the modified form of the original epitope than the original epitope induced immune reaction or the parental antibody. Thus these mimotopes might surprisingly be able to induce but are not necessarily inducing a broader immune reaction than the parental antibody and can be used for a more wide targeting of forms of Aß.

Figure 8 shows examples for in vivo characterisations of the immune response elicited by mimotope vaccination against full length Aß. Surprisingly, the mimotopes selected by using MV-001 and MV-003 induce a cross reaction not only with the truncated or modified short epitopes used to create the antibodies but also induce cross reactivity to full length, non modified forms of Aß as good as the original sequence or even more efficiently than p4371/p4373. For MV-002 original epitope as well as for the mimotopes identified, no such cross reactivity can be detected demonstrating a transfer of specificity of the antibody to the free N-Terminus of unmodified Aß11-40/42. Thus the mimotopes presented in this invention constitute optimised vaccine candidates to target a broad spectrum of naturally occurring forms of the Aß peptides as have been found in the brain of AD patients. The forms include but are not limited to Aß1-40/42, and N-terminally truncated forms like Aß3-40/42, Aß(pE)3-40/42 and unmodified Aß11-40/42 respectively.

In Table 4 and 5 further examples of the immune response elicited by mimotope vaccination against full length Aß by using MV-001 and MV-003 derived mimotopes are described.

Table 4: *In vivo characterisation of mimotopes: MV-001*

Internal Peptide number	**SEQ ID No.**	**Detection of Aß/truncated/modified forms**
p4381	**19**	**+**
p4383	**21**	**+**
p4385	**23**	**+**
p4386	**24**	**+**
p4390	**28**	**+**
p4707	**38**	**+**
p4714	**45**	**+**
p4715	**46**	**+**
p4725	**55**	**+**
p4730	**59**	**+**
p4738	**67**	**+**
p4740	**69**	**+**
p4748	**77**	**+**

p4753	**82**	**+**

All peptides listed in Table 4 mount specific immune reactions against full length and/or truncated and modified forms of Aß or fragments thereof.

Table 5: *In vivo characterisation of mimotopes: MV-003*

Internal Peptide number	**SEQ ID No.**	**Detection of Aß/truncated/modified forms**
p4395	**1**	**+**
p4396	**2**	**+**
p4397	**3**	**+**
p4399	**4**	**+**

All peptides listed in Table 5 mount specific immune reactions against full length and/or truncated and modified forms of Aß or fragments thereof.

2.5: In vivo characterisation of mimotopes for the efficacy to reduce AD like disease in transgenic animals

The Tg2576 AD mouse model was used to study the preclinical efficacy of the mimotope vaccines. This transgenic line is expressing human APP carrying the Swedish double mutation at aa position 670/671 under the control of a hamster prion protein (PrP) promoter which results in overexpression of the protein. It is currently one of the most widely employed models in AD research. The Tg2576 model recapitulates various hallmarks of AD pathology including disease-specific amyloid plaque deposition and astrocytosis. As all other AD model systems available to date, it does not reflect all cardinal neuropathological features of AD.

To assess whether treatment with mimotopes is capable of preventing cerebral Aß accumulation, Tg2576 mice were s.c. injected 6 times at monthly intervals with peptide-KLH conjugates adsorbed to ALUM (adjuvant: aluminium hydroxide) or PBS adsorbed to ALUM (referred to as PBS or control) alone. Up to eight weeks

after the last immunization, animals were sacrificed, their brains harvested and analyzed for their Aß load (AD-like pathology). The mice were sacrificed under deep anaesthesia. Subsequently, the brain was isolated, fixed in 4%PFA and dehydrated by graded Ethanol series followed by incubation in Xylene and paraffin embedding. Each paraffin-embedded brain was sectioned at 7µM using a slicing microtome and sections were mounted on glass slides.

As a method to assay AD-like pathology in Tg2576 animals, we analyzed the relative area occupied by amyloid deposits in the brain of treated animals. This analysis was performed using an automated area recognition programme. To identify the plaques, sections were stained with the monoclonal antibody (mAb) 3A5 (specific for Aß40/42). Mimotope treated animals were compared to control animals. All animals have been sacrificed at an age of 13,5-14 months. For this analysis 3 slides/animal covering the cortex and hippocampus were selected, stained with mAb 3A5 and subsequently documented using the Mirax-system (Zeiss). For the calculation of the area occupied by amyloid plaques, we analysed up to four individual sections per slide and sections carrying tissue artefacts and aberrant staining intensities have been excluded after inspection of the result pictures.

For the mimotopes derived from MV001 an area analysis using three exemplary candidates was performed: Analysis was performed following repeated vaccination using peptide-KLH conjugate vaccines. The control group showed an average occupation of 0,35% as compared to 0,11%, 0,14% and 0,22% for the mimotope treated animals respectively. This corresponds to a reduction following mimotope treatment of 67% in group 2, a 60% reduction in group 3 and a 36% reduction in group 4 (see Fig. 9).

A similar picture can be detected for the group of MV003 derived mimotopes. Here the example of p4395 is depicted. As described for the MV001 derived mimotopes, an analysis of the area occupied by amyloid plaques following peptide-conjugate vaccination has been performed. The control group showed an average occupation of 0,35% as compared to 0,21% for the mimotope treated animals respectively. This corresponds to a reduction following mi-

motope treatment of 38% in group 2 (see Fig. 10).

Thus, this set of data clearly indicates a beneficial effect of mimotope vaccine treatment on AD like pathology in transgenic animals.

Claims:

1. Use of at least one compound comprising an amino acid sequence selected from the group consisting of SEFKHG(C), TLHEFRH(C), ILFRHG(C), TSVFRH(C), SQFRHY(C), LMFRHN(C), SPNQFRH(C), ELFKHHL(C), THTDFRH(C), DEHPFRH(C), QSEFKHW(C), ADHDFRH(C), YEFRHAQ(C) and TEFRHKA(C) for producing a medicament for preventing and/or treating β-amyloidoses.

2. Use of at least one compound comprising the amino acid sequence

$X_1RX_2DX_3(X_4)_n(X_5)_m(X_6)_o$ (Formula I),

wherein

X_1 is isoleucine (I) or valine (V),
X_2 is tryptophan (W) or tyrosine (Y),
X_3 is threonine (T), valine (V), alanine (A), methionine (M), glutamine (Q) or glycine (G),
X_4 is proline (P), alanine (A), tyrosine (Y), serine (S), cysteine (C) or glycine (G),
X_5 is proline (P), leucine (L), glycine (G) or cysteine (C),
X_6 is cysteine (C),
n, m and o are, independently, 0 or 1,

said compound having a binding capacity to an antibody which is specific for an epitope of the amyloid-beta-peptide (Aβ) comprising the amino acid sequence EFRHDSGY and/or pEFRHDSGY

for producing a medicament for preventing and/or treating β-amyloidoses.

3. Use according to claim 2, characterised in that the compound comprises a peptide having an amino acid sequence selected from the group consisting of IRWDTP(C), VRWDVYP(C), IRYDAPL(C), IRYDMAG(C), IRWDTSL(C), IRWDQP(C), IRWDG(C) and IRWDGG(C).

4. Use of at least one compound comprising the amino acid sequence

$EX_1WHX_2X_3(X_4)_n(X_5)_m$ (Formula II),

wherein

X_1 is valine (V), arginine (R) or leucine (L),
X_2 is arginine (R) or glutamic acid (E),
X_3 is alanine (A), histidine (H), lysine (K), leucine (L), tyrosine (Y) or glycine (G),
X_4 is proline (P), histidine (H), phenylalanine (F) or glutamine (Q) or Cysteine
X_5 is cysteine (C),
n and m are, independently, 0 or 1,

said compound having a binding capacity to an antibody which is specific for an epitope of the amyloid-beta-peptide (Aβ) comprising the amino acid sequence EVHHQKL

for producing a medicament for preventing and/or treating β-amyloidoses.

5. Use according to claim 4, characterised in that the compound comprises a peptide having an amino acid sequence selected from the group consisting of EVWHRHQ(C), ERWHEKH(C), EVWHRLQ(C), ELWHRYP(C), ELWHRAF(C), ELWHRA(C), EVWHRG(C), EVWHRH(C) and ERWHEK(C), preferably EVWHRHQ(C), ERWHEKH(C), EVWHRLQ(C), ELWHRYP(C) and ELWHRAF(C).

6. Use of at least one compound comprising an amino acid sequence selected from the group consisting of QDFRHY(C), SEFKHG(C), TSFRHG(C), TSVFRH(C), TPFRHT(C), SQFRHY(C), LMFRHN(C), SAFRHH(C), LPFRHG(C), SHFRHG(C), ILFRHG(C), QFKHDL(C), NWFPHP(C), EEFKYS(C), NELRHST(C), GEMRHQP(C), DTYFPRS(C), VELRHSR(C), YSMRHDA(C), AANYFPR(C), SPNQFRH(C), SSSFFPR(C), EDWFFWH(C), SAGSFRH(C), QVMRHHA(C), SEFSHSS(C), QPNLFYH(C), ELFKHHL(C), TLHEFRH(C), ATFRHSP(C), APMYFPH(C), TYFSHSL(C), HEPLFSH(C), SLMRHSS(C), EFLRHTL(C), ATPLFRH(C), QELKRYY(C), THTDFRH(C), LHIPFRH(C), NELFKHF(C), SQYFPRP(C), DEHPFRH(C), MLPFRHG(C), SAMRHSL(C), TPLMFWH(C), LQFKHST(C), ATFRHST(C), TGLMFKH(C), AEFSHWH(C), QSEFKHW(C), AEFMHSV(C),

ADHDFRH(C), DGLLFKH(C), IGFRHDS(C), SNSEFRR(C), SELRHST(C), THMEFRR(C), EELRHSV(C), QLFKHSP(C), YEFRHAQ(C), SNFRHSV(C), APIQFRH(C), AYFPHTS(C), NSSELRH(C), TEFRHKA(C), TSTEMWH(C), SQSYFKH(C), (C)SEFKH, SEFKH(C), (C)HEFRH and HEFRH(C) for producing a medicament for preventing and/or treating β-amyloidoses.

7. Use according to claim 6, characterised in that the compound comprises a peptide having an amino acid sequence selected from the group consisting of QDFRHY(C), SEFKHG(C), TSFRHG(C), TSVFRH(C), TPFRHT(C), SQFRHY(C), LMFRHN(C), SAFRHH(C), LPFRHG(C), SHFRHG(C), ILFRHG(C), QFKHDL(C), NWFPHP(C), EEFKYS(C), SPNQFRH(C), TLHEFRH(C), THTDFRH(C), DEHPFRH(C), QSEFKHW(C), ADHDFRH(C), DGLLFKH(C), EELRHSV(C), TEFRHKA(C), (C)SEFKH, SEFKH(C), (C)HEFRH and HEFRH(C), preferably SEFKHG(C), TSVFRH(C), SQFRHY(C), LMFRHN(C), ILFRHG(C), SPNQFRH(C), ELFKHHL(C), TLHEFRH(C), THTDFRH(C), DEHPFRH(C), QSEFKHW(C), ADHDFRH(C), YEFRHAQ(C), TEFRHKA(C).

8. Use according to any one of claims 1 to 7, characterised in that the compound is a polypeptide comprising 4 to 20 amino acid residues.

9. Use according to any one of claims 1 to 8, characterised in that the compound is coupled to a pharmaceutically acceptable carrier, preferably KLH (Keyhole Limpet Hemocyanin).

10. Use according to any one of claims 1 to 9, characterised in that the compound is formulated for intravenous, subcutaneous, intradermal or intramuscular administration.

11. Use according to any one of claims 1 to 10, characterised in that the compound is formulated with an adjuvant, preferably aluminium hydroxide.

12. Use according to any one of claims 1 to 11, characterised in that the compound is contained in the medicament in an amount of from 0.1 ng to 10 mg, preferably 10 ng to 1 mg, in particular 100 ng to 10 µg.

13. Use of a compound as defined in any one claims 1 to 10 for treating and/or ameliorating symptoms of synucleopathy.

14. Use according to claim 13, characterised in that the synucleopathy is selected from the group of Parkinson's Disease, Dementia with Lewy Bodies, multiple system atrophy and neurodegeneration with brain iron accumulation.

15. Peptide having an amino acid sequence selected from the group consisting of IRWDTP(C), VRWDVYP(C), IRYDAPL(C), IRYDMAG(C), IRWDTSL(C), IRWDQP(C), IRWDG(C), IRWDGG(C), EVWHRHQ(C), ERWHEKH(C), EVWHRLQ(C), ELWHRYP(C), ELWHRAF(C), ELWHRA(C), EVWHRG(C), EVWHRH(C), ERWHEK(C), QDFRHY(C), SEFKHG(C), TSFRHG(C), TSVFRH(C), TPFRHT(C), SQFRHY(C), LMFRHN(C), SAFRHH(C), LPFRHG(C), SHFRHG(C), ILFRHG(C), QFKHDL(C), NWFPHP(C), EEFKYS(C), NELRHST(C), GEMRHQP(C), DTYFPRS(C), VELRHSR(C), YSMRHDA(C), AANYFPR(C), SPNQFRH(C), SSSFFPR(C), EDWFFWH(C), SAGSFRH(C), QVMRHHA(C), SEFSHSS(C), QPNLFYH(C), ELFKHHL(C), TLHEFRH(C), ATFRHSP(C), APMYFPH(C), TYFSHSL(C), HEPLFSH(C), SLMRHSS(C), EFLRHTL(C), ATPLFRH(C), QELKRYY(C), THTDFRH(C), LHIPFRH(C), NELFKHF(C), SQYFPRP(C), DEHPFRH(C), MLPFRHG(C), SAMRHSL(C), TPLMFWH(C), LQFKHST(C), ATFRHST(C), TGLMFKH(C), AEFSHWH(C), QSEFKHW(C), AEFMHSV(C), ADHDFRH(C), DGLLFKH(C), IGFRHDS(C), SNSEFRR(C), SELRHST(C), THMEFRR(C), EELRHSV(C), QLFKHSP(C), YEFRHAQ(C), SNFRHSV(C), APIQFRH(C), AYFPHTS(C), NSSELRH(C), TEFRHKA(C), TSTEMWH(C), SQSYFKH(C), (C)SEFKH, SEFKH(C), (C)HEFRH and HEFRH(C).

16. Peptide according to claim 15, characterised in that the peptide is coupled to a pharmaceutically acceptable carrier, preferably KLH (Keyhole Limpet Hemocyanin).

17. Pharmaceutical formulation, preferably a vaccine, comprising at least one peptide according to claim 15 or 16.

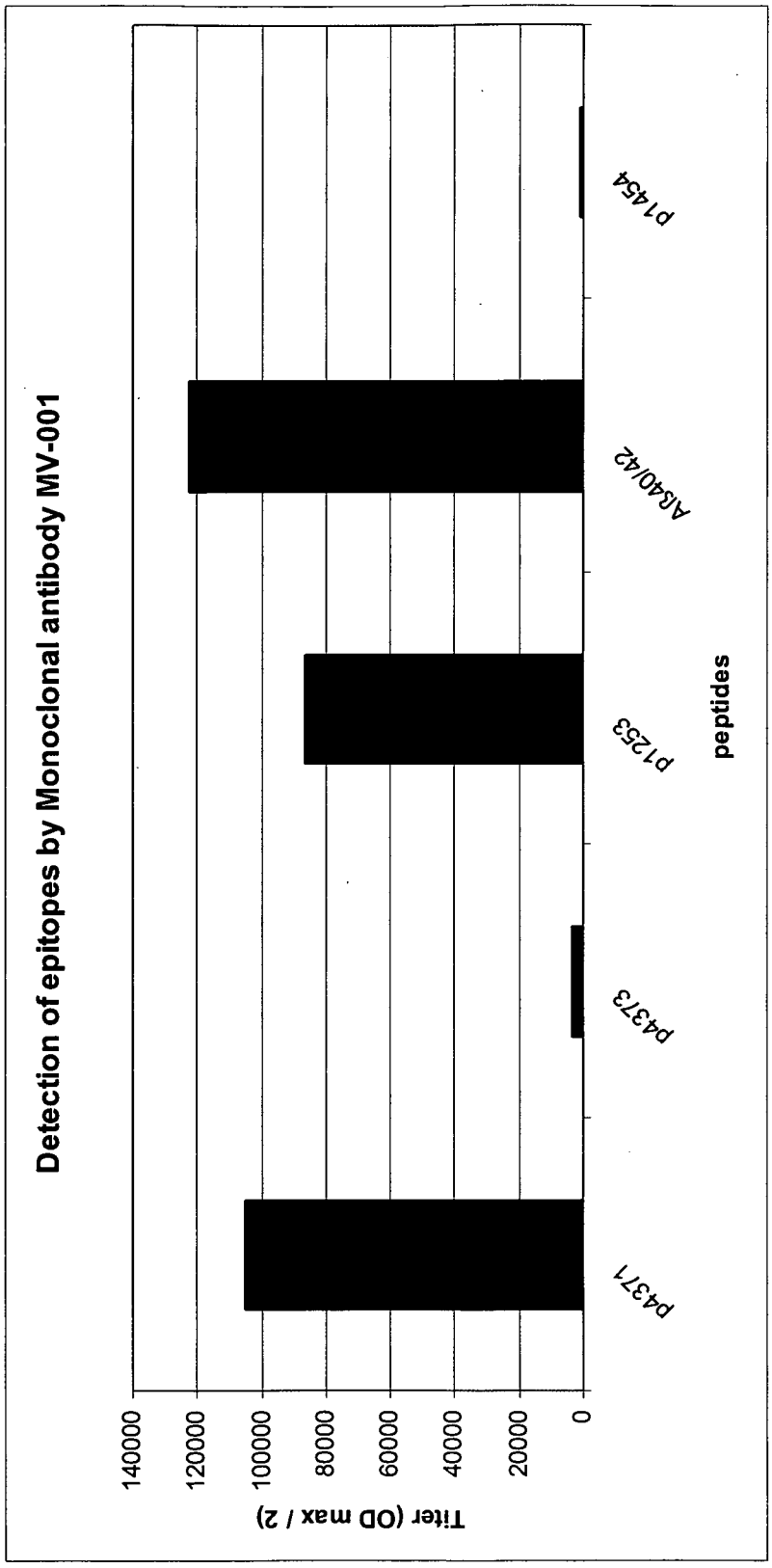
Detection of epitopes by Monoclonal antibody MV-001
Titer (OD max / 2)
140000
120000
100000
80000
60000
40000
20000
0
peptides
p437l
p437s
p1253
Aß40/42
p1454

Fig. 1

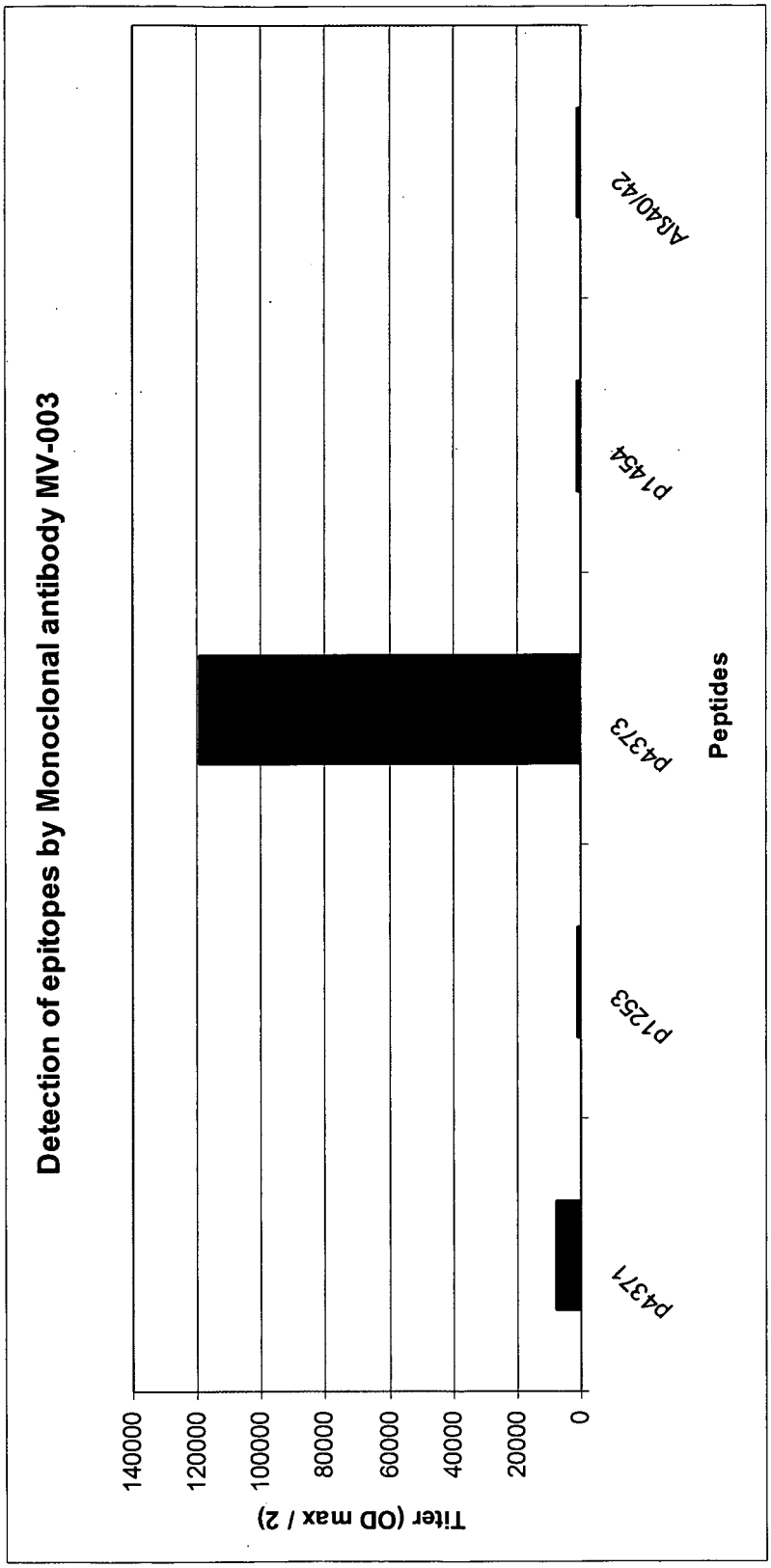
Detection of epitopes by Monoclonal antibody MV-003
Titer (OD max / 2)
140000
120000
100000
80000
60000
40000
20000
0
Peptides
p437
p1253
p437
p1454
Aß40/42

Fig. 2

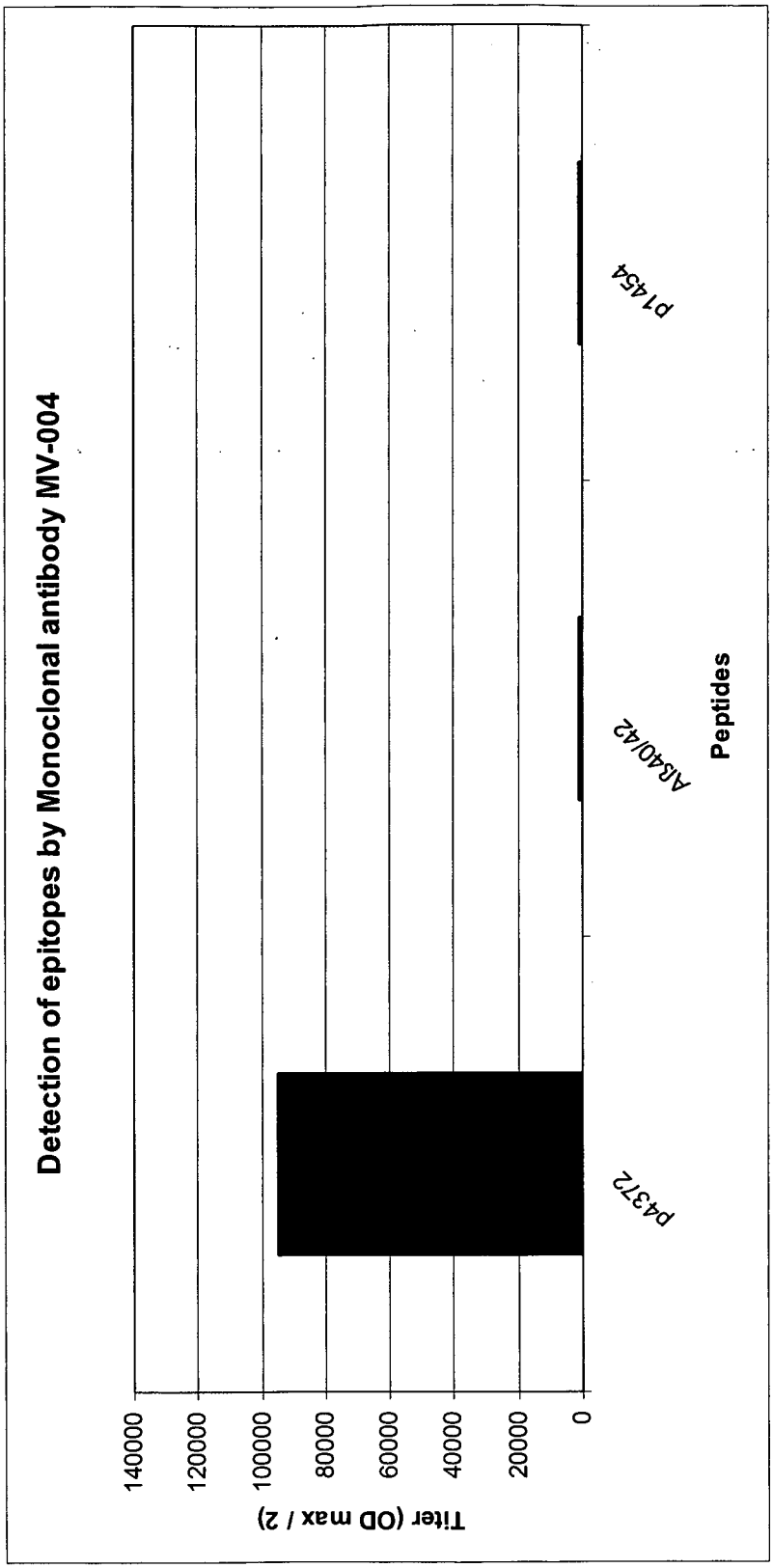
Detection of epitopes by Monoclonal antibody MV-004
Titer (OD max / 2)
140000
120000
100000
80000
60000
40000
20000
0
p43?2
Aß40/42
p1454
Peptides

Fig. 3

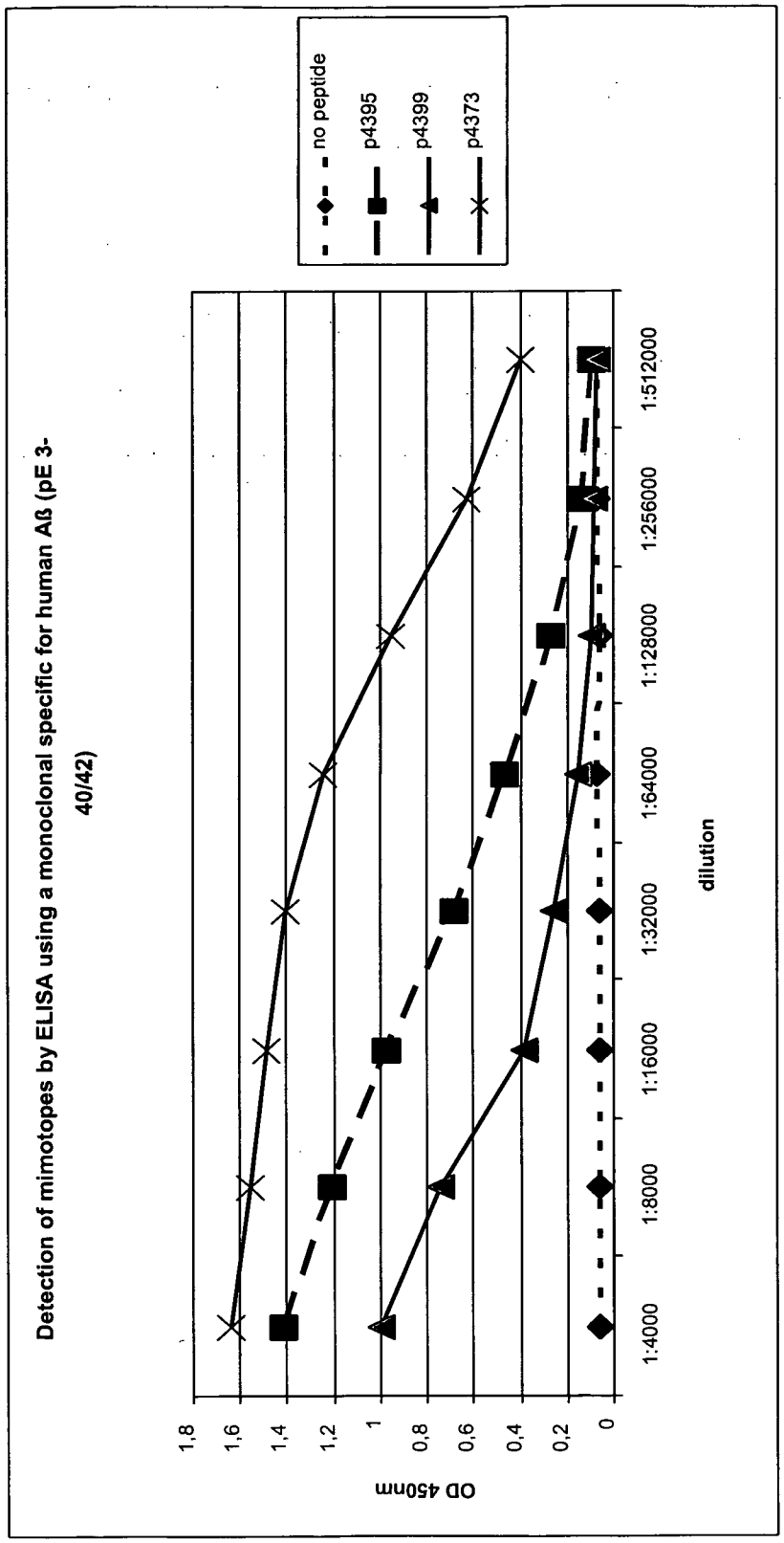
Detection of mimotopes by ELISA using a monoclonal specific for human Aß (pE 3-40/42)
no peptide
p4395
p4399
p4373
OD 450nm
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
1:4000
1:8000
1:16000
1:32000
1:64000
1:128000
1:256000
1:512000
dilution

Fig. 4A

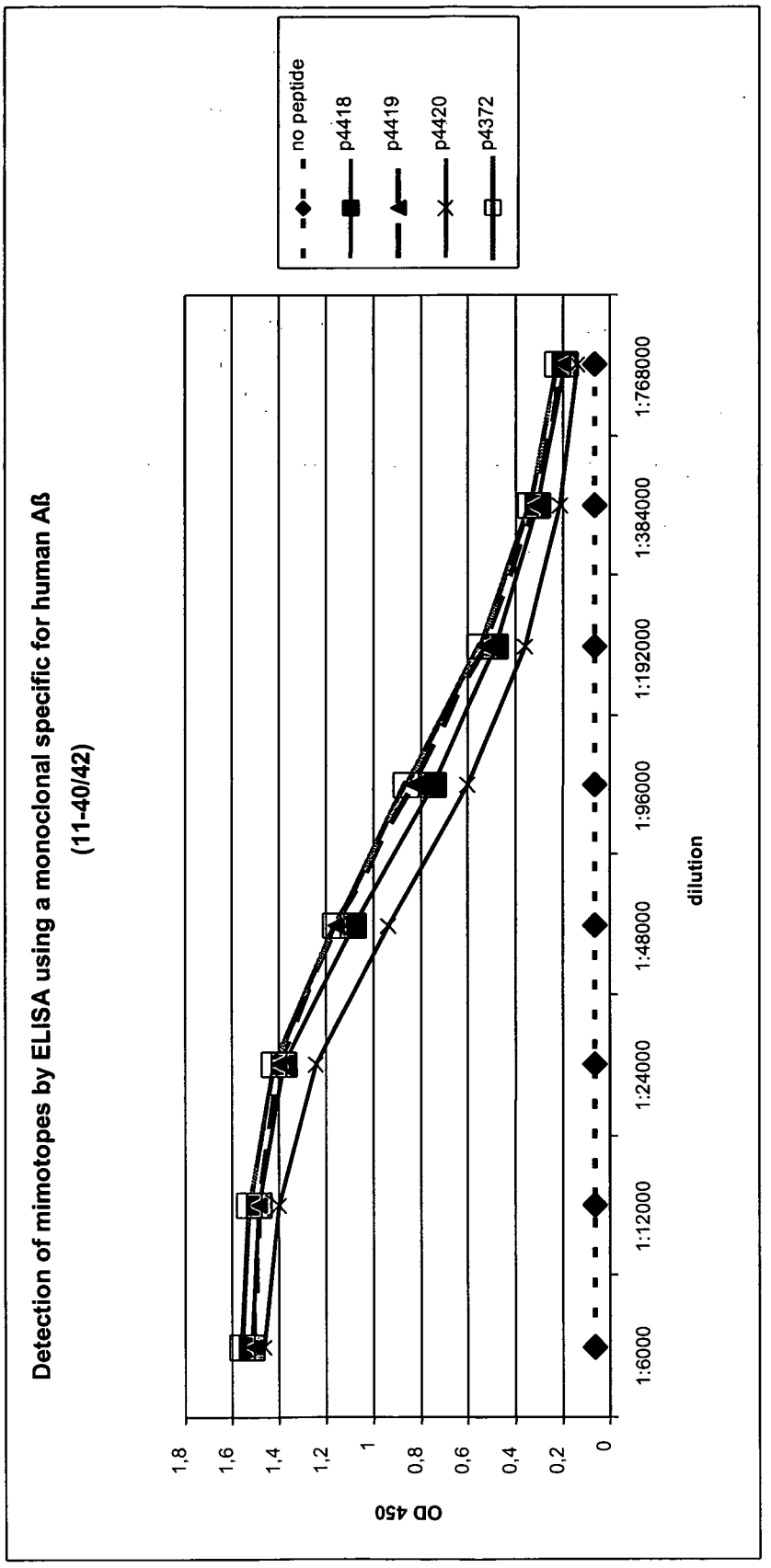
Detection of mimotopes by ELISA using a monoclonal specific for human Aß
(11-40/42)
no peptide
p4418
p4419
p4420
p4372
OD 450
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
1:6000
1:12000
1:24000
1:48000
1:96000
1:192000
1:384000
1:768000
dilution

Fig. 4B

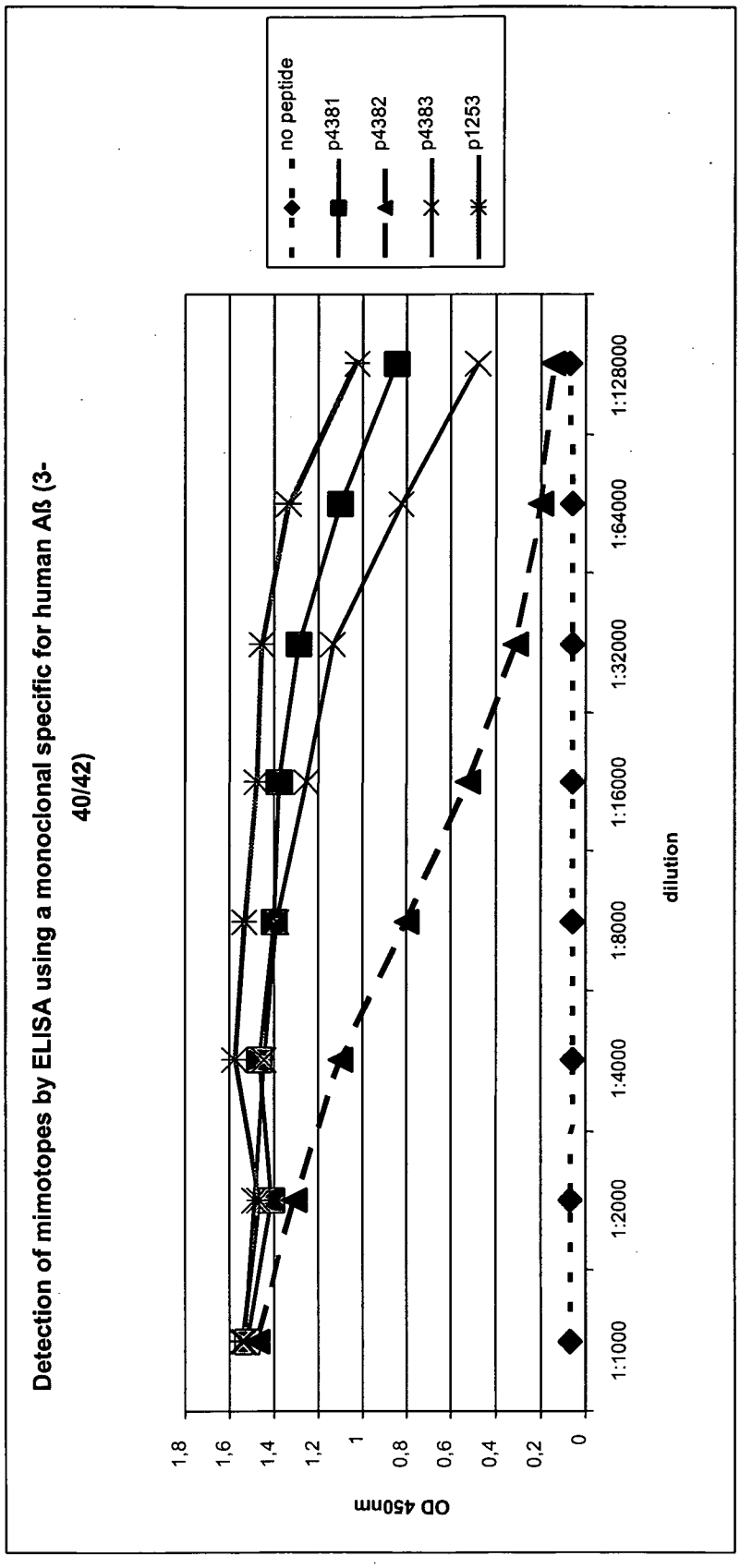
Detection of mimotopes by ELISA using a monoclonal specific for human Aß (3-40/42)
no peptide
p4381
p4382
p4383
p1253
OD 450nm
1,8
1,6
1,4
1,2
1
0,8
0,6
0,4
0,2
0
1:1000
1:2000
1:4000
1:8000
1:16000
1:32000
1:64000
1:128000
dilution

Fig. 4C

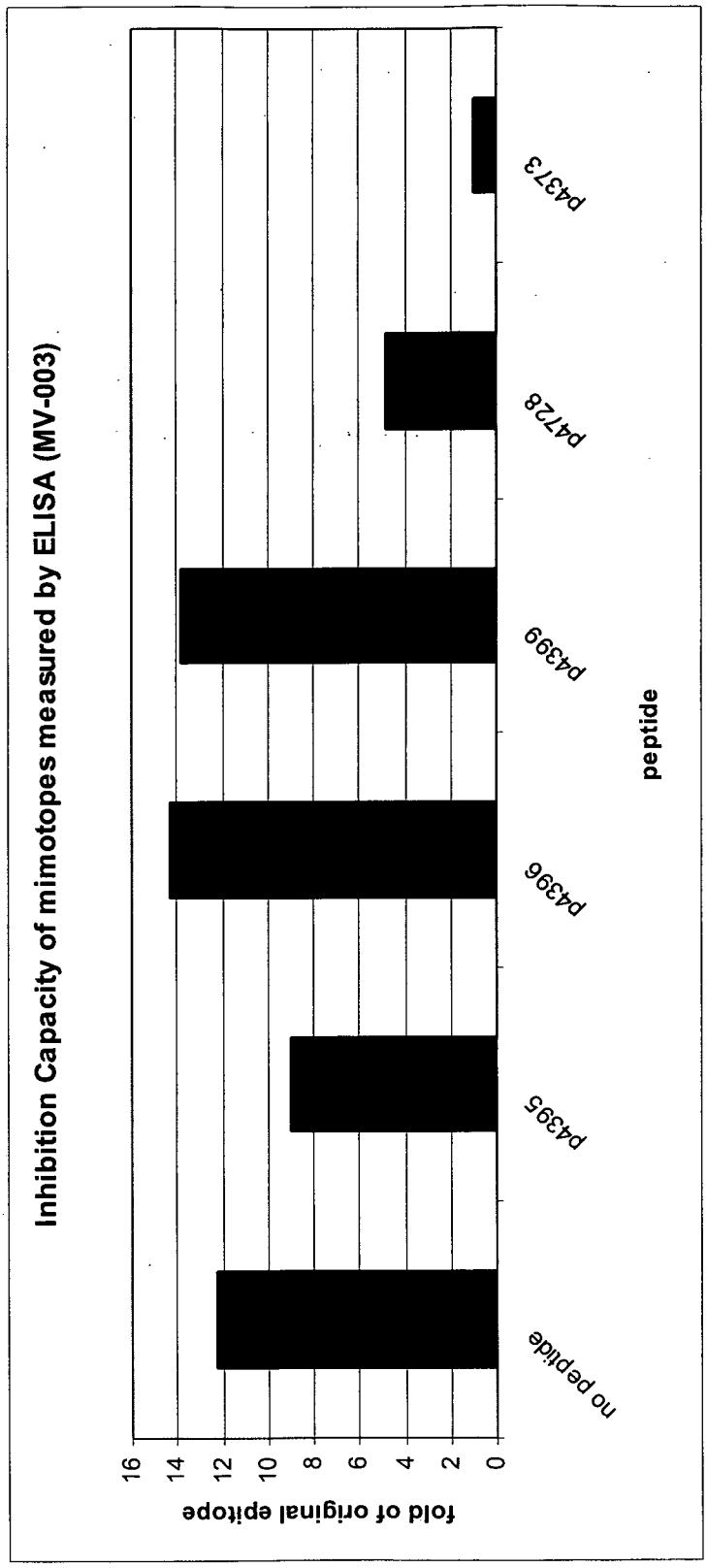
Inhibition Capacity of mimotopes measured by ELISA (MV-003)
fold of original epitope
0
2
4
6
8
10
12
14
16
no peptide
p4395
p4396
p4399
p4728
p4373
peptide

Fig. 5A

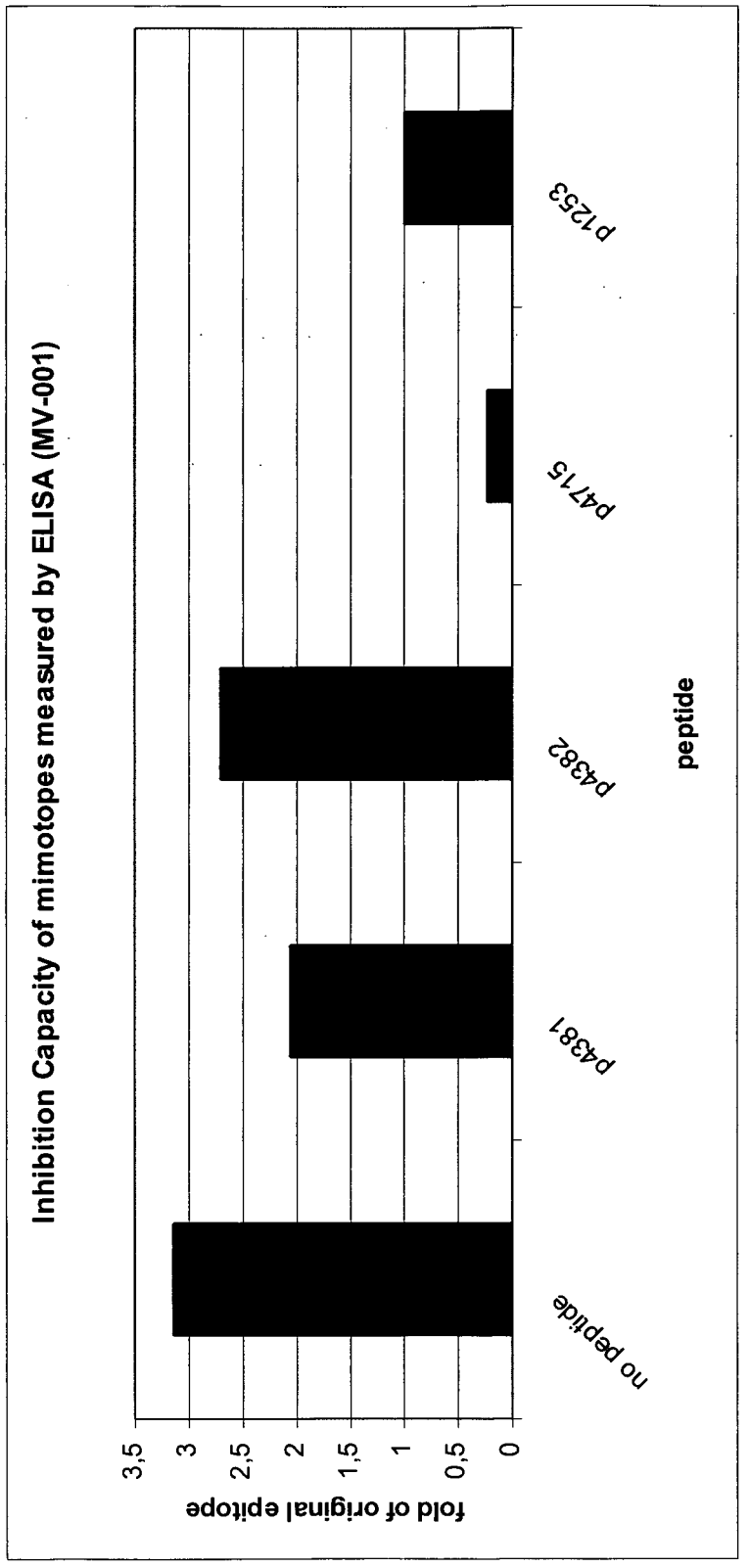
Inhibition Capacity of mimotopes measured by ELISA (MV-001)
fold of original epitope
3,5
3
2,5
2
1,5
1
0,5
0
no peptide
p4381
p4382
p4715
p1253
peptide

Fig. 5B

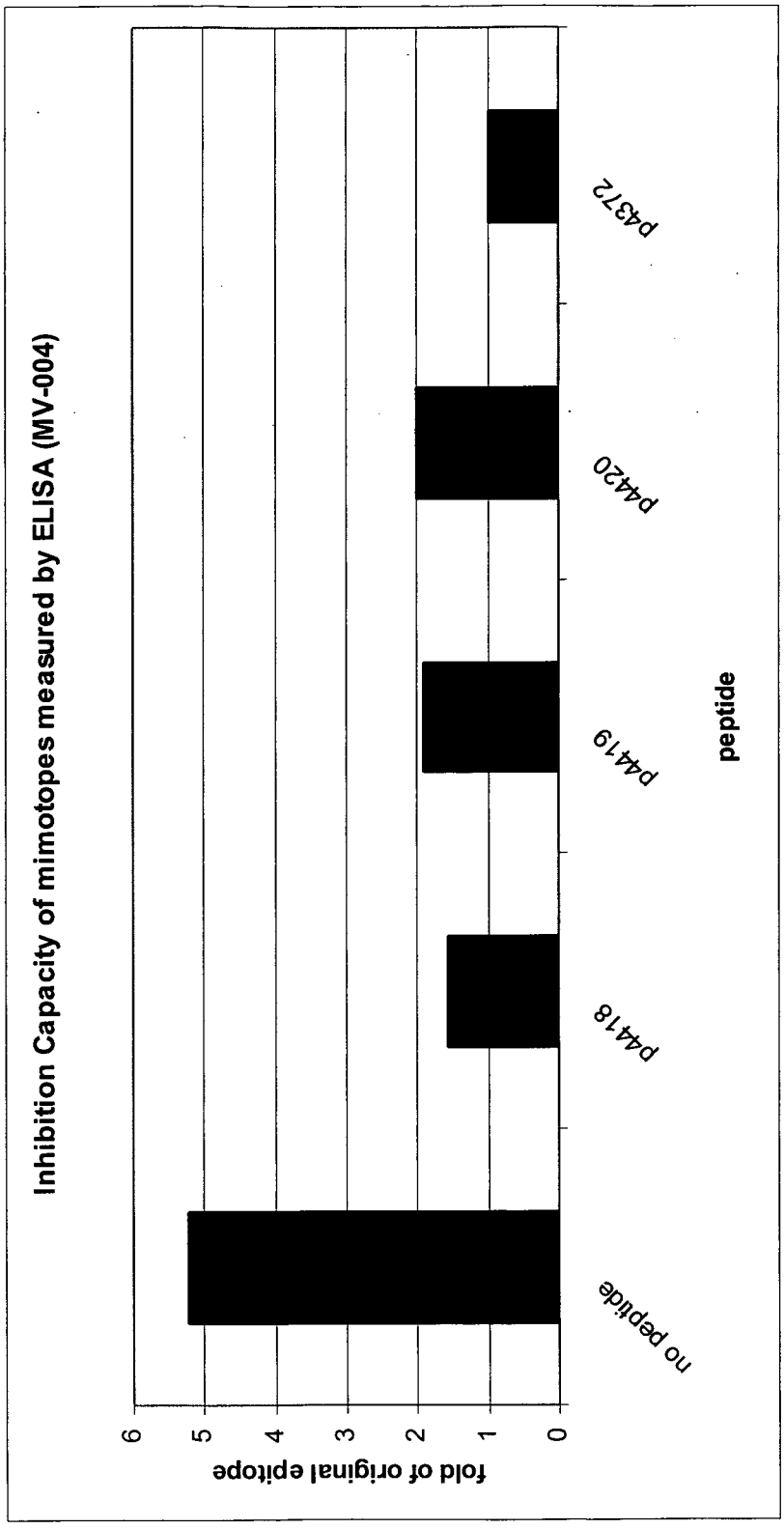
Inhibition Capacity of mimotopes measured by ELISA (MV-004)
fold of original epitope
0
1
2
3
4
5
6
no peptide
P4418
P4419
P4420
P4372
peptide

Fig. 5C

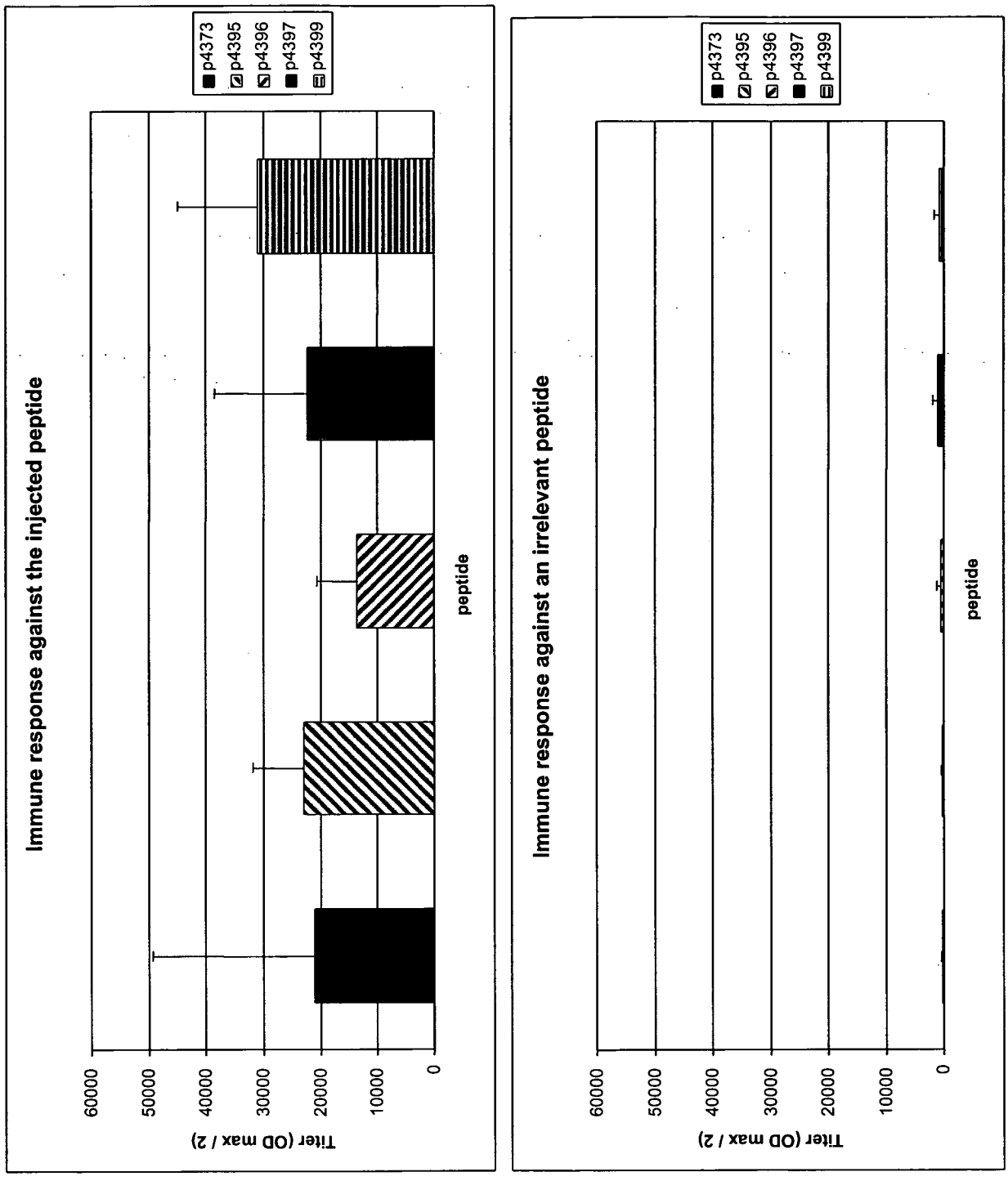
Immune response against the injected peptide
p4373
p4395
p4396
p4397
p4399
Titer (OD max / 2)
60000
50000
40000
30000
20000
10000
0
peptide
Immune response against an irrelevant peptide
p4373
p4395
p4396
p4397
p4399
Titer (OD max / 2)
60000
50000
40000
30000
20000
10000
0
peptide

Fig. 6A

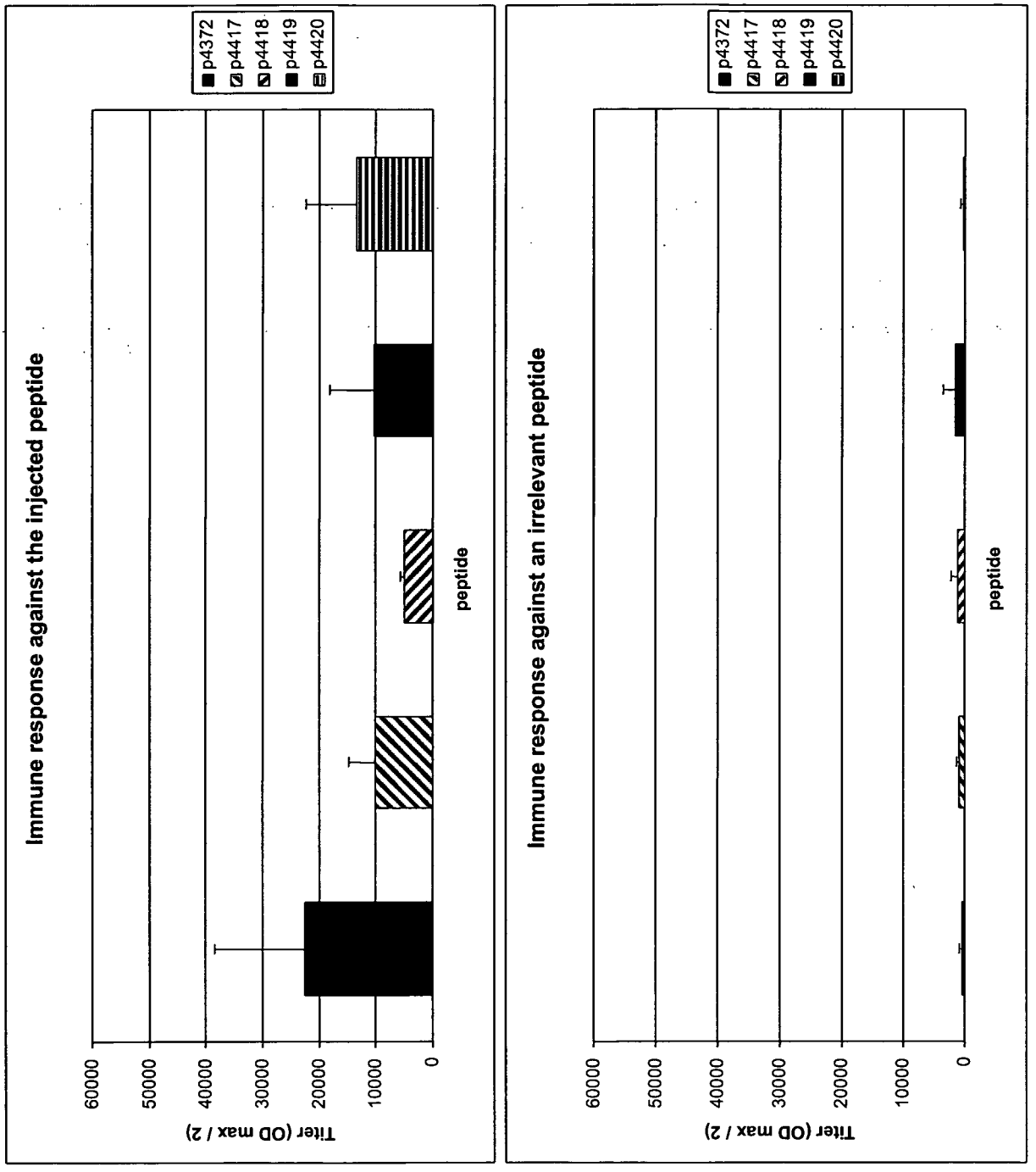
Immune response against the injected peptide
p4372
p4417
p4418
p4419
p4420
Titer (OD max / 2)
60000
50000
40000
30000
20000
10000
0
peptide
Immune response against an irrelevant peptide
p4372
p4417
p4418
p4419
p4420
Titer (OD max / 2)
60000
50000
40000
30000
20000
10000
0
peptide

Fig. 6B

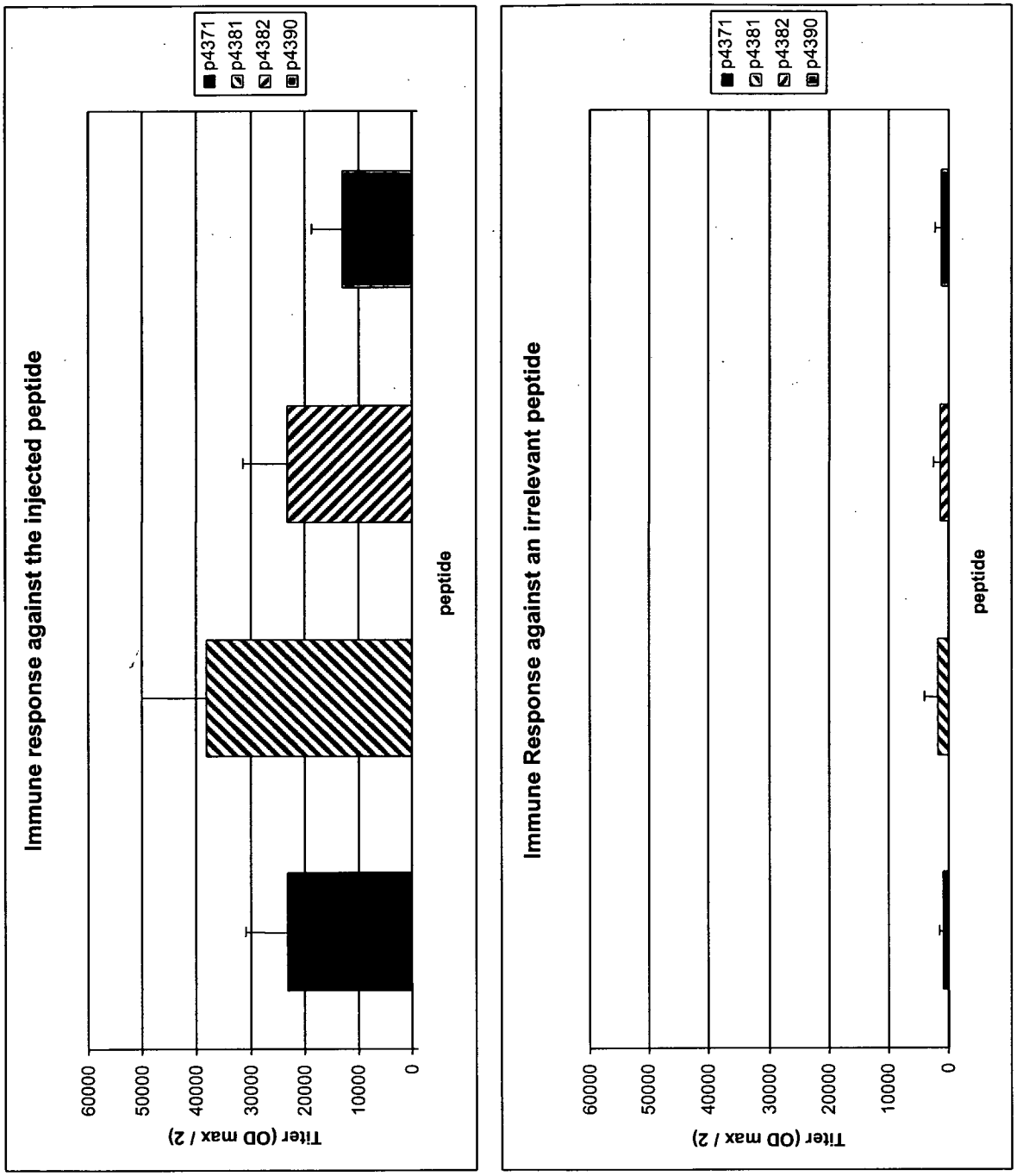
Immune response against the injected peptide
p4371
p4381
p4382
p4390
Titer (OD max / 2)
60000
50000
40000
30000
20000
10000
0
peptide
Immune Response against an irrelevant peptide
p4371
p4381
p4382
p4390
Titer (OD max / 2)
60000
50000
40000
30000
20000
10000
0
peptide

Fig. 6C

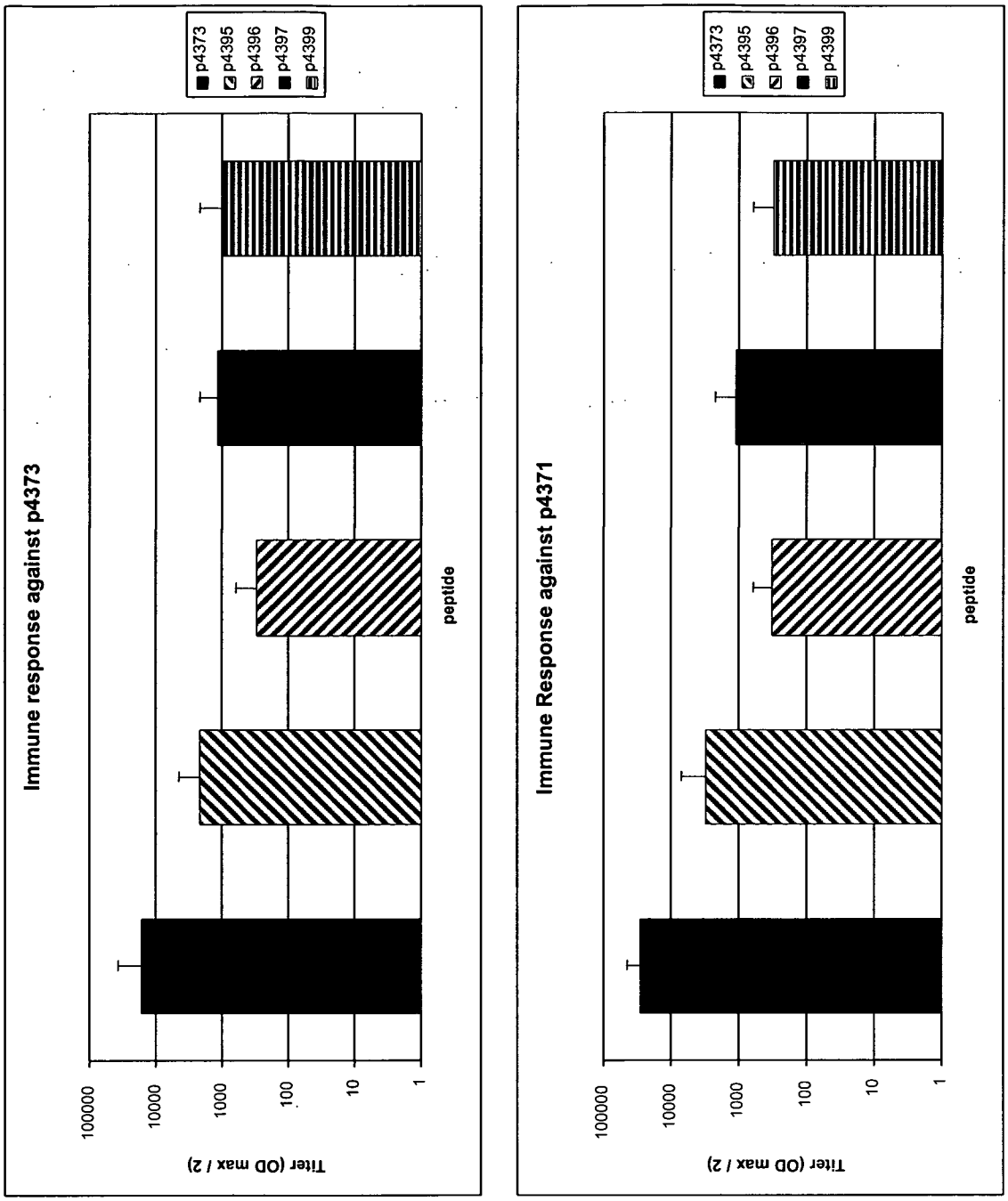
Immune response against p4373
p4373
p4395
p4396
p4397
p4399
Titer (OD max / 2)
100000
10000
1000
100
10
1
peptide
Immune Response against p4371
p4373
p4395
p4396
p4397
p4399
Titer (OD max / 2)
100000
10000
1000
100
10
1
peptide

Fig. 7A

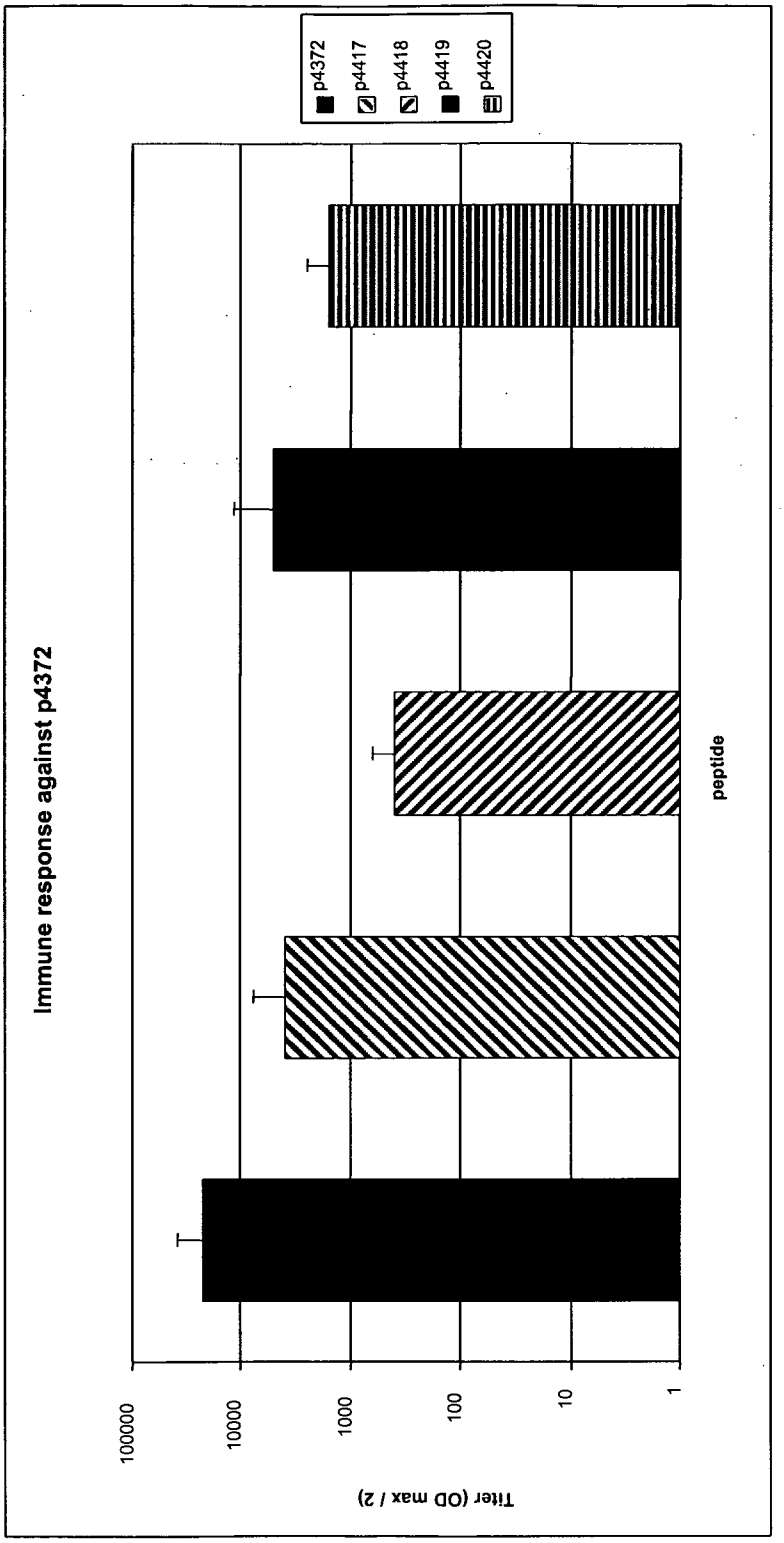
Immune response against p4372
p4372
p4417
p4418
p4419
p4420
Titer (OD max / 2)
100000
10000
1000
100
10
1
peptide

Fig. 7B

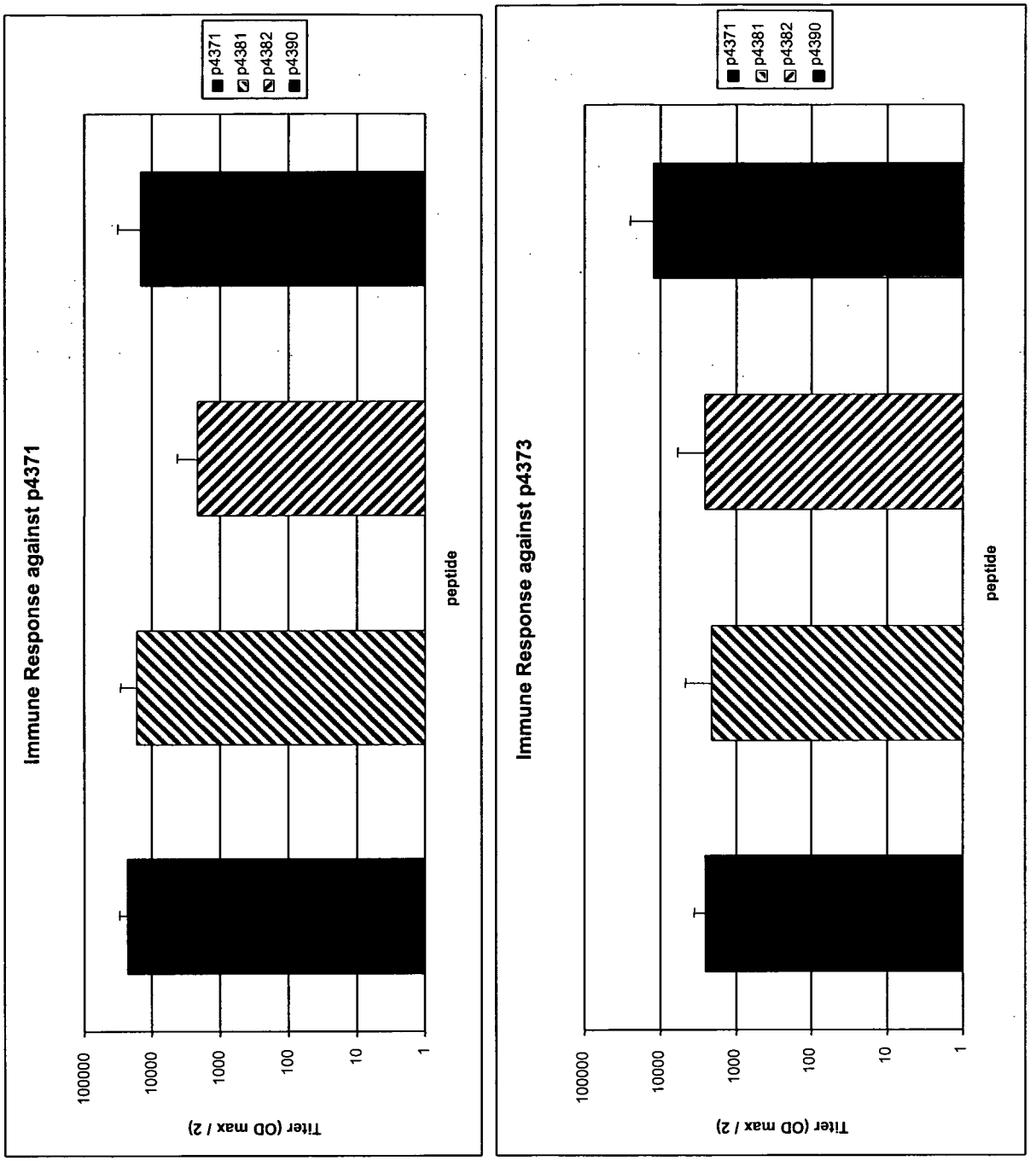
Immune Response against p4371
p4371
p4381
p4382
p4390
Titer (OD max / 2)
100000
10000
1000
100
10
1
peptide
Immune Response against p4373
p4371
p4381
p4382
p4390
Titer (OD max / 2)
100000
10000
1000
100
10
1
peptide

Fig. 7C

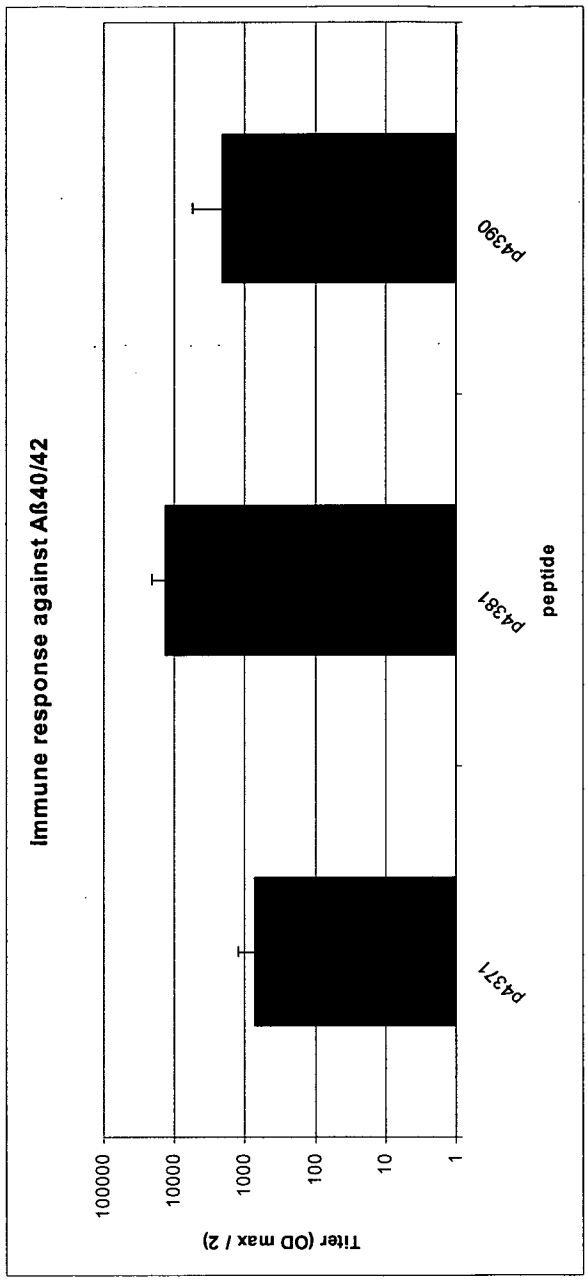
Immune response against Aß40/42
Titer (OD max / 2)
100000
10000
1000
100
10
1
peptide
p4371
p4381
p4390

Fig. 8A

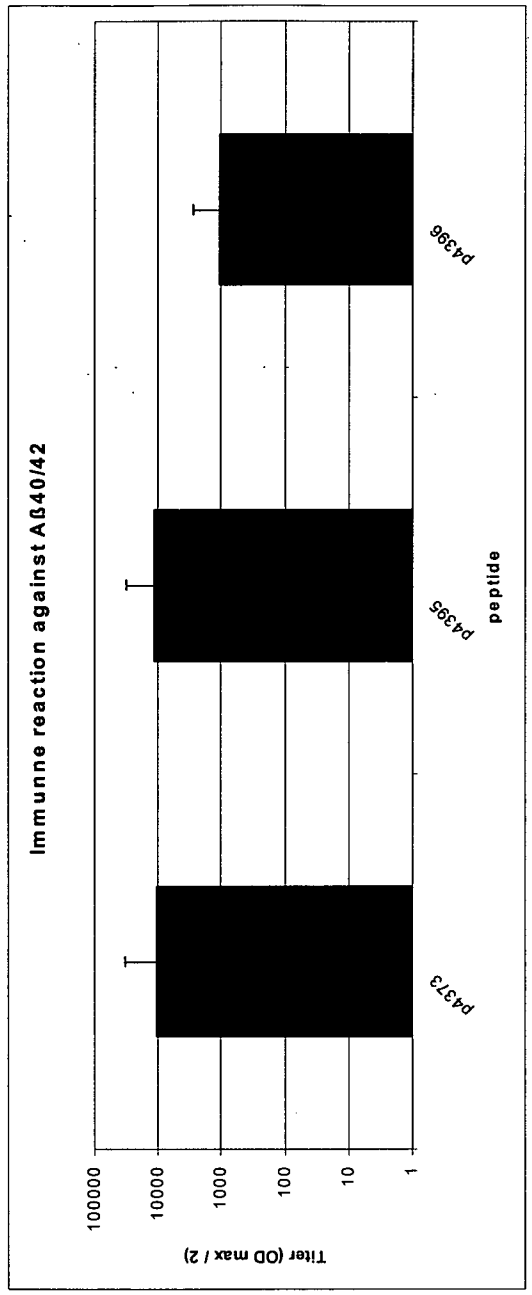
Immunne reaction against Aß40/42
Titer (OD max / 2)
100000
10000
1000
100
10
1
peptide
p4373
p4395
p4396

Fig. 8B

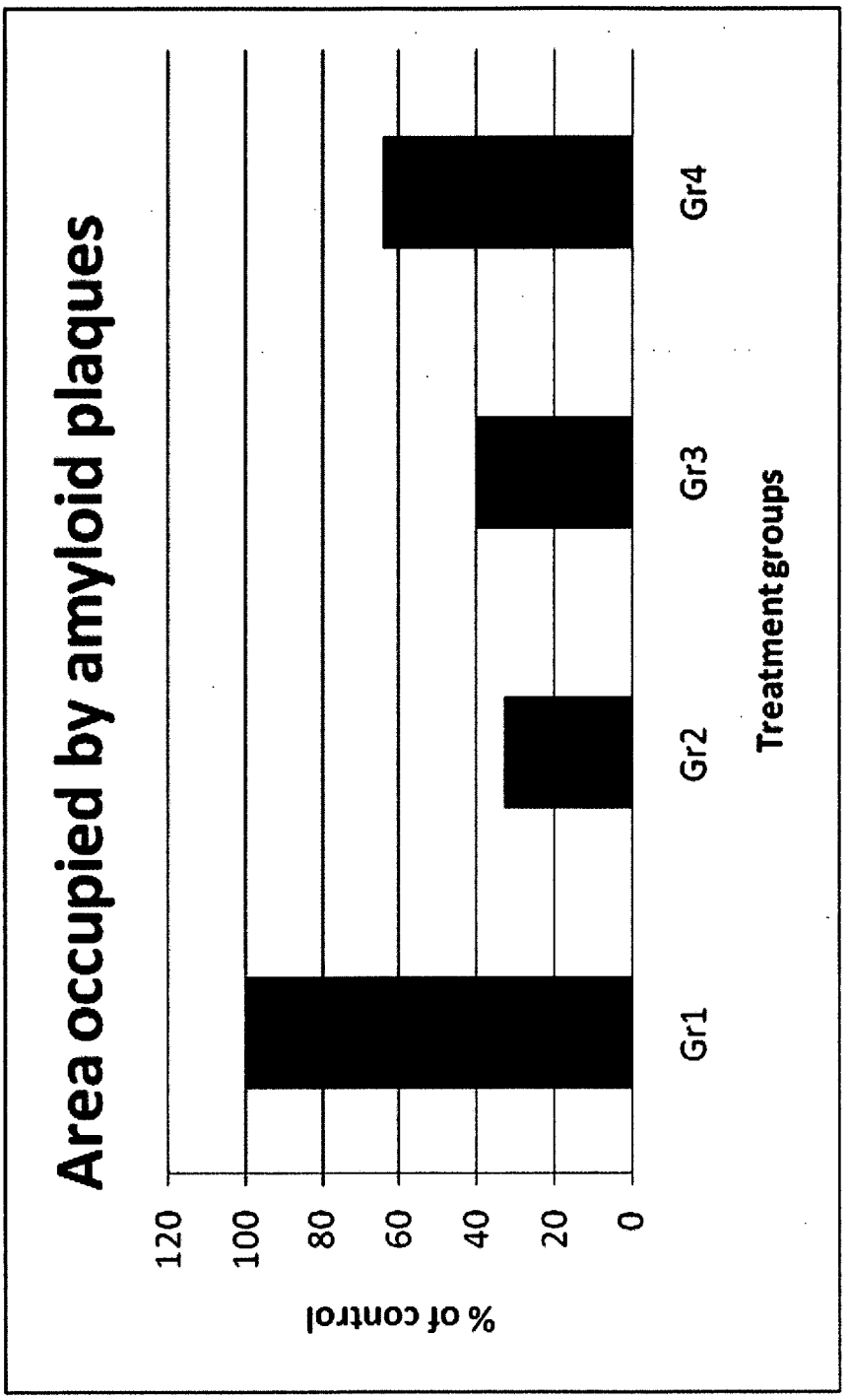
Area occupied by amyloid plaques
% of control
120
100
80
60
40
20
0
Gr1
Gr2
Gr3
Gr4
Treatment groups

Fig. 9

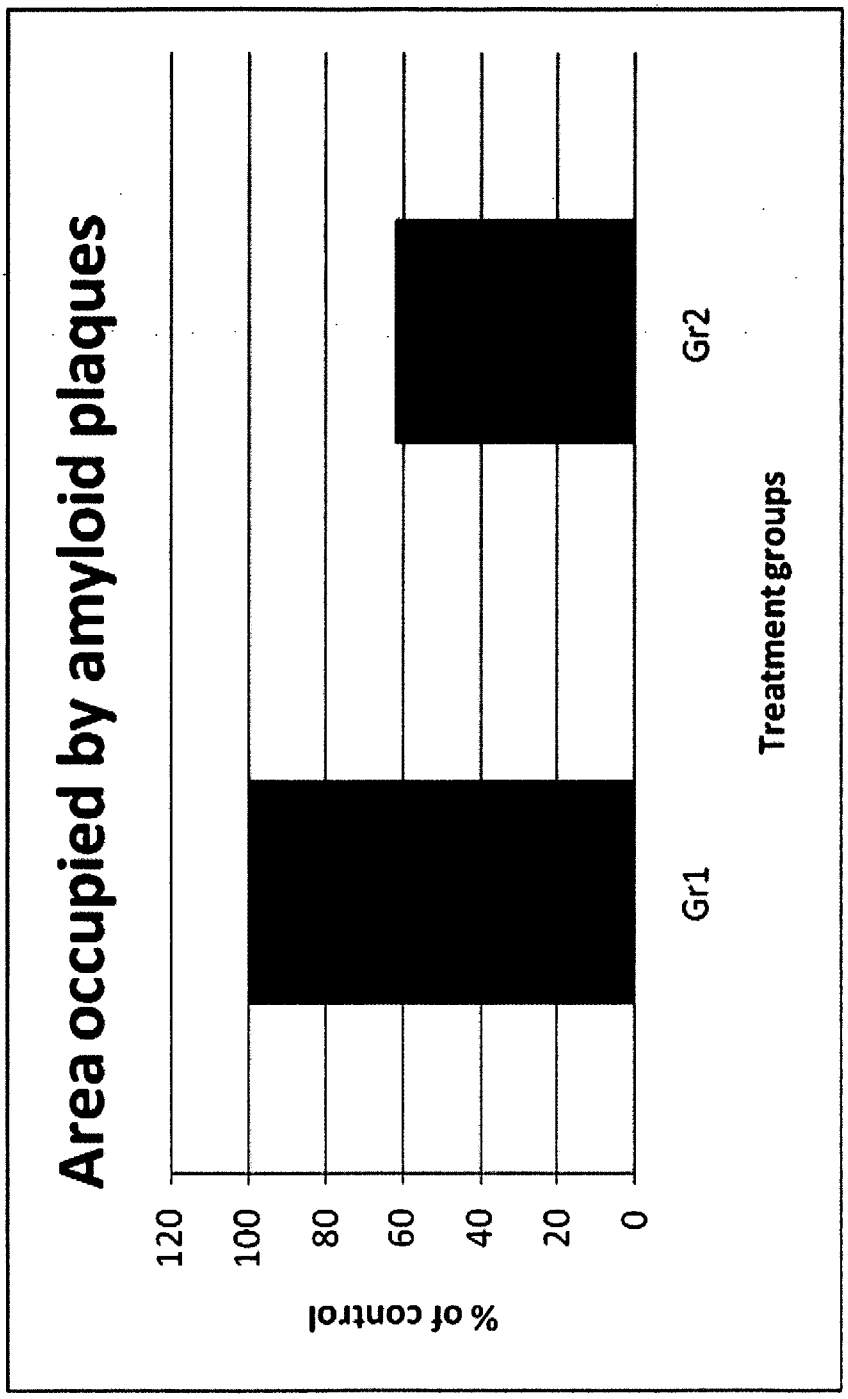
Area occupied by amyloid plaques
% of control
120
100
80
60
40
20
0
Gr1
Gr2
Treatment groups

Fig. 10