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(56) Related Art
<http://www.marketwired.com/press-release/first-human-clinical-study-of-hiv-vaccine-vacc-c5-approved-to-begin-oslo-bionor-1662580.htm> [retrieved on 2/3/17]
<http://www.hivandhepatitis.com/hiv-prevention/hiv-vaccines/3465-vacc-4x-therapeutic-hiv-vaccine-linked-to-lower-viral-load-in-phase-iibstudy> [retrieved on 2/3/17]
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(54) Title: HIV VACCINE

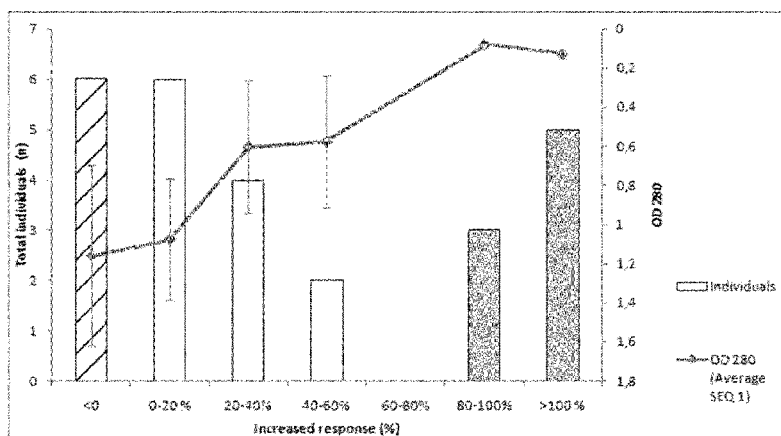


Fig. 1

(57) Abstract: The present invention relates to novel combinations of active agents and methods for the treatment of HIV infection and AIDS. In particular, the present invention relates to novel combinations of (1) therapeutic agents which can effect stabilisation of a complex between domains in certain HIV proteins with (2) HIV-specific vaccine peptides.

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HIV VACCINE

FIELD OF THE INVENTION

The present invention relates to novel combinations of active agents and methods for the treatment of HIV infections and AIDS. In particular, the present invention relates to novel combinations of (1) therapeutic agents which can effect stabilisation of a complex between domains in certain HIV proteins with (2) HIV-specific vaccine peptides. The novel combinations may further be administered with other therapeutic agents, such as in combination with immunomodulatory compounds and/or reservoir purging agents, such as histone deacetylase (HDAC) inhibitors.

BACKGROUND OF THE INVENTION

In recent years a large body of research evidence has accumulated supporting the concept that AIDS is an immunological disease induced by HIV-1 rather than simply being caused by loss of CD4+ T-lymphocytes as a result of chronic cytopathic viral infection. It is therefore important to develop interventions that target the chronic immune stimulation induced by HIV-1 as well as the virus itself, (Sommerfelt 2011, Recent Translational Research in HIV/AIDS Ed. Dr. Yi-Wei Tang. ISBN 979-953-307-189-2. pp 493-510).

Previous research shows that antibodies to the carboxyterminal C5 domain of HIV-1 gp120 has been associated with lower immune activation and slower disease progression (Loomis-Price et al. 1998 J. Inf. Dis. 178 :1306-1316 ; Warren RQ et al. 1991 J. Clin. Immunol 11: 13-21; Lifson et al. 1991 J. Inf. Dis 163 :959-965). Indeed, disease progression was shown to accelerate if humoral (i.e. antibody) responses to this domain were lost (Wong et al. 1993 J. Inf. Dis 168: 1523-1527). Furthermore long term nonprogressors (LTNP) which represent 5% of HIV-infected individuals have sustained humoral responses to the carboxyterminal C5 domain of HIV-1 gp120 and can live in the absence of antiretroviral therapy for many years despite having some degree of viral load (Liegler et al. 1998 J. Infec. Dis. 178: 669-79; Gougeon et al. 1996 J. Immunol. 156:3509-20; Muro-Cacho et al. 1995 J. Immunol. 154 :5555-66 ; Easterbrook et al. 1999 J. Infect. 28:71-73).

The C5 domain of gp120 is 13 amino acids long (amino acid residues 499-511 of gp120, and has the reference sequence B.FR 83.HXB2 - TKAKRRVVQREKR). Its conservation across multiple virus clades is shown in Table 1. The only regions that show any substantial variation are at positions 500 and 507 of the sequence which may contain predominantly amino acids K, R and E at position (500) or predominantly Q and E at position (507).

Table 1 (C5-domain for different multiple clades)

C5 SEQUENCES Residues 497-511	VIRAL CLADES (%)					
	A	A1	A2	B	C	D

APT K AKRRVV Q REKR	3.1%	/	/	58.3%	0.7 %	/
APT K AKRRVV E REKR	21.9%	12.8%	/	/	23.5%	33.0%
APT R AKRRVV Q REKR	3.1%	/	/	12.4%	/	1.7%
APT R AKRRVV E REKR	15.6%	27.7%	33.3%	/	3.0%	33.3%
APT E AKRRVV E REKR	/	/	/	/	16.8%	3.3%
	43.7%	40.5%	33.3%	70.7%	44.0%	68.3%

The table provided is based on 1066 sequences downloaded from the Los Alamos HIV-database 3rd of May 2008.

The sequences grouped in the following viral clades:

A: 32 sequences, A1: 47 sequences, A2: 10 sequences, B: 453 sequences, C: 464 sequences, and D: 60 sequences.

This carboxyterminal constant region C5 of HIV-1 gp120 is immunodominant and highly conserved across multiple HIV subtypes. It is exposed on the 3D structure of native gp120, on virions and on cell surface expressed gp120. Indeed, the C5 domain resembles human leukocyte antigen (HLA) classes I and II molecules and has the ability to bind peptides and deletion of the C5 domain abrogates peptide binding (Cadogan *et al.* AIDS Research and Human Retroviruses (2008); Vol. 24: 845-855). In this way the C5 domain can mimic the activities of human HLA.

International Patent Applications WO2011/000962 and WO2012/092934 disclose methods for treating HIV infections by administering e.g. at least one immunogen which induces antibodies that stabilise association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120, and certain peptides suitable for such use.

Naturally occurring HIV sequences in vaccine candidates are not capable of stimulating a stable immune response due to the viruses inherent ability to hide by changing the appearance of the epitopes presented on the cell surface of infected cells. The immune system is fooled to believe that a particular amino acid sequence is relevant when in fact the amino acids of importance is hidden.

A study of titers of antibodies against the gag p24 protein, has shown that slow progression towards development of AIDS is associated with high titers, while fast progression towards development of AIDS is associated with low titers. It is shown that persons with low p24 antibody titer develop significantly faster AIDS than persons with high p24 antibody titers (Zwart G., et al. Virology, 201, p. 285-93, June 1994), indicating that p24 can play a key role to control the development of AIDS.

New HIV p24 peptides are described in WO91/13360, wherein the peptides are used in a method of discriminating between a false and true diagnosed HIV-positive serum sample.

Johnson R.P., et al., The Journal of Immunology, Vol.147, p.1512-1521, No.5, September 1, 1991 describe an analysis of the fine specificity of gag-specific CTL-responses in three HIV-1 seropositive individuals, the gag-specific CTL-responses were found to be mediated by CD3+CD8+ lymphocytes which are HLA class I restricted.

EP-A-0 356 007 discloses antigenic determinants, in particular it relates to synthetic polypeptide sequences which are related to proteins present in the HIV-1 and which can be used as a basis for a potential vaccine against AIDS.

Rosenberg E.S. et al., *Science*, Vol.278, 21 November 1997, p.1447-1450 describe that virus specific CD4+ T helper lymphocytes are critical to the maintenance of effective immunity in a number of chronic viral infections, but are characteristically undetectable in chronic human immunodeficiency virus-type 1 (HIV-1) infection. HIV-1-specific proliferative responses to p24 were inversely related to viral load. They conclude that the HIV-1-specific helper cells are likely to be important in immunotherapeutic interventions and vaccine development.

EP 0 230 222, EP 0 270 114, DE 37 11 016 and GB 2 188 639 all in the name of F. Hoffmann-La Roche & Co. Aktiengesellschaft concern recombinant expression and purification of an HTLVIII Gag/Env gene protein or fusionproteins. The proteins consisting of native sequences can be purified to homogeneity and used as a basis for diagnostic tests for detection of antibodies against viruses associated with AIDS. The gag/env protein may also be formulated for use as a vaccine for protection against AIDS through prophylactic immunization.

From a diagnostic and therapeutic point of view, the major problems with using p24 as part of an assay or therapy is associated with the high number of epitopes on p24 which stimulates production of a large number of antibodies with poor specificity, which through repeated boosting on potential mutated sequences can create autoantibodies (Autoantibodies to the alfa/beta T-cell receptors in HIV infection; dysregulation and mimicry. Lake D.F., et al., *Proc. Natl. Acad. Sci. USA*, (23): 10849-53, Nov. 8 1994). Further, it is reported that the p24 antibody titer does not reach the same high levels as for the envelope proteins (gp120 and gp41). Normally antibodies to p24 are developed in the very early phase of the infection, but the titer is fairly quickly stabilized after the initial infection period. Later the p24 titer is gradually decreasing while the opposite happens with gp160. These findings can also be seen in relation to recent reports stating that cytotoxic T-cell activity is antagonized by naturally occurring HIV-1 gag variants (Klenerman P., et al., *Nature*, 2:369 (6479), p. 355, 2 June 1994). This can be one of the reasons why a rapid stabilization of the p24 titer is seen and why it later starts to decrease.

International Patent Application WO00/52040 discloses methods for treating HIV infections by administering e.g. HIV specific peptides based on conserved regions of HIV gag p24.

There is a need to provide improved treatments for the HIV infections and AIDS.

OBJECT OF THE INVENTION

It is an object of embodiments of the invention to provide effective combinations of therapeutic agents and methods which can be used in the prevention and/or treatment of HIV infection and AIDS.

The present invention is based on the finding that a combination of (1) therapeutic agents which can effect stabilisation of a complex between domains in certain HIV proteins with (2) HIV-specific vaccine peptides, provides an effective method for treating HIV infections, in particular because the combinations may act synergistically with the first therapeutic agent serving to prevent the immune activation that drives HIV disease progression, and the second agents induces virus control by training immune cells to seek out and kill virus-producing cells. Therefore, the combination of the invention could thus contribute to an eradication strategy for HIV infection and may also contribute to a preventive vaccine strategy. Such combinations may also provide other advantageous effects particularly in relation to the properties of pharmaceutical compositions when formulated as a combination therapy.

It is a further object of embodiments of the invention to enhance the effect of a therapeutic HIV vaccine by the use of immunomodulatory compounds and/or reservoir purging agents, such as histone deacetylase (HDAC) inhibitors in the prevention and/or treatment and/or eradication of HIV infection and AIDS.

SUMMARY OF THE INVENTION

It has been found that peptide constructs ("peptide multimers", such as a "peptide dimer") composed of amino acid sequences from the C5 domain of gp120 and of amino acid sequences from the transmembrane domain of gp41 are recognized by antisera isolated from a large fraction of LTNP (long-term non-progressing) HIV infected subjects, whereas the same constructs are substantially not recognized by antisera from subjects not infected with HIV or antisera from non-LTNP HIV-infected subjects. Similar results have been observed for peptide constructs composed of C5 and C2 derived peptide hybrids. These peptide constructs used in combination with HIV proteins with HIV-specific vaccine peptides may be used as very efficient therapeutic vaccines with increased potential as compared to either the peptide constructs or the HIV-specific vaccine peptides used alone.

In particular, testing for antibodies in HIV longterm nonprogressors (LTNP) with antigens comprising amino acid sequences of the C5 domain combined with various other amino acid sequences found on gp160 outside the C5 domain have shown surprising properties. This combination of amino acid sequences is useful for identifying a set of antibody responses unique for HIV infected individuals that despite the infection show no signs of disease progression. Similar antigens that incorporate cross clade viral variation will be used to induce broad anti-C5 and anti C5:CX (meaning an association between C5 and a non-C5

region in gp41 or gp120) humoral responses equivalent to those found in long term nonprogressor/elite controllers.

It is therefore concluded herein that the LTNP state characterizing 5% of HIV-infected individuals is at least partly a consequence of the ability of these infected individuals to develop antibodies against conformational epitopes composed of amino acids from both C5 and from TM-gp41 or C2. Such antibodies will, due to their binding to both C5 and to TM-gp41 or C2, *stabilise* a specific conformation where C5 is complexed to tm-gp41 and/or C2. Consequently, this opens for the development and production of novel antibodies which share the same specificity as do the antibodies identified herein, but it also opens for the development of immunogenic agents which will be capable of inducing antibodies which can stabilise the complex formation between C5 and TM-gp41 on the one hand or C5 and C2 on the other hand.

Peptide antigens to the carboxyterminal C5 domain of the HIV-1 envelope glycoprotein gp120 conjugated or complexed (CX) to regions on the transmembrane gp41 and/or constant domain C2 of gp120 can be used as vaccine agents for eliciting antibody immune responses to prevent/suppress chronic immune stimulation associated with C5 in HIV infected individuals.

The C5 domain of HIV-1 gp120 may be associated with immune activation in a number of ways:

1) C5 may be presented as a peptide on different HLA molecules on infected cells. The variation of positions 500 and 507 indicate a plasticity to interact with multiple HLA molecules.

2) C5 can bind peptide and function as an HLA molecule to interact with T-Cell receptors. Other molecules involved in interaction with the TCR complex are present on the cell surface or incorporated into the virus particle. Cadogan et al. 2008 AIDS Res and Hum Retroviruses 24:845-55.

As noted this opens for several new ways of targeting the immune activation exerted by HIV:

If C5 is stabilised by remaining bound/complexed to gp41 and/or C2, C5 would remain inert/inactive. C5 therefore appears to vacillate between binding to gp41 and C2. On the other hand, when C5 is disengaged from either gp41 or C2 it can lead to immune activation.

It should therefore be possible to block C5 associated immune activation in a number of ways, which are all contemplated according to the present invention:

Peptide multimers comprising peptides from C5 in interaction with gp41 and C2 mimic the in vivo complex between C5 and gp41 or C2 and will be able to induce antibody responses against the native complex. These antibodies can in turn block C5 associated immune activation by "locking" C5 conformationally.

Also, small molecules that block disengagement of C5 and keep it stable with gp41 or C2 (in a manner similar to the antibodies induced by the peptide multimers) or small molecules or antibodies that bind the free C5 and thereby render it inert and block immune activation. For instance, small molecules corresponding to regions of C2 and gp41 that interact with C5 can be used to inhibit this C5-associated immune activation.

Vaccines based on the C5 domain of HIV-1 complexed/conjugated to domains of gp41 and/or C2 are different from conventional antibody approaches to HIV vaccines since the antibodies to be induced are generally non-neutralising. Other approaches to HIV vaccines involve larger antigens that have addressed the entire gp120, gp41 or the uncleaved precursor gp160. However, they have not addressed the regions of the C5 domain specifically complexed with gp41 and/or C2.

It is however envisioned that the combination of therapeutic agents based on the C5 domain of HIV-1 with HIV-specific vaccine peptides will provide better and improved vaccines.

So, in a first aspect of the present invention there is provided a method for reducing and/or delaying pathological effects of human immunodeficiency virus I (HIV) in a human infected with HIV, the method comprising administering (1) an effective amount of at least one immunogen, which induces antibodies that stabilise association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120; and (2) at least one HIV-specific peptide selected from the group of amino acid sequences:

Xaa₁ Xaa₂ Xaa₃ Xaa₄ Xaa₅ Xaa₆ Ala Xaa₈ Xaa₉ Gln Thr Pro Trp Xaa₁₄ Xaa₁₅ Xaa₁₆ Xaa₁₇ Xaa₁₈ Val Xaa₂₀ (SEQ ID NO: 47);

wherein Xaa in position 1 is Lys or Arg,

Xaa in position 2 is Ala, Gly, Ser or Arg,

Xaa in position 3 is Leu or Met,

Xaa in position 4 is Gly or Arg,

Xaa in position 5 is Pro, Thr, Val, Ser, Gln or Ala,

Xaa in position 6 is Gly, Ala, Lys, Arg, Gln or Glu,

Xaa in position 8 is Thr or Ser,

Xaa in position 9 is Leu or Ile,

Xaa in position 14 is Thr, Ser or Val,

Xaa in position 15 is Ala or Ser,

Xaa in position 16 is Cys or Ser,

Xaa in position 17 is Gln or Leu,

Xaa in position 18 is Gly, Glu or Arg, and

Xaa in position 20 is Gly or Arg;

Xaa₁ Xaa₂ Xaa₃ Xaa₄ Xaa₅ Gly Leu Asn Pro Leu Val [Gly]_n Xaa₁₂ Xaa₁₃ Tyr Xaa₁₅ Pro Xaa₁₇ Xaa₁₈ Ile Leu Xaa₂₁ Xaa₂₂ (SEQ ID NO: 50);

wherein Xaa in position 1 is Arg, Lys, Asp or none,
 Xaa in position 2 is Trp, Gly, Lys or Arg,
 Xaa in position 3 is Ile, Leu, Val or Met,
 Xaa in position 4 is Ile, Val or Leu,
 Xaa in position 5 Leu, Met, Val or Pro,
 Xaa in position 12 is Arg or Lys,
 Xaa in position 13 is Met or Leu,
 Xaa in position 15 is Ser, Cys or Gln,
 Xaa in position 17 is Thr, Val, Ile, Ser or Ala,
 Xaa in position 18 is Ser, Gly or Thr,
 Xaa in position 21 is Asp, Glu, Cys or Gly,
 Xaa in position 22 is Gly or none, and

$n = 0, 1, 2$ or 3 ;

Xaa₁ Xaa₂ Xaa₃ Pro Ile Pro Xaa₇ Xaa₈ Xaa₉ Xaa₁₀ Xaa₁₁ Xaa₁₂ [Gly]_n Xaa₁₃ Xaa₁₄ Xaa₁₅ Xaa₁₆
 Xaa₁₇ Xaa₁₈ Xaa₁₉ Xaa₂₀ Xaa₂₁ Xaa₂₂ Xaa₂₃ Xaa₂₄ (SEQ ID NO: 55);

wherein Xaa in position 1 is Asn, Ser, Gly, His, Ala, Pro, Arg or none,
 Xaa in position 2 is Asn, Ala or Lys,
 Xaa in position 3 is Pro, Gln, Gly, Ile or Leu,
 Xaa in position 7 is Val or Ala,
 Xaa in position 8 is Gly or Lys,
 Xaa in position 9 is Glu, Asp, Lys, Phe or Thr,
 Xaa in position 10 is Ile, Met, Val or Leu,
 Xaa in position 11 is Tyr, Leu or none,
 Xaa in position 12 is Ser or none,
 Xaa in position 13 is Arg or none,
 Xaa in position 14 is Asp, Arg, Trp, Ala or none,
 Xaa in position 15 is Ile or none,
 Xaa in position 16 is Tyr or none,
 Xaa in position 17 is Lys or Arg,
 Xaa in position 18 is Arg, Lys or Asp,
 Xaa in position 19 is Trp or Gly,
 Xaa in position 20 is Ile, Met, Val, Gln or Ala,
 Xaa in position 21 is Ile, Val or Ala,
 Xaa in position 22 is Leu, Met or Val,
 Xaa in position 23 is Gly or Cys,
 Xaa in position 24 is Leu or none,
 $n = 1, 2$ or 3 ; and

Xaa₁ Xaa₂ Ile Ile Xaa₅ Xaa₆ Xaa₇ Xaa₈ Xaa₉ Leu Xaa₁₁ [Gly]_n [Arg]_m Xaa₁₂ Xaa₁₃ Xaa₁₄ Xaa₁₅
 Xaa₁₆ Xaa₁₇ Xaa₁₈ Xaa₁₉ Xaa₂₀ Xaa₂₁ Xaa₂₂ Xaa₂₃ Xaa₂₄ Xaa₂₅ (SEQ ID NO: 61);

wherein Xaa in position 1 is Pro, Lys, Arg or none,
 Xaa in position 2 is Glu, Arg, Phe or Lys,
 Xaa in position 5 is Pro or Thr,
 Xaa in position 6 is Met, Thr or Nleu,
 Xaa in position 7 is Phe or Leu,
 Xaa in position 8 is Ser, Thr, Ala or Met,
 Xaa in position 9 is Ala, Glu or Leu,
 Xaa in position 11 is Ser or none,
 Xaa in position 12 is Ala, Arg or none,
 Xaa in position 13 is Ile, Leu or none,
 Xaa in position 14 is Ser, Ala, Leu or none,
 Xaa in position 15 is Tyr, Glu or Asp,
 Xaa in position 16 is Gly or Asp,
 Xaa in position 17 is Ala or Leu,
 Xaa in position 18 is Thr, Ile, Val, Leu or Asn,
 Xaa in position 19 is Pro, Thr or Ser,
 Xaa in position 20 is Tyr, Phe, Nleu, His or Gln,
 Xaa in position 21 is Asp, Asn, Leu or Ala,
 Xaa in position 22 is Leu, Ile, Val or Asn,
 Xaa in position 23 is Asn, Tyr, Cys or Gly,
 Xaa in position 24 is Thr, Met, Ile, Ala, Val or none,
 Xaa in position 25 is Gly or none,
 n = 1, 2 or 3 and m = 0, 1, 2 or 3 independent of each other;

wherein the terminal ends of each HIV specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls;

or salts of any of the HIV specific peptides.

In a second aspect is provided a method for reducing and/or delaying pathological effects of human immunodeficiency virus I (HIV) in a human infected with HIV, the method comprising administering (1) an effective amount of at least one agent capable of stabilising association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120; and (2) at least one HIV-specific peptide selected from the group of amino acid sequences of SEQ ID NOs: 47, 50, 55 and 61, as defined in the first embodiment;

wherein the terminal ends of each HIV specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls;

or salts of any of the HIV specific peptides.

In a third aspect is provided a method of reducing the risk of developing acquired immunodeficiency syndrome (AIDS) or HIV disease, the method comprising administering (1) an effective amount of at least one immunogen, which induces an antibody that stabilises association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120; and (2) at least one HIV-specific peptide selected from the group of amino acid sequences of SEQ ID NOs: 47, 50, 55 and 61, as defined in the first embodiment;

wherein the terminal ends of each HIV specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls;

or salts of any of the HIV specific peptides.

In a fourth aspect is provided a method of reducing the risk of developing acquired immunodeficiency syndrome (AIDS), the method comprising administering (1) an effective amount of at least one agent capable of stabilising association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120; in combination with (2) at least one HIV-specific peptide selected from the group of amino acid sequences of SEQ ID NOs: 47, 50, 55 and 61, as defined in the first embodiment;

wherein the terminal ends of each HIV specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls

or salts of any of the HIV specific peptides.

In a fifth aspect is provided a composition comprising (1) an immunogen as defined above, such as a peptide multimer, said multimer comprising

- a first peptide comprising the amino acid sequence of the 13 amino acid residue amino acid sequence of the C5 domain of HIV gp120 including between 0 and 4 amino acid substitutions, a subsequence thereof, or an amino acid sequence comprising the inverso-, retro- or retro-inverso form of said amino acid sequence or subsequence, and

- at least one second peptide having an amino acid stretch present in the transmembrane domain of gp41 or present in the constant C2 domain of gp120 or having an amino acid stretch present in any one of SEQ ID NOs. 6-13 or having a inverso-, retro- or retro-inverso form of an amino acid stretch present in the transmembrane domain of gp41 or present in the constant C2 domain of gp120,

wherein said peptide multimer is capable of inducing an antibody which can bind and stabilise the association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120, and wherein said peptide multimer lacks amino acids N-terminal of C5 in gp120; in combination with (2) at least one HIV-specific peptide selected from the group of amino acid sequences of SEQ ID NOs: 47, 50, 55 and 61, as defined in the first embodiment; wherein the terminal ends of each HIV specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls; or salts of any of the HIV peptides.

In a sixth aspect is provided an immunogenic composition as defined in the fifth aspect optionally comprising a pharmaceutically acceptable diluent, vehicle and/or one or more immunological adjuvants.

LEGENDS TO THE FIGURES

Fig. 1: Combined histogram and line plot. The line plot shows ratios between measured OD values for peptide solution A (SEQ ID NO: 1 alone) and B (SEQ ID NO: 1 combined with SEQ ID NO: 6), and the histogram shows average responses within each ratio interval for SEQ ID NO: 1. Error bars are calculated as stdev/square root of n. See Example 4 for details.

Fig. 2: Comparing responses to A (SEQ ID NO: 1 alone) and B (SEQ ID NO: 1 combined with SEQ ID NO: 6) in different groups of subjects (LTNP, HIV positives, and blood donors). Boxes indicate interquartile range. Median value is indicated by a horizontal line. The lines extending from each end of the box = 1.5 lengths in unit of interquartile range. Crosses = Values beyond the ends of the lines.

Fig. 3: Inhibition of antibody binding using different antigens. Antigens used: BI400-B, C5 (BI400-015), gp41 peptide (BI400-201), C2 peptide (BI400-201d), recombinant gp41. BI301-23 is an irrelevant peptide unrelated to HIV, PBS is phosphate buffered saline without any peptide antigen. See Example 5 for details.

Fig. 4: Cross competition of BI400-B antibody binding to C5/gp41 using serum from LTNP.

LTNP-pool 1 is a pool consisting of sera collected from five defined LTNP patients.

LTNP-pool 2 is a pool consisting of sera collected from four other defined LTNP patients.

BD pool is a pool consisting of 10 sera from healthy blood donors.

Fig. 5: Prevalence of anti-C5/gp41 antibodies in HIV infected individuals varies according to viral load. Boxes indicate interquartile range. The median value is indicated by a horizontal line. The lines extending from each end of the box = 1.5 lengths in unit of interquartile range. See Example 5 for details.

Fig. 6: IFN- γ ELISPOT responses in A2 mice immunized with Vacc-HIV compared to control group when tested against Vacc-4x, Vacc-4x constituent peptides (Vacc-10, Vacc-11, Vacc-12, Vacc-13) or pools of their corresponding overlapping 15-mer peptides.

DETAILED DISCLOSURE OF THE INVENTION

Definitions

When terms such as "one", "a" or "an" are used in this disclosure they mean "at least one", or "one or more" unless otherwise indicated. Further, the term "comprising" is intended to mean "including" and thus allows for the presence of other constituents, features, conditions, or steps than those explicitly recited.

"HIV" unless otherwise indicated generally denotes human immunodeficiency virus I.

"HIV disease" is composed of several stages including the acute HIV infection which often manifests itself as a flu-like infection and the early and medium stage symptomatic disease, which has several non-characteristic symptoms such as skin rashes, fatigue, night sweats, slight weight loss, mouth ulcers, and fungal skin and nail infections. Most HIV infected will experience mild symptoms such as these before developing more serious illnesses. It is generally believed that it takes five to seven years for the first mild symptoms to appear. As HIV disease progresses, some individuals may become quite ill even if they have not yet been diagnosed with AIDS (see below), the late stage of HIV disease. Typical problems include chronic oral or vaginal thrush (a fungal rash or spots), recurrent herpes blisters on the mouth (cold sores) or genitals, ongoing fevers, persistent diarrhea, and significant weight loss. "AIDS" is the late stage HIV disease and is a condition which progressively reduces the effectiveness of the immune system and leaves individuals susceptible to opportunistic infections and tumors.

When using the term "gp120" herein is meant the \approx 120 kDa N-terminal glycoprotein enzymatic cleavage product of gp160, which in turn is the sole expression product of the HIV env gene. gp120 forms the "spikes" on infective HIV virions and is non-covalently bound to gp41.

"gp41" denotes the \approx 41 kDa glycoprotein C-terminal enzymatic cleavage product of gp160. gp41 is located intracellularly in HIV infected cells or inside the viral capsid in infective HIV virions. gp41 has an N-terminal transmembrane domain which binds non-covalently to gp120. This transmembrane domain is termed "the transmembrane domain of gp41" or "tm-gp41" herein. The term includes within its scope naturally occurring mutated versions of the sequence as e.g. those set forth in Formula III.

"C5" or the "C5 domain" denotes the 13 C-terminal amino acid residues of gp120.

"C2" or the "C2 domain" denotes a conserved region in gp120. Regions in C2 form an antiparallel β -sheet with C5 in the inner proximal domain of gp120.

"Reducing and/or delaying pathological effect of HIV" is in the present context meant to denote that use of the methods of the invention provides for a statistically significant reduction and/or delay in morbidity seen in individual infected with HIV which are treated according to the present invention. That is, the time of onset of manifest disease symptoms characterizing AIDS is later compared to non-treated controls and/or the number of pathological manifestations is reduced to controls not receiving the treatment of the present invention.

The expression "association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120" means that C5 can interacting non-covalently with both or one of the tm-gp41 and C2. The interaction with tm-gp41 is intermolecular, whereas the interaction with C2 is intramolecular.

An "agent capable of stabilising" association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120 is a

composition of matter which prevents or statistically reduces release of C5 from its intermolecular binding to gp41 and/or from its intramolecular binding to C2. Generally, such an agent is any substance of matter capable of exerting this effect, but important examples are antibodies, antibody fragments, and antibody analogues. However, also other molecules having proper binding affinity for a complex between C5 on the one hand and tm-gp41 and/or C2 on the other, is an agent according the present invention – the precise molecular format is less important than the binding characteristics, and it is according to the invention also possible that such an agent may be a receptor or a receptor analogue, but also small molecule stabilisers are capable of functioning as an agent of the present invention.

The term "antibody" herein is used in the broadest sense and specifically includes full-length monoclonal antibodies, polyclonal antibodies, multispecific antibodies (e.g., bispecific antibodies), and antibody fragments, so long as they exhibit the desired biological activity, i.e. to function as an agent described above. Various techniques relevant to the production of antibodies are provided in, e.g., Harlow, et al., *Antibodies: A Laboratory Manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, N.Y., (1988).

An "antibody fragment or antibody analogue" comprises a portion of a full-length antibody, preferably antigen-binding or variable regions thereof. Examples of antibody fragments/analogues include Fab, Fab', F(ab)₂, F(ab')₂, F(ab)₃, Fv (typically the VL and VH domains of a single arm of an antibody), single-chain Fv (scFv), dsFv, Fd fragments (typically the VH and CH1 domain), and dAb (typically a VH domain) fragments; VH, VL, VhH, and V-NAR domains; minibodies, diabodies, triabodies, tetrabodies, and kappa bodies (see, e.g., Ill et al., *Protein Eng* 1997;10: 949-57); camel IgG; IgNAR; and multispecific antibody fragments formed from antibody fragments, and one or more isolated CDRs or a functional paratope, where isolated CDRs or antigen-binding residues or polypeptides can be associated or linked together so as to form a functional antibody fragment. Various types of antibody fragments have been described or reviewed in, e.g., Holliger and Hudson, *Nat Biotechnol* 2005; 23, 1126-1136; WO2005040219, and published U.S. Patent Applications 20050238646 and 20020161201.

The term "antibody derivative", as used herein, comprises a full-length antibody or a fragment of an antibody, preferably comprising at least antigen-binding or variable regions thereof, wherein one or more of the amino acids are chemically modified, e.g., by alkylation, PEGylation, acylation, ester formation or amide formation or the like, e.g., for linking the antibody to a second molecule. This includes, but is not limited to, PEGylated antibodies, cysteine-PEGylated antibodies, and variants thereof.

A "conjugate" as used herein comprises an agent according to the invention such as an antibody derivative associated with or linked to a second agent, such as a cytotoxic agent, a detectable agent, etc. A conjugate may be constituted of covalently linked peptides (an example of a conjugate is a fusion peptide comprising two peptides linked via peptide bonds so that the conjugate in that case may be an expression product from a nucleic acid

fragment), but a conjugate can also be a combination of peptides covalent linked via chemical conjugation (a traditional example is conjugation using glutaraldehyde). Another example of a more complex conjugation is the example where an agent or peptide multimer or other chemical substance of the present invention is linked to a carrier molecule, which in turn is coupled to other agents, peptide multimers or other chemical substances of the present invention (e.g. when such chemical substances are bound to a poly-lysine carrier (a lysine "tree")).

A "humanized" antibody is a human/non-human chimeric antibody that contains a minimal sequence derived from non-human immunoglobulin. For the most part, humanized antibodies are human immunoglobulins (recipient antibody) in which residues from a hypervariable region of the recipient are replaced by residues from a hypervariable region of a non-human species (donor antibody) such as mouse, rat, rabbit, or non-human primate having the desired specificity, affinity, and capacity. In some instances, framework region (FR) residues of the human immunoglobulin are replaced by corresponding non-human residues. Furthermore, humanized antibodies may comprise residues that are not found in the recipient antibody or in the donor antibody. These modifications are made to further refine antibody performance. In general, a humanized antibody will comprise substantially all of at least one, and typically two, variable domains, in which all or substantially all of the hypervariable loops correspond to those of a non-human immunoglobulin and all or substantially all of the FR residues are those of a human immunoglobulin sequence. The humanized antibody can optionally also comprise at least a portion of an immunoglobulin constant region (Fc), typically that of a human immunoglobulin. For further details, see, e.g., Jones et al., *Nature* 321:522-525 (1986); Riechmann et al., *Nature* 332:323-329 (1988); and Presta, *Curr. Op. Struct. Biol.* 2:593-596 (1992), WO 92/02190, US Patent Application 20060073137, and US Patents 6,750,325, 6,632,927, 6,639,055, 6,548,640, 6,407,213, 6,180,370, 6,054,297, 5,929,212, 5,895,205, 5,886,152, 5,877,293, 5,869,619, 5,821,337, 5,821,123, 5,770,196, 5,777,085, 5,766,886, 5,714,350, 5,693,762, 5,693,761, 5,530,101, 5,585,089, and 5,225,539.

An antibody having a "biological characteristic" of a reference antibody, is one that possesses one or more of the biological characteristics of that antibody that distinguish it from other antibodies that bind to the same antigen.

The term "peptide" is in the present context intended to mean both short peptides of from 2 to 10 amino acid residues, oligopeptides of from 11 to 100 amino acid residues, and polypeptides of more than 100 amino acid residues. When referring to amino acids in peptides, it is intended that the amino acids are L-amino acids, unless other information is provided.

A "protein" is intended to denote a functional biomolecule comprising at least one peptide; when comprising at least two peptides, these may form complexes, be covalently lin-

ked, or may be non-covalently linked. The polypeptide(s) in a protein can be glycosylated and/or lipidated and/or comprise prosthetic groups.

A "peptide multimer" denotes a molecule which is constituted by at least two peptides in a non-natural configuration relative to each other. Examples are peptides from the same or from different proteins which are covalently linked via the side chains of at least one of their amino acids, or which are linked via their termini (e.g. via peptide bonds) but in a configuration which does not appear in nature. Typical examples of peptide multimers are detailed below.

A "variant" or "analogue" of a peptide refers to a peptide having an amino acid sequence that is substantially identical to a reference peptide, typically a native or "parent" polypeptide. The peptide variant may possess one or more amino acid substitutions, deletions, and/or insertions at certain positions within the native amino acid sequence.

"Conservative" amino acid substitutions are those in which an amino acid residue is replaced with an amino acid residue having a side chain with similar physicochemical properties. Families of amino acid residues having similar side chains are known in the art, and include amino acids with basic side chains (e.g., lysine, arginine, histidine), acidic side chains (e.g., aspartic acid, glutamic acid), uncharged polar side chains (e.g., glycine, asparagine, glutamine, serine, threonine, tyrosine, cysteine, tryptophan), nonpolar side chains (e.g., alanine, valine, leucine, isoleucine, proline, phenylalanine, methionine), beta-branched side chains (e.g., threonine, valine, isoleucine) and aromatic side chains (e.g., tyrosine, phenylalanine, tryptophan, histidine). A particular form of conservative amino acid substitutions include those with amino acids, which are not among the normal 20 amino acids encoded by the genetic code. Since preferred embodiments of the present invention entail use of synthetic peptides, it is unproblematic to provide such "non-naturally occurring" amino acid residues in the peptides disclosed herein, and thereby it is possible to exchange the natural saturated carbon chains in the side chains of amino acid residues with shorter or longer saturated carbon chains – for instance, lysine may be substituted with an amino acid having an the side chain $-(\text{CH}_2)_n\text{NH}_3$, where n is different from 4, and arginine may be substituted with an amino acid having the side chain $-(\text{CH}_2)_n\text{NHC}(=\text{NH}_2)\text{NH}_2$, where n is different from 3, etc. Similarly, the acidic amino acids aspartic acid and glutamic acid may be substituted with amino acid residues having the side chains $-(\text{CH}_2)_n\text{COOH}$, where $n > 2$.

A "retro form" of a peptide is a form of a peptide where the order of the amino acids in N- to C-terminal direction has been inverted. For instance, the retro form of ALDFR is the peptide RFDLA.

An "inverso" form is characterized by the fact that each amino acid in the inverso form is in the opposite stereochemical configurational compared to the corresponding amino acid in the peptide. So, if the peptide is composed of L-amino acids, the inverso form is composed of D-amino acids.

A "retro-inverso" form of a peptide is a form of a peptide which is both an inverso form and a retro form. The retro-inverso form of L-ala – L-Arg – L-Lys is D-Lys – D-Arg – D-ala.

The term "substantially identical" in the context of two amino acid sequences means that the sequences, when optimally aligned, such as by the programs GAP or BESTFIT using default gap weights, share at least about 50, at least about 60, at least about 70, at least about 80, at least about 90, at least about 95, at least about 98, or at least about 99 percent sequence identity. In one embodiment, residue positions that are not identical differ by conservative amino acid substitutions. Sequence identity is typically measured using sequence analysis software. Protein analysis software matches similar sequences using measures of similarity assigned to various substitutions, deletions and other modifications, including conservative amino acid substitutions. For instance, the publicly available GCG software contains programs such as "Gap" and "BestFit" which can be used with default parameters to determine sequence homology or sequence identity between closely related polypeptides, such as homologous polypeptides from different species of organisms or between a wild-type protein and a mutein thereof. See, *e.g.*, GCG Version 6.1. Polypeptide sequences can also be compared using FASTA or ClustalW, applying default or recommended parameters. A program in GCG Version 6.1., FASTA (*e.g.*, FASTA2 and FASTA3) provides alignments and percent sequence identity of the regions of the best overlap between the query and search sequences (Pearson, *Methods Enzymol.* 1990;183:63-98; Pearson, *Methods Mol. Biol.* 2000;132:185-219). Another preferred algorithm when comparing a sequence to a database containing a large number of sequences from various organisms, or when deducing the is the computer program BLAST, especially blastp, using default parameters. See, *e.g.*, Altschul et al., *J. Mol. Biol.* 1990;215:403-410; Altschul et al., *Nucleic Acids Res.* 1997;25:3389-402 (1997); each herein incorporated by reference. "Corresponding" amino acid positions in two substantially identical amino acid sequences are those aligned by any of the protein analysis software mentioned herein, typically using default parameters.

The term "subsequence" in general means any consecutive stretch of at least 3 amino acids or, when relevant, of at least 3 nucleotides, derived directly from a naturally occurring amino acid sequence or nucleic acid sequence, respectively. However, when discussing peptide multimers of the present invention, the subsequence may be as short as 1 or 2 amino acids. This is because the inventive peptide multimers include amino acids from different peptide domains, where the amino acids together at least form a conformational epitope for an antibody. Hence, such a conformational epitope could be composed of 4 amino acids from C5, but only 1 or 2 from tm-gp41 – the important point is here that this combined epitope from 2 domains is capable of being stabilised, i.e. that antibody binding to the same epitope in vivo will stabilise the configuration between C5 and tm-gp41 and/or C2.

A nucleic acid is "operably linked" when it is placed into a functional relationship with another nucleic acid sequence. For example, DNA for a presequence or secretory leader is

operably linked to DNA for a polypeptide if it is expressed as a preprotein that participates in the secretion of the polypeptide; a promoter or enhancer is operably linked to a coding sequence if it affects the transcription of the sequence; or a ribosome-binding site is operably linked to a coding sequence if it is positioned so as to facilitate translation. Generally, "operably linked" means that the DNA sequences being linked are contiguous, and, in the case of a secretory leader, contiguous and in reading phase. However, enhancers do not have to be contiguous. Linking is accomplished by ligation at convenient restriction sites. If such sites do not exist, the synthetic oligonucleotide adaptors or linkers are used in accordance with conventional practice.

An "isolated" molecule is a molecule that is the predominant species in the composition wherein it is found with respect to the class of molecules to which it belongs (i.e., it makes up at least about 50% of the type of molecule in the composition and typically will make up at least about 70%, at least about 80%, at least about 85%, at least about 90%, at least about 95%, or more of the species of molecule, e.g., peptide, in the composition). Commonly, a composition of an antibody molecule will exhibit 98% - 99% homogeneity for antibody molecules in the context of all present peptide species in the composition or at least with respect to substantially active peptide species in the context of proposed use.

In the context of the present invention, "treatment" or "treating" refers to preventing, alleviating, managing, curing or reducing one or more symptoms or clinically relevant manifestations of a disease or disorder, unless contradicted by context. For example, "treatment" of a patient in whom no symptoms or clinically relevant manifestations of a disease or disorder have been identified is preventive or prophylactic therapy, whereas "treatment" of a patient in whom symptoms or clinically relevant manifestations of a disease or disorder have been identified generally does not constitute preventive or prophylactic therapy.

The term antigen denotes a substance of matter which is recognized by the immune system's specifically recognizing components (antibodies, T-cells).

The term "immunogen" is in the present context intended to denote a substance of matter, which is capable of inducing an adaptive immune response in an individual, where said adaptive immune response targets the immunogen. In relation to the present invention, an immunogen will induce antibodies that react with the immunogen. In other words, an immunogen is an antigen, which is capable of inducing immunity.

The terms "epitope", "antigenic determinant" and "antigenic site" are used interchangeably herein and denotes the region in an antigen or immunogen which is recognized by antibodies (in the case of antibody binding epitopes, also known as "B-cell epitopes") or by T-cell receptors when the epitope is complexed to an MHC molecule (in the case of T-cell receptor binding epitopes, i.e. "T-cell epitopes").

The term "immunogenically effective amount" has its usual meaning in the art, i.e. an amount of an immunogen, which is capable of inducing an immune response, which

significantly engages pathogenic agents, which share immunological features with the immunogen.

The term "vaccine" is used for a composition comprising an immunogen and which is capable of inducing an immune response which is either capable of reducing the risk of developing a pathological condition or capable of inducing a therapeutically effective immune response which may aid in the cure of (or at least alleviate the symptoms of) a pathological condition.

The term "pharmaceutically acceptable" has its usual meaning in the art, *i.e.* it is used for a substance that can be accepted as part of a medicament for human use when treating the disease in question and thus the term effectively excludes the use of highly toxic substances that would worsen rather than improve the treated subject's condition.

A "T helper lymphocyte epitope" (a T_H epitope) is peptide, which binds an MHC Class II molecule and can be presented on the surface of an antigen presenting cell (APC) bound to the MHC Class II molecule. An "immunological carrier" is generally a substance of matter which includes one or many T_H epitopes, and which increase the immune response against an antigen to which it is coupled by ensuring that T-helper lymphocytes are activated and proliferate. Examples of known immunological carriers are the tetanus and diphtheria toxoids and keyhole limpet hemocyanin (KLH).

The term "adjuvant" has its usual meaning in the art of vaccine technology, *i.e.* a substance or a composition of matter which is 1) not in itself capable of mounting a specific immune response against the immunogen of the vaccine, but which is 2) nevertheless capable of enhancing the immune response against the immunogen. Or, in other words, vaccination with the adjuvant alone does not provide an immune response against the immunogen, vaccination with the immunogen may or may not give rise to an immune response against the immunogen, but the combined vaccination with immunogen and adjuvant induces an immune response against the immunogen which is stronger than that induced by the immunogen alone.

Specific aspects and embodiments of the invention

In some aspects the invention relates to method for reducing and/or delaying pathological effects of human immunodeficiency virus I (HIV) in a human infected with HIV, the method comprising administering an effective amount of an agent capable stabilising association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120 in combination with at least one HIV-specific peptide according to the invention. Other aspects are much similar, but relates to methods of reducing the risk of developing acquired immunodeficiency syndrome (AIDS), the method comprising administering an effective amount of an agent capable of stabilising association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120.

These aspects primarily aim at treating HIV infected individuals with agents which can mimic the antibodies which according to the present invention are characteristic for HIV infected long-term non-progressors – this is the most straightforward therapeutic utilisation of the findings underlying the present invention. Where the some aspects aims at reducing pathological effects of HIV or prolonging the time it takes to develop manifest AIDS, the other aspects aims at reducing the risk of developing AIDS altogether and may therefore be used in individuals which are currently treated prophylactically with antiretroviral therapy.

In one embodiment, the first agent is a molecule comprising at least one amino acid sequence selected independently from an amino acid sequence derived from the transmembrane domain of gp41 and an amino acid sequence derived from the C2 domain, wherein the at least one amino acid sequence binds the C5 domain and optionally comprises at least one D-amino acid; in certain embodiments all the amino acids in the amino acid sequence are D-amino acids. The molecule is preferably a peptide, and in certain embodiments this peptide consists of the at least one amino acid sequence. The amino acid sequences typically include at most 10 amino acid residues, such as at most 9, at most 8, at most 7, at most 6, and at most 5 amino acid residues. Preferred molecules are therefore peptides having 4, 5, 6, 7, 8, 9, or 10 amino acid residues. Specific embodiments of the at least one molecule are therefore the peptides having or comprising SEQ ID NO: 34, 35, 36, 37, 39, 40, 42, 43 and 45, which may all be composed partly or entirely of D-amino acids. Also molecules comprising peptides having Formula III are interesting embodiments of the at least one molecule.

In one embodiment, the agent in the first aspect of the invention is selected from an antibody, an antibody fragment or an antibody analogue. The antibody may be a fully human antibody, a humanized antibody, or a chimeric antibody, or a derivative thereof. Typically, the antibody is an IgA, an IgD, an IgG, an IgE or an IgM – the antibody may be both monoclonal and polyclonal. The antibody fragment is typically selected from a Fab fragment, a Fab' fragment, a Fab'-SH fragment, a F(ab)2 fragment, a F(ab')2 fragment, an Fv fragment, a Heavy chain Ig (a llama or camel Ig), a V_{HH} fragment, a single domain FV, and a single-chain antibody fragment, and the antibody analogue is typically selected from a scFV, a dsFV, a minibody, a diabody, a triabody, a kappa body, an IgNAR, a tandAb, a BiTE, and a multispecific antibody.

In one embodiment of the invention, the agent binds to and stabilises association between one or more amino acid residues in the amino acid stretch TZ¹AKRRVZ²REKR, where Z¹ is K, R or E and where Z² is Q or E, and one or more amino acid residues in an amino acid stretch in the transmembrane domain of gp41 and/or in the constant C2 domain of gp120. This amino acid stretch from C5 is highly conserved across the multiple HIV clades known and effective interaction with this stretch by the agent is therefore believed to be highly advantageous.

Other aspects of the invention relates to a method for reducing the risk of or reducing and/or delaying pathological effects of human immunodeficiency virus I (HIV) in a human infected with HIV, the method comprising administering an effective amount of an immunogen, which induces antibodies that stabilise association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120 in combination with at least one HIV-specific peptide, whereas other aspects relates to a prophylactic method using the same means. In other words, this aspect relates to therapeutic active immunotherapy, whereas other aspects relates to prophylactic immunotherapy of HIV disease, including AIDS. This also entails prophylaxis of HIV infection.

These particular aspects are based on the realisation that it is feasible to *induce* the same type of antibody repertoire in the average HIV infected individual as the one that is found in the HIV LTNP individuals. By carefully selecting peptide regions in both C5 and in tm-gp41 and/or C2 in order to prepare peptide multimers that mimic the antibody binding epitopes present in HIV composed of these regions, it becomes possible to prepare vaccines which will induce the desired immunity – interestingly, this approach does not aim at vaccinating so as to obtain neutralizing antibodies in the classical sense.

In one embodiment the immunogen is selected from a peptide multimer detailed below when discussing other aspects of the invention, a composition detailed below, a nucleic acid fragment discussed in relation to other aspects, a virus or plasmid vector discussed elsewhere, or a plasmid or virus composition discussed under that aspect.

In common for previous aspects they all include embodiments where the targeted association between the C5 domain and C2 and/or the transmembrane domain of gp41 involves at least one amino acid in the sequence TZ¹AKRRVVZ²REKR, where Z¹ is K, R or E and where Z² is Q or E and an amino acid and involves at least one amino acid in the transmembrane domain of gp41 or at least one amino acid in the constant C2 domain of gp120. As explained above, this particular sequence is extremely well-conserved across known HIV clades, and therefore it is the interaction between this sequence and tm-gp41 or C2 it is most feasible to target.

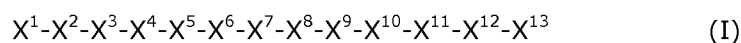
Other aspects of the present invention relates to a composition comprising (1) an immunogen as defined above, such as a peptide multimer, said multimer comprising

- a first peptide comprising the amino acid sequence of the 13 amino acid residue amino acid sequence of the C5 domain of HIV gp120 including between 0 and 4 amino acid substitutions, a subsequence thereof, or an amino acid sequence comprising the inverso-, retro- or retro-inverso form of said amino acid sequence or subsequence, and
- at least one second peptide comprising an amino acid stretch present in the transmembrane domain of gp41 or present in the constant C2 domain of gp120 or comprising an amino acid stretch present in any one of SEQ ID NOs. 6-13 or comprising an inverso-, retro- or retro-inverso form of an amino acid stretch present in the transmembrane domain of gp41 or present in the constant C2 domain of gp120,

wherein said peptide multimer is capable of inducing an antibody which can bind and stabilise the association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120, and wherein said peptide multimer lacks amino acids N-terminal of C5 in gp120 in combination and (2) at least one HIV-specific peptide as defined above.

In other words, this aspect relates to peptide multimers which have a resemblance in 3 dimensions with the epitopes which characterise the interacting areas in C5 on the one hand and tm-gp41 and/or C2 on the other in combination with at least one HIV-specific peptides. The peptide multimers are useful immunogens that can induce antibodies having the same characteristics as the antibodies found in HIV LTNP individuals (such peptide multimers also are promising diagnostic/prognostic tools). The inclusion of retro-, inverso-, and retro-inverso peptides i.e. enables production of proteolytically stable peptides as well as peptides that are truly foreign compared to the HIV counterpart.

In one embodiment of the peptide multimer, said first peptide comprises the amino acid sequence having formula (I):

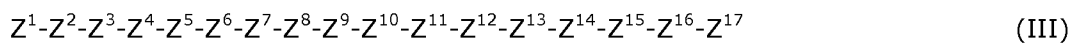


wherein X^1 is Thr, X^2 is selected from Lys, Arg, Har and Glu, X^3 is selected from Ala and Val, X^4 is selected from Arg, Har, Lys and Cit (citrulline), X^5 is selected from Arg, Har, Lys and Cit, X^6 is selected from Arg, Har, Lys and Cit, X^7 is selected from Val, Leu, Ile and Nle (norleucine), X^8 is selected from Val, Leu, Ile and Nle, X^9 is selected from Gln, Glu, Asn and Asp, X^{10} is selected from Arg, Har and Cit, X^{11} is selected from Glu and Asp, X^{12} is Lys, and X^{13} is selected from Arg, Har and Cit,

or comprises a subsequence the amino acid sequence of formula (I), or comprises the inverso-, retro- or retro-inverso form of said amino acid sequence or subsequence. The first peptide may further comprise the dipeptide Ala-Pro linked to the N-terminus of the amino acid sequence having formula I and/or the first peptide may further comprise the dipeptide $X^{14}-X^{15}$ linked to the C-terminus of the amino acid sequence having formula (I), wherein X^{14} is selected from Ala and Val, and wherein X^{15} is selected from Val, Leu and Nle.

Particularly interesting peptides derived from C5 are set forth in the preamble to the Examples and constitute embodiments of a first peptide of the peptide multimers to be used according to the invention.

A number of naturally occurring mutants of gp41 and gp120 has been observed, so when stating that the second peptide comprises an amino acid stretch present in the transmembrane domain of gp41 or present in the constant C2 domain of gp120, this is intended to denote that the amino acid stretch is present in any such naturally occurring form. So, the at least second peptide, when derived from gp41, is in certain embodiments one which includes the amino acid sequence having the formula (III):



wherein Z^1 is Asp, Z^2 is Arg, Z^3 is Pro, Z^4 is Glu or Gly, Z^5 is Gly or Arg, Z^6 is Ile, Z^7 is Glu, Z^8 is Glu, Z^9 is Glu, Z^{10} is Gly, Z^{11} is Gly, Z^{12} is Glu or is absent, Z^{13} is Arg or Gln, Z^{14} is Asp or Gly, Z^{15} is Arg or Lys, Z^{16} is Asp or Gly and Z^{17} is Arg, or includes a subsequence of formula (III), such as a subsequence having at least 5 amino acid residues (such as at least 6, at least 7, at least 8, at least 9, at least 10, at least 11, at least 12, at least 13, at least 14, at least 15, or at least 16 amino acid residues). Further, this embodiment of the second peptide may contain amino acid substitutions which result in a sequence identity of at least 80% with a corresponding amino acid sequence found in gp41.

Particularly interesting peptides derived from C20 and gp41 are set forth in the preamble to the Examples and constitute embodiments of a second peptide of the peptide multimers of the invention.

In certain embodiments of the peptide multimer, the first peptide and the at least one second peptide are associated via a linker; the linker can be any peptide linker, such as a glycine, a lysine or an arginine linker, a polyhistidiny tag, Protein G, and Protein A but it is also possible to use a bis-maleimide linker, a disulfide linker, or a polyethylene glycol (PEG) linker. In practice, any linker found useful in peptide chemistry is also useful as a linker for use according to the present invention. Thus, the invention contemplates the use of "simple" linear peptides which are conjugated or fused to each other, but also peptide multimers where the individual peptides derived from C5 and other regions of gp120 or gp41 are linked via non-peptide linkers e.g. complementary nucleic acids, nucleic acid derivatives or analogues e.g. PNA, LNA. Use of multiple linker types are also within the scope of the present invention, and it is e.g. also a part of the invention to utilise linear peptides which include intrachain disulphide linkers.

Particularly interesting peptide multimers of the invention are set forth in the preamble to the examples.

In certain embodiments, at least one of the first and at least one second peptides in the peptide multimer comprises an N- or C-terminal modification, such as an amidation, acylation, or acetylation. When the C-terminal end of a peptide is an amide, suitable amides included those having the formula $-C(O)-NR^xR^y$, wherein R^x and R^y are independently selected from hydrogen and C_{1-6} alkyl, which alkyl group may be substituted with one or more fluoro atoms, for example $-CH_3$, $-CH_2CH_3$ and $-CF_3$, a particular amide group which may be mentioned is $-C(O)NH_2$. When the N-terminal end of the peptide is acetylated, suitable acetylated N-terminal ends include those of formula $-NH-C(O)R^z$, wherein R^z is hydrogen, C_{1-6} alkyl, which alkyl group may be substituted with one or more fluoro atoms, for example $-CH_3$, $-CH_2CH_3$ and $-CF_3$, or phenyl.

Since the peptide multimers are contemplated as vaccine agents or diagnostic agents, they are in certain embodiments coupled to a carrier molecule, such as an immunogenic carrier. The peptides of the peptide multimers may thus be linked to other

molecules either as recombinant fusions (e.g. via CLIP technology) or through chemical linkages in an oriented (e.g. using heterobifunctional cross-linkers) or nonoriented fashion. Linking to carrier molecules such as for example diphtheria toxin, latex beads (convenient in diagnostic and prognostic embodiments), and magnetic beads (also convenient in diagnostic and prognostic embodiments), polylysine constructs etc, are all possible according to the invention.

The immunogenic carrier is conveniently selected from carrier proteins such as those conventionally used in the art (e.g. diphtheria or tetanus toxoid, KLH etc.), but it is also possible to use shorter peptides (T-helper epitopes) which can induce T-cell immunity in larger proportions of a population. Details about such T-helper epitopes can e.g. be found in WO 00/20027, which is hereby incorporated by reference herein – all immunologic carriers and “promiscuous” (i.e. universal) T-helper epitopes discussed therein are useful as immunogenic carriers in the present invention.

In certain embodiments, the carrier is a virus like particle, i.e. a particle sharing properties with virions without being infectious. Such virus-like particles may be provided chemically (e.g. Jennings and Bachmann *Ann. Rev. Pharmacol. Toxicol.* 2009. 49:303-26 *Immunodrugs: Therapeutic VLP-based vaccines for chronic diseases*) or using cloning techniques to generate fusion proteins (e.g. Peabody et al. *J. Mol. Biol.* 2008; 380: 252-63. *Immunogenic display of diverse peptides on virus-like particles of RNA phage MS2*). Another example is “Remune”, an HIV vaccine originally made by Immune Response Corporation, which consists of formalin inactivated HIV that has been irradiated to destroy the viral genome. The company was started by Jonas Salk who used the same technique to generate the killed polio vaccine in widespread use today. However, on fixation of HIV, gp120 fell off leaving only gp41 on the virion surface. This opens for the possibility of directly admixing C5-derived peptides disclosed herein with Remune particles, because it should still be possible to obtain the binding between C5 and gp41 on a Remune particle.

Embodiments of the invention also include those wherein the first peptide is selected from the group consisting of SEQ ID NO: 1, 2, 3, 4, and 5 or a fragment thereof, or the inverso-, retro- or retro-inverso form of a peptides selected from SEQ ID NO: 1, 2, 3, 4, and 5 or a fragment thereof, and wherein the second peptide is selected from the group consisting of SEQ ID NO: 6, 7, 8, 9, 10, 11, 12, 13, or 46 or a fragment thereof or the inverso-, retro- or retro-inverso form of a peptides selected from SEQ ID NO: 6, 7, 8, 9, 10, 11, 12, 13, or 46 or a fragment thereof. As mentioned above, in such a case the fragment may be very short, as long as the peptide multimer provides for the ability to induce antibodies which will stabilise association between C5 and gp41 and/or C2. A number of interesting peptide multimers for use in the present invention are listed in the Preamble to the Examples.

As used herein “a fragment” or “a subsequence” refers to a smaller part of a given sequence, such as a sequence that has the same functional properties but wherein 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20 have been deleted.

In an embodiment, the peptide multimer of the invention comprises at most 70 amino acids, such as the most 69, at most 68, at most 67, at most 66, at most 65, at most 64, at most 63, at most 62, at most 61, at most 60, at most 59, at most 58, at most 57, at most 56, at most 55, at most 54, at most 53, at most 52, at most 51, at most 50, at most 49, at most 48, at most 47, at most 46, at most 45, at most 44, at most 43, at most 42, at most 41, at most 40, at most 39, at most 38, at most 37, at most 36, at most 35, at most 34, at most 33, at most 32, at most 31, at most 30, at most 29, at most 28, at most 27, at most 26, at most 25, at most 24, at most 23, at most 22, at most 21, at most 20, at most 19, at most 18, at most 17, at most 16, at most 15, at most 14, at most 13, at most 12, at most 11, at most 10, at most 9, at most 8, or at most 7 amino acids.

In an embodiment, the peptide multimer for use in the invention comprises at least 6 amino acid residues, such as at least 7, at least 8, at least 9, at least 10, at least 11, at least 12, at least 13, at least 14, at least 15, at least 16, at least 17, at least 18, at least 19, at least 20, at least 21, at least 22, at least 23, at least 24, at least 25, at least 26, at least 27, at least 28, at least 29, at least 30, at least 31, at least 32, at least 33, at least 34, at least 35, at least 36, at least 37, at least 38, at least 39, at least 40, at least 41, at least 42, at least 43, at least 44, at least 45, at least 46, at least 47, at least 48, at least 49, at least 50, at least 51, at least 52, at least 53, at least 54, at least 55, at least 56, at least 57, at least 58, at least 59, at least 60, at least 61, at least 62, at least 63, at least 64, at least 65, at least 66, at least 67, at least 68, or at least 69 amino acid residues.

In one embodiment, the peptide multimer for use in the invention consists of 6 amino acid residues or 7 amino acid residues or 8 amino acid residues or 9 amino acid residues or 10 amino acid residues or 11 amino acid residues or 12 amino acid residues or 13 amino acid residues or 14 amino acid residues or 15 amino acid residues or 16 amino acid residues or 17 amino acid residues or 18 amino acid residues or 19 amino acid residues or 20 amino acid residues or 21 amino acid residues or 22 amino acid residues or 23 amino acid residues or 24 amino acid residues or 25 amino acid residues or 26 amino acid residues or 27 amino acid residues or 28 amino acid residues or 29 amino acid residues or 30 amino acid residues or 31 amino acid residues or 32 amino acid residues or 33 amino acid residues or 34 amino acid residues or 35 amino acid residues or 36 amino acid residues or 37 amino acid residues or 38 amino acid residues or 39 amino acid residues or 40 amino acid residues or 41 amino acid residues or 42 amino acid residues or 43 amino acid residues or 44 amino acid residues or 45 amino acid residues or 46 amino acid residues or 47 amino acid residues or 48 amino acid residues or 49 amino acid residues or 50 amino acid residues or 51 amino acid residues or 52 amino acid residues or 53 amino acid residues or 54 amino acid residues or 55 amino acid residues or 56 amino acid residues or 57 amino acid residues or 58 amino acid residues or 59 amino acid residues or 60 amino acid residues or 61 amino acid residues or 62 amino acid residues or 63 amino acid residues or 64 amino acid residues or 65 amino acid

residues or 66 amino acid residues or 67 amino acid residues or 68 amino acid residues or 69 amino acid residues or 70 amino acid residues.

One aspect of the present invention relates to an immunogenic composition (such as a vaccine composition) comprising a composition of peptide multimers which have a resemblance in 3 dimensions with the epitopes which characterise the interacting areas in C5 on the one hand and tm-gp41 and/or C2 on the other in combination with at least one HIV-specific peptides, in combination with a pharmaceutically acceptable diluent or vehicle and optionally one or more immunological adjuvant.

In common for aspects of the invention is that they all include embodiments where the at least one HIV-specific peptide is selected from the group of amino acid sequences of SEQ ID NOs: 47, 50, 55 and 61, as defined above;

wherein the terminal ends of each HIV specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls;
or salts of any of the HIV specific peptides.

In some embodiments two or more of the Cys residues of said HIV-specific peptide may form part of an intrachain- or interchain disulphide binding, a $-S-(CH_2)_p-S-$, or a $-(CH_2)_p-$ bridge wherein $p = 1-8$ optionally intervened by one or more heteroatoms such as O, N and S and/or the said peptide sequences are immobilized to a solid support.

In some embodiments the amino acid sequence of SEQ ID NO: 47 is selected from the group of SEQ ID NO: 48 and SEQ ID NO: 49.

In some embodiments the amino acid sequence of SEQ ID NO: 50 is selected from the group of SEQ ID NO: 51, SEQ ID NO: 52, SEQ ID NO: 53 and SEQ ID NO: 54.

In some embodiments the amino acid sequence of SEQ ID NO: 55 is selected from the group of SEQ ID NO: 56, SEQ ID NO: 57, SEQ ID NO: 58, SEQ ID NO: 59 and SEQ ID NO: 60.

In some embodiments the amino acid sequence of SEQ ID NO: 61 is selected from the group of SEQ ID NO: 62, SEQ ID NO: 63, SEQ ID NO: 64, SEQ ID NO: 65 and SEQ ID NO: 66.

In some embodiments the at least one HIV-specific peptide comprises at least, two, three, or four peptides selected from each of the groups of SEQ ID NO: 47, SEQ ID NO: 50, SEQ ID NO: 55 and SEQ ID NO: 61.

In some embodiments the at least one HIV-specific peptide consists of or comprises the peptides of SEQ ID NO: 49, SEQ ID NO: 52, SEQ ID NO: 57 and SEQ ID NO: 64.

Preparation of immunogenic compositions includes the use of state-of-the-art constituents such as immunological adjuvants. Apart from these adjuvants, which are detailed, by way of example, below, immunogenic compositions are prepared as generally taught in the art:

The preparation of vaccines which contain peptide sequences as active ingredients is generally well understood in the art, as exemplified by U.S. Patents 4,608,251; 4,601,903; 4,599,231; 4,599,230; 4,596,792; and 4,578,770, all incorporated herein by reference. Typically, such vaccines are prepared as injectables either as liquid solutions or suspensions; solid forms suitable for solution in, or suspension in, liquid prior to injection may also be prepared. The preparation may also be emulsified. The active immunogenic ingredient is often mixed with excipients which are pharmaceutically acceptable and compatible with the active ingredient. Suitable excipients are, for example, water, saline, dextrose, glycerol, ethanol, or the like, and combinations thereof. In addition, if desired, the vaccine may contain minor amounts of auxiliary substances such as wetting or emulsifying agents, pH buffering agents, or adjuvants which enhance the effectiveness of the vaccines; cf. the detailed discussion of adjuvants below.

The vaccines are conventionally administered parenterally, by injection, for example, either subcutaneously, intracutaneously, intradermally, subdermally or intramuscularly. Additional formulations which are suitable for other modes of administration include suppositories and, in some cases, oral, nasal, buccal, sublingual, intraperitoneal, intravaginal, anal, epidural, spinal, and intracranial formulations. For suppositories, traditional binders and carriers may include, for example, polyalkalene glycols or triglycerides; such suppositories may be formed from mixtures containing the active ingredient in the range of 0.5% to 10% (w/w), preferably 1-2% (w/w). Oral formulations include such normally employed excipients as, for example, pharmaceutical grades of mannitol, lactose, starch, magnesium stearate, sodium saccharine, cellulose, magnesium carbonate, and the like. These compositions take the form of solutions, suspensions, tablets, pills, capsules, sustained release formulations or powders and may contain 10-95% (w/w) of active ingredient, preferably 25-70% (w/w).

The peptides and peptide multimers may be formulated into a vaccine as neutral or salt forms. Pharmaceutically acceptable salts include acid addition salts (formed with the free amino groups of the peptide) and which are formed with inorganic acids such as, for example, hydrochloric or phosphoric acids, or such organic acids as acetic, oxalic, tartaric, mandelic, and the like. Salts formed with the free carboxyl groups may also be derived from inorganic bases such as, for example, sodium, potassium, ammonium, calcium, or ferric hydroxides, and organic bases such as isopropylamine, trimethylamine, 2-ethylamino ethanol, histidine, procaine, and the like.

The vaccines are administered in a manner compatible with the dosage formulation, and in such amount as will be therapeutically effective and immunogenic. The quantity to be administered depends on the subject to be treated, including, e.g., the capacity of the individual's immune system to mount an immune response, and the degree of immunity desired. Suitable dosage ranges are of the order of several hundred micrograms of active ingredient per vaccination with a preferred range from about 0.1 μg to 2,000 μg (even though higher amounts in the 1-10 mg range are contemplated), such as in the range from about 0.5

μg to 1,000 μg , preferably in the range from 1 μg to 500 μg and especially in the range from about 10 μg to 100 μg . Suitable regimens for initial administration and booster shots are also variable but are typified by an initial administration followed by subsequent inoculations or other administrations.

Some of the peptides and peptide multimers are sufficiently immunogenic in a vaccine, but for some of the others the immune response will be enhanced if the vaccine further comprises an adjuvant substance. The immunogenic molecules described herein can be therefore be formulated with adjuvants:

The adjuvants to be combined are known to induce humoral responses and include: i) Salt suspensions (e.g. varieties of salts containing aluminum ions or calcium ions), ii) Oil-in-water emulsions (e.g. varieties of squalane-based or squalene-based emulsions), iii) Water-in-oil emulsions (e.g. Montanide ISA51 or ISA720), iv) Neutral liposomes, v) Cationic liposomes, vi) Microspheres, vii) Immunostimulating complexes (e.g. ISCOMs or ISCOMATRIX), viii) Pattern-recognition receptor agonists (e.g. agonists for C-type lectin receptors (CLRs), NOD-like receptors (NLRs), RIG-like helicases (RLHs), Triggering receptor expressed on myeloid cells (TREM) and Toll-like receptors (TLRs)), ix) Saponins (i.e. Any saponin derived from *Quillaja saponaria* or *Platycodon grandiflorum*), x) Virosomes/Virus-like particles, xi) Enterotoxins (i.e. Cholera toxin, CTA1-DD or *Escherichia coli* heat-labile enterotoxin), and combinations thereof.

For a further enhancement of the vaccine antigenic properties, they could be combined with a well known adjuvant with an oral immune modulant or adjuvant such as a Cox-2 inhibitor or a immunomodulating compound.

A further aspect of the invention is the use of the vaccine combined with adjuvant, with one or more further therapeutic agents, such as an (oral) immunomodulating agent and/or a reservoir purging agent.

The terms "therapeutic agent", such as "immunomodulating agent" or virus reservoir purging agent as used herein, includes but is not limited to cytokines, such as interferons, monoclonal antibodies, such as anti-PD1 antibodies, cyclophosphamide, Thalidomide, Levamisole, and Lenalidomide.

"A virus reservoir purging agent", includes but is not limited to auranofin, IL-7, prostratin, bryostatin, HDAC inhibitors, such as vorinostat, Disulfiram and any suitable agent disclosed in any one of WO2013050422, WO2012051492 A3 and in Barton et al., Clinical Pharmacology & Therapeutics (2013); 93 1, 46–56l, including but not limited to a NF-kappa-B-inducer selected from the group comprising: PMA, prostratin, bryostatin and TNF-alpha, and/or b) a histone deacetylase inhibitor selected from the different families (hydroxamates, cyclic peptides, aliphatic acids, and benzamides) including: TSA, SAHA, MS-275, aminosuberoyl hydroxamic acids, M-Carboxycinnamic acid bishydroxamate, LAQ-824, LBH-589, belinostat (PXD-101), Panobinostat (LBH-589), a cinnamic hydroxamic acid analogue of M-carboxycinnamic acid bishydroxamate, IF2357, aryloxyalkanoic acid hydroxamides,

depsipeptide, apicidin, cyclic hydroxamic acid- containing peptide group of molecules, FK-228, red FK, cyclic peptide mimic linked by an aliphatic chain to a hydroxamic acid, butyrate, phenylbutyrate, sodium butyrate, valproic acid, pivaloyloxymethyl butyrate, 5 NOX-275, and MGCD0103. Any of the above virus reservoir purging agents may be used alone or in combination with any one other suitable virus reservoir purging agent, such as with another class of HIV inducers.

DNA methylation, probably together with repressive histone modifications, may also contribute to a "lock" in a silent state of the provirus and makes its return to an active state difficult. These observations suggest that HDAC or HMT or DNA methylation inhibitors together with efficient cART constitute good anti-latency drug candidates aimed at reducing/eliminating the pool of latent reservoirs to a level bearable by the host immune system.

Accordingly suitable immunomodulatory compounds or purging agents may be DNA methylation inhibitors selected from the two classes (non-nucleoside and nucleoside demethylating agents) including: 5-azacytidine (azacitidine), Sinefungin, 5-aza-2'-deoxycytidine (5-aza-CdR, decitabine), 1-3-Darabinofuranosyl-5-azacytosine (fazarabine) and dihydro-5-azacytidine (DHAC), 5-fluorodeoxycytidine (FdC), oligodeoxynucleotide duplexes containing 2-H pyrimidinone, zebularine, antisense oligodeoxynucleotides (ODNs), MG98, (-)-epigallocatechin-3-gallate, hydralazine, procaine and procainamide.

Other suitable immunomodulatory compounds or purging agents to be used according to the present invention includes histone deacetylase inhibitor is selected from the different families of HDACI (hydroxamates, cyclic peptides, aliphatic acids, and benzamides) including TSA, SAHA, MS-275, aminosuberoyl hydroxamic acids, M-Carboxycinnamic acid bishydroxamate, LAQ-824, LBH-589, belinostat (PXD-101), Panobinostat (LBH-589), a cinnamic hydroxamic acid analogue of M-carboxycinnamic acid bishydroxamate, IF2357, aryloxyalkanoic acid hydroxamides, depsipeptide, apicidin, cyclic hydroxamic acid-containing peptide group of molecules, FK-228, red FK, cyclic peptide mimic linked by an aliphatic chain to a hydroxamic acid, butyrate, phenylbutyrate, sodium butyrate, valproic acid, pivaloyloxymethyl butyrate, 5 NOX-275, and MGCD0103.

Other suitable immunomodulatory compounds or purging agents to be used according to the present invention includes histone methyltransferase inhibitors (chaetocin and BIX-01294); Inhibitors of Enhancers of Zeste 2 (EZH2) – such as 3-deazaneplanocin A (DZNep) used alone or in combination with other classes of immunomodulatory compounds or purging agents.

Other suitable adjuvants includes response-selective C5a agonists, such as EP54 and EP67 described in Hung CY et al. An agonist of human complement fragment C5a enhances vaccine immunity against *Coccidioides* infection. Vaccine (2012) and Kollessery G et al. Tumor-specific peptide based vaccines containing the conformationally biased, response-

selective C5a agonists EP54 and EP67 protect against aggressive large B cell lymphoma in a syngeneic murine model. *Vaccine* (2011) 29: 5904-10.

Various methods of achieving adjuvant effect for the vaccine are thus known. General principles and methods are detailed in "The Theory and Practical Application of Adjuvants", 1995, Duncan E.S. Stewart-Tull (ed.), John Wiley & Sons Ltd, ISBN 0-471-95170-6, and also in "Vaccines: New Generation Immunological Adjuvants", 1995, Gregoriadis G *et al.* (eds.), Plenum Press, New York, ISBN 0-306-45283-9, both of which are hereby incorporated by reference herein, but a number of later publications also deal with the technology of incorporating adjuvants: Roestenberg M *et al.*, *PLoS One*. 2008;**3**(12):e3960. Epub 2008 Dec 18; Relyveld E and Chermann JC, *Biomed Pharmacother*. 1994;**48**(2):79-83; Hsu FJ *et al.*, *Blood*. 1997 May 1;**89**(9):3129-35; Galli G *et al.*, *Proc Natl Acad Sci U S A*. 2009 May 12;**106**(19):7962-7. Epub 2009 Apr 27; Bojang KA *et al.*, *Lancet*. 2001 Dec 8;**358**(9297):1927-34; Odunsi K *et al.*, *Proc Natl Acad Sci U S A*. 2007 Jul 31;**104**(31):12837-42. Epub 2007 Jul 25; Patel GB and Sprott GD; *Crit Rev Biotechnol*. 1999;**19**(4):317-57. Review; Agger EM *et al.*, *PLoS One*. 2008 Sep 8;**3**(9):e3116; Kirby DJ *et al.* *J Drug Target*. 2008 May;**16**(4):282-93; Florindo HF *et al.*, *Vaccine*. 2008 Aug 5;**26**(33):4168-77. Epub 2008 Jun 17; Sun HX *et al.*, *Vaccine*. 2009 May 28; Guy B, *Nat Rev Microbiol*. 2007 Jul;**5**(7):505-17. Review.; Vandepapelière P *et al.*, *Vaccine*. 2008 Mar 4;**26**(10):1375-86. Epub 2008 Jan 14; Ghochikyan A *et al.* *Vaccine*. 2006 Mar 20;**24**(13):2275-82. Epub 2005 Dec 5; Xie Y *et al.*, *Vaccine*. 2008 Jun 25;**26**(27-28):3452-60. Epub 2008 May 1; Chung YC *et al.*, *Vaccine*. 2008 Mar 28;**26**(15):1855-62. Epub 2008 Feb 25; Maier M *et al.*, *Vaccine*. 2005 Oct 25;**23**(44):5149-59; Sundling C *et al.*, *J Gen Virol*. 2008 Dec;**89**(Pt 12):2954-64.

In the methods and compositions of the invention the immunogen, or the agent and (2) the at least one HIV-specific peptide, may be administered in combination with one or more further therapeutically active agents, such as agents for the treatment and or prevention of HIV and/or AIDS.

One aspect of the invention is the use of the vaccine combined with adjuvant, with one or more further therapeutic agents, such as an (oral) immunomodulating agent and/or a reservoir purging agent.

The terms "therapeutic agent", such as "immunomodulating agent" or virus reservoir purging agent as used herein, includes but is not limited to cytokines, such as interferons, monoclonal antibodies, such as ant-PD1 antibodies, cyclophosphamide, Thalidomide, Levamisole, and Lenalidomide.

"A virus reservoir purging agent", includes but is not limited to auranofin, IL-7, prostratin, bryostatin, HDAC inhibitors, such as vorinostat, and Disulfiram, and the further agents described herein.

The failure of antiretroviral therapy (ART) to eradicate HIV-1 infection lies in the observation that HIV-1 remains quiescent in latent reservoirs. Latently infected resting CD4+

cells (either naive or long lived memory cells) carry transcriptionally silent HIV-1 and represent the predominant reservoir of HIV-1 infection. Other cells may also act as reservoirs (Reviewed in Alexaki et al., 2008, *Curr. HIV Res.* 6:388-400) such as macrophages, dendritic cells and astrocytes (where HIV-1 infection occurs via a CD4-independent mechanism). It is these latent reservoirs that represent the major challenge to eradication of HIV-1 infection. Approaches towards eradication include attempts to purge reservoirs by selective activation of latently infected cells (such as memory cells) in the presence of ART such that released virus may not infect and replicate in neighbouring cells (Richman et al., 2009, *Science* 323:1304-1307). Agents include histone deacetylase inhibitors, cytokines, such as IL-2 and IL-7, as well as bryostatin, the protein kinase C activator (Kovochich et al., 2011, *PLoS ONE* 6 (4):e18270). Therapeutic vaccines have the advantage of being able to penetrate sanctuary sites less well accessed by ART such as lymphoid tissue (Pantaleo et al., 1991, *Proc. Natl. Acad. Sci. USA* 88:9838-42; Fox et al., 1991, *J. Infect. Dis.* 164:1051-57) and the central nervous system (Alexaki et al., 2008, *Curr. HIV Res.* 6:388-400), that represent regions for viral persistence. This relates to therapeutic interventions targeting both the virus itself as well as HIV-associated immune activation.

A number of studies have been conducted with the aim of providing compounds that can safely and effectively be used to treat diseases associated with abnormal production of TNF- α . See, e.g., Marriott, J.B., et al, *Expert Opin. Biol. Ther.* (4): 1-8 (2001); G.W. Muller, et al, *Journal of Medicinal Chemistry*, 39(17): 3238-3240 (1996); and G.W. Muller, et al, *Bioorganic & Medicinal Chemistry Letters*, 8: 2669-2674 (1998). Some studies have focused on a group of compounds selected for their capacity to potently inhibit TNF- α production by LPS stimulated PBMC. L.G. Corral, et al, *Ann. Rheum. Dis.*, 58 (suppl I): 1107-1113 (1999). These compounds, often referred to as immunomodulatory compounds, show not only potent inhibition of TNF- α , but also marked inhibition of LPS induced monocyte IL1B and IL12 production. LPS induced IL6 is also inhibited by immunomodulatory compounds, albeit partially. These compounds are potent stimulators of LPS induced IL10. Particular examples include, but are not limited to, the substituted 2-(2,6-dioxopiperidin-3-yl)phthalimides and substituted 2-(2,6-dioxopiperidin-3-yl)-1-oxoisindoles as described in US 6281230 and US 6316471. Monocyte/macrophage function is part of the Innate Immune System that serves as a first line of defense against an infection. By modulating the host's monocytes and macrophages, immunomodulatory compounds can change the dynamics of the response to a viral infection, such as influenza.

Histone deacetylases (HDAC) are a class of enzymes that remove acetyl groups from N-acetylated lysines amino acid on histone proteins. Currently 18 HDACs have been identified in mammals. They have been divided into four classes based on cellular localization, function, and sequence similarity. Class I includes HDACs 1, 2, 3, and 8 which are found primarily in the nucleus. Class II HDACs (HDACs 4, 5, 6, 7, 9, and 10) are found primarily in the cytoplasm but may be able to shuttle between the nucleus and the cytoplasm; class IIa comprises four

HDACs (HDACs 4, 5, 7 and 9) while class IIb comprises two HDACs (HDACs 6 and 10) which are expressed only in the cytoplasm. HDAC11, which is ubiquitously expressed, shares sequence similarities with both class I and class II HDACs and represents Class IV. Class III (also called "sirtuin family") groups NAD⁺-dependent proteins which do not act primarily on histones.

In the methods and compositions of the invention the immunogen, or the agent and (2) the at least one HIV-specific peptide, may be administered in combination, such as in a composition comprising an immunomodulatory compound and/or a reservoir purging agent, such as a histone deacetylase (HDAC) inhibitor.

The immunomodulatory compounds may be selected from anti-PD1 antibodies, such as MDX-1106 (Merck), THALOMID[®] (thalidomide), anti-PD1 antibodies, cyclophosphamide, Levamisole, lenalidomide, CC-4047 (pomalidomide), CC-11006 (Celgene), and CC-10015 (Celgene), and immunomodulatory compound described in any one of WO2007028047, WO2002059106, and WO2002094180. The immunomodulatory compound may be selected from 4-(amino)-2-(2,6-dioxo(3-piperidyl))-isoindoline-1,3-dione and 3-(4-amino-1-oxo-1,3-dihydro-isoindol-2-yl)-piperidine-2,6-dione. In particular the immunomodulatory compound is lenalidomide. The immunomodulatory compound may be enantiomerically pure.

The reservoir purging agent, such as a histone deacetylase (HDAC) inhibitor, may be selected from M344 (4-(dimethylamino)-N-[7-(hydroxyamino)-7-oxoheptyl]benzamide), chidamide (CS055/HBI-800), 4SC-202, (4SC), Resminostat (4SC), hydroxamic acids such as vorinostat (SAHA), belinostat (PXD101), LAQ824, trichostatin A and panobinostat (LBH589); benzamides such as entinostat (MS-275), CI994, and mocetinostat (MGCD0103), cyclic tetrapeptides (such as trapoxin, such as trapoxin B), and the depsipeptides, such as romidepsin (ISTODAX), electrophilic ketones, and the aliphatic acid compounds such as phenylbutyrate, valproic acid, Oxamflatin, ITF2357 (generic givinostat), Apicidin, MC1293, CG05, and CG06; compounds that activate transcription factors including NF-KappaB, Prostratin, auranofin, bryostatin, a nontumorigenic phorbol ester, DPP (12-deoxyphorbol-13-phenylacetate), PMA, and Phorbol 12-myristate 13-acetate (PMA); Compounds that activate HIV mRNA elongation including P-TEF-b kinase and hexamethylbisacetamide (HMBA); IL-7; T-cell stimulating factors including anti-CD3/CD28 - T-cell stimulating Ab's; Kinase inhibitors including Tyrphostin A, Tyrphostin B, and Tyrphostin C; PTEN (phosphatase and tensin homologue) gene inhibitors including SF1670 (Echelon Bioscience), Disulfiram (DSF), an inhibitor of acetaldehyde dehydrogenase, Protein Tyrosine Phosphatase Inhibitors including bpV(HOPic), bpV(phen), and bpV(pic) (Calbiochem; EMD Millipore), Toll-like receptors agonists including Toll-like receptor-9 (TLR9) and Toll-like receptor-7 (TLR9) agonists, quercetin, lipoic acid, sodium butyrate, TNF-alpha, PHA, Tat. In particular the reservoir purging agent is romidepsin.

In the methods of the invention components comprising (1) the immunogen, or the agent, (2) the at least one HIV-specific peptide and/or (3) the one or more further

therapeutically active agents, may be administered simultaneously, sequentially or separately in any order.

Thus the invention provides a pharmaceutical composition comprising at least two of components (1) to (3) above optionally in combination with one or more pharmaceutically acceptable adjuvants, diluents or carriers.

Similarly, the invention also provides a combination product comprising at least two of components (1) to (3), wherein each of component is formulated in admixture with a pharmaceutically-acceptable adjuvant, diluent or carrier. In this aspect of the invention, the combination product may be either a single (combination) pharmaceutical formulation or a kit-of-parts. In a kit-of-parts some or all of the components may be formulated separately and may be each be provided in a form that is suitable for administration in conjunction with the other(s).

The component(s) may also be provided for use, e.g. with instructions for use, in combination with one or more further component(s) as defined above.

The peptides for use in the invention may be produced synthetically using art recognised methods. Further details for the synthetic production of such peptides are found in the Examples. Alternatively the peptides may be produced recombinantly. When recombinantly producing the peptides for use in the invention by means of transformed cells, it is convenient, although far from essential, that the expression product is either exported out into the culture medium or carried on the surface of the transformed cell.

When an effective producer cell has been identified it is preferred, on the basis thereof, to establish a stable cell line which carries the vector of the invention and which expresses the nucleic acid fragment of the invention. Preferably, this stable cell line secretes or carries the peptide expression product, thereby facilitating purification thereof.

In general, plasmid vectors containing replicon and control sequences which are derived from species compatible with the host cell are used in connection with the hosts. The vector ordinarily carries a replication site, as well as marking sequences which are capable of providing phenotypic selection in transformed cells. For example, *E. coli* is typically transformed using pBR322, a plasmid derived from an *E. coli* species (see, e.g., Bolivar *et al.*, 1977). The pBR322 plasmid contains genes for ampicillin and tetracycline resistance and thus provides easy means for identifying transformed cells. The pBR plasmid, or other microbial plasmid or phage must also contain, or be modified to contain, promoters which can be used by the prokaryotic microorganism for expression.

Those promoters most commonly used in recombinant DNA construction include the β -lactamase (penicillinase) and lactose promoter systems (Chang *et al.*, 1978; Itakura *et al.*, 1977; Goeddel *et al.*, 1979) and a tryptophan (*trp*) promoter system (Goeddel *et al.*, 1979; EP-A-0 036 776). While these are the most commonly used, other microbial promoters have been discovered and utilized, and details concerning their nucleotide sequences have been published.

In addition to prokaryotes, eukaryotic microbes, such as yeast cultures may also be used, and also here the promoter should be capable of driving expression. *Saccharomyces cerevisiae*, or common baker's yeast is the most commonly used among eukaryotic microorganisms, although a number of other strains are commonly available. For expression in *Saccharomyces*, the plasmid YRp7, for example, is commonly used (Stinchcomb *et al.*, 1979; Kingsman *et al.*, 1979; Tschemper *et al.*, 1980).

Suitable promoting sequences in yeast vectors include the promoters for 3-phosphoglycerate kinase (Hitzman *et al.*, 1980) or other glycolytic enzymes (Hess *et al.*, 1968; Holland *et al.*, 1978), such as enolase, glyceraldehyde-3-phosphate dehydrogenase, hexokinase, pyruvate decarboxylase, phosphofructokinase, glucose-6-phosphate isomerase, 3-phosphoglycerate mutase, pyruvate kinase, triosephosphate isomerase, phosphoglucose isomerase, and glucokinase. In constructing suitable expression plasmids, the termination sequences associated with these genes are also incorporated into the expression vector 3' of the sequence desired to be expressed to provide polyadenylation of the mRNA and termination.

Other promoters, which have the additional advantage of transcription controlled by growth conditions are the promoter region for alcohol dehydrogenase 2, isocytochrome C, acid phosphatase, degradative enzymes associated with nitrogen metabolism, and the aforementioned glyceraldehyde-3-phosphate dehydrogenase, and enzymes responsible for maltose and galactose utilization. Any plasmid vector containing a yeast-compatible promoter, origin of replication and termination sequences is suitable.

In addition to microorganisms, cultures of cells derived from multicellular organisms may also be used as hosts. In principle, any such cell culture is workable, whether from vertebrate or invertebrate culture. Examples of such useful host cell lines are VERO and HeLa cells, Chinese hamster ovary (CHO) cell lines, and W138, BHK, COS-7 293, *Spodoptera frugiperda* (SF) cells, *Drosophila melanogaster* cell lines (such as Schneider 2 (S₂)), and MDCK cell lines.

Expression vectors for such cells ordinarily include (if necessary) an origin of replication, a promoter located in front of the gene to be expressed, along with any necessary ribosome binding sites, RNA splice sites, polyadenylation site, and transcriptional terminator sequences.

For use in mammalian cells, the control functions on the expression vectors are often provided by viral material. For example, commonly used promoters are derived from polyoma, Adenovirus 2, and most frequently Simian Virus 40 (SV40). The early and late promoters of SV40 virus are particularly useful because both are obtained easily from the virus as a fragment which also contains the SV40 viral origin of replication (Fiers *et al.*, 1978). Smaller or larger SV40 fragments may also be used, provided there is included the approximately 250 bp sequence extending from the *Hind*III site toward the *Bgl*I site located in the viral origin of replication. Further, it is also possible, and often desirable, to utilize

promoter or control sequences normally associated with the desired gene sequence, provided such control sequences are compatible with the host cell systems.

An origin of replication may be provided either by construction of the vector to include an exogenous origin, such as may be derived from SV40 or other viral (e.g., other Polyoma viruses, Adeno, VSV, BPV) or may be provided by the host cell chromosomal replication mechanism. If the vector is integrated into the host cell chromosome, the latter is often sufficient.

As for routes of administration and administration schemes of polypeptide based vaccines which have been detailed above, these are also applicable for the nucleic acid vaccines of the invention and all discussions above pertaining to routes of administration and administration schemes for polypeptides apply *mutatis mutandis* to nucleic acids. To this should be added that nucleic acid vaccines can also be administered intravenously and intraarterially. Furthermore, it is well-known in the art that nucleic acid vaccines can be administered by use of a so-called gene gun and/or by use of electroporation, and hence also these and equivalent modes of administration are regarded as part of the present invention.

Under normal circumstances, the nucleic acid fragment is introduced in the form of a vector wherein expression is under control of a viral promoter. For more detailed discussions of vectors according to the invention, cf. the discussion above. Also, detailed disclosures relating to the formulation and use of nucleic acid vaccines are available, cf. Donnelly JJ *et al.*, 1997, *Annu. Rev. Immunol.* **15**: 617-648 and Donnelly JJ *et al.*, 1997, *Life Sciences* **60**: 163-172. Both of these references are incorporated by reference herein.

An alternative of using peptide immunogens or nucleic acid immunogens is the use of live immunogen technology. This entails administering a non-pathogenic microorganism which has been transformed with a nucleic acid fragment or a vector of the present invention. The non-pathogenic microorganism can be any suitable attenuated bacterial strain (attenuated by means of passaging or by means of removal of pathogenic expression products by recombinant DNA technology), e.g. *Mycobacterium bovis* BCG., non-pathogenic *Streptococcus* spp., *E. coli*, *Salmonella* spp., *Vibrio cholerae*, *Shigella*, etc. Reviews dealing with preparation of state-of-the-art live vaccines can e.g. be found in Saliou P, 1995, *Rev. Prat.* **45**: 1492-1496 and Walker PD, 1992, *Vaccine* **10**: 977-990, both incorporated by reference herein. For details about the nucleic acid fragments and vectors used in such live vaccines, cf. the discussion below.

As an alternative to bacterial live immunogens, the nucleic acid fragment of the invention can be incorporated in a non-virulent viral vaccine vector such as a vaccinia strain or any other suitable poxvirus.

Normally, the non-pathogenic microorganism or virus is administered only once to a subject, but in certain cases it may be necessary to administer the microorganism/virus more than once in a lifetime in order to maintain protective immunity. It is even contemplated that

immunization schemes as those detailed above for polypeptide vaccination will be useful when using live or virus vaccines.

Alternatively, live or virus immunization is combined with previous or subsequent polypeptide and/or nucleic acid immunization. For instance, it is possible to effect primary immunization with a live or virus vaccine followed by subsequent booster immunizations using the polypeptide or nucleic acid approach.

A set of numbered embodiments according to the invention are as follows:

1. A method for reducing and/or delaying pathological effects of human immunodeficiency virus I (HIV) in a human infected with HIV, the method comprising administering (1) an effective amount of at least one agent capable stabilising association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120; in combination with (2) at least one HIV-specific peptide selected from the group of amino acid sequences:

Xaa₁ Xaa₂ Xaa₃ Xaa₄ Xaa₅ Xaa₆ Ala Xaa₈ Xaa₉ Gln Thr Pro Trp Xaa₁₄ Xaa₁₅ Xaa₁₆ Xaa₁₇ Xaa₁₈ Val Xaa₂₀ (SEQ ID NO: 47);

wherein Xaa in position 1 of the peptide derivate is Lys or Arg,
 Xaa in position 2 is Ala, Gly, Ser or Arg,
 Xaa in position 3 is Leu or Met,
 Xaa in position 4 is Gly or Arg,
 Xaa in position 5 is Pro, Thr, Val, Ser, Gln or Ala,
 Xaa in position 6 is Gly, Ala, Lys, Arg, Gln or Glu,
 Xaa in position 8 is Thr or Ser,
 Xaa in position 9 is Leu or Ile,
 Xaa in position 14 is Thr, Ser or Val,
 Xaa in position 15 is Ala or Ser,
 Xaa in position 16 is Cys or Ser,
 Xaa in position 17 is Gln or Leu,
 Xaa in position 18 is Gly, Glu or Arg, and
 Xaa in position 20 is Gly or Arg;

Xaa₁ Xaa₂ Xaa₃ Xaa₄ Xaa₅ Gly Leu Asn Pro Leu Val [Gly]_n Xaa₁₂ Xaa₁₃ Tyr Xaa₁₅ Pro Xaa₁₇ Xaa₁₈ Ile Leu Xaa₂₁ Xaa₂₂ (SEQ ID NO: 50)

wherein Xaa in position 1 is Arg, Lys, Asp or none
 Xaa in position 2 is Trp, Gly, Lys or Arg,

Xaa in position 3 is Ile, Leu, Val or Met,
 Xaa in position 4 is Ile, Val or Leu,
 Xaa in position 5 Leu, Met, Val or Pro,
 Xaa in position 12 is Arg or Lys,
 Xaa in position 13 is Met or Leu,
 Xaa in position 15 is Ser, Cys or Gln,
 Xaa in position 17 is Thr, Val, Ile, Ser or Ala,
 Xaa in position 18 is Ser, Gly or Thr,
 Xaa in position 21 is Asp, Glu, Cys or Gly,
 Xaa in position 22 is Gly or none, and

n = 0, 1, 2 or 3;

Xaa₁ Xaa₂ Xaa₃ Pro Ile Pro Xaa₇ Xaa₈ Xaa₉ Xaa₁₀ Xaa₁₁ Xaa₁₂ [Gly]_n Xaa₁₃ Xaa₁₄ Xaa₁₅ Xaa₁₆
 Xaa₁₇ Xaa₁₈ Xaa₁₉ Xaa₂₀ Xaa₂₁ Xaa₂₂ Xaa₂₃ Xaa₂₄ (SEQ ID NO: 55)

wherein Xaa in position 1 is Asn, Ser, Gly, His, Ala, Pro, Arg or none,
 Xaa in position 2 is Asn, Ala or Lys,
 Xaa in position 3 is Pro, Gln, Gly, Ile or Leu,
 Xaa in position 7 is Val or Ala,
 Xaa in position 8 is Gly or Lys,
 Xaa in position 9 is Glu, Asp, Lys, Phe or Thr,
 Xaa in position 10 is Ile, Met, Val or Leu,
 Xaa in position 11 is Tyr, Leu or none,
 Xaa in position 12 is Ser or none,
 Xaa in position 13 is Arg or none,
 Xaa in position 14 is Asp, Arg, Trp, Ala or none,
 Xaa in position 15 is Ile or none,
 Xaa in position 16 is Tyr or none,
 Xaa in position 17 is Lys or Arg,
 Xaa in position 18 is Arg, Lys or Asp,
 Xaa in position 19 is Trp or Gly,
 Xaa in position 20 is Ile, Met, Val, Gln or Ala,
 Xaa in position 21 is Ile, Val or Ala,
 Xaa in position 22 is Leu, Met or Val,
 Xaa in position 23 is Gly or Cys,
 Xaa in position 24 is Leu or none,
 n = 1, 2 or 3, and

Xaa₁ Xaa₂ Ile Ile Xaa₅ Xaa₆ Xaa₇ Xaa₈ Xaa₉ Leu Xaa₁₁ [Gly]_n [Arg]_m Xaa₁₂ Xaa₁₃ Xaa₁₄ Xaa₁₅
 Xaa₁₆ Xaa₁₇ Xaa₁₈ Xaa₁₉ Xaa₂₀ Xaa₂₁ Xaa₂₂ Xaa₂₃ Xaa₂₄ Xaa₂₅ (SEQ ID NO: 61)

wherein the Xaa in position 1 is Pro, Lys, Arg or none,
Xaa in position 2 is Glu, Arg, Phe or Lys,
Xaa in position 5 is Pro or Thr,
Xaa in position 6 is Met, Thr or Nleu,
Xaa in position 7 is Phe or Leu,
Xaa in position 8 is Ser, Thr, Ala or Met,
Xaa in position 9 is Ala, Glu or Leu,
Xaa in position 11 is Ser or none,
Xaa in position 12 is Ala, Arg or none,
Xaa in position 13 is Ile, Leu or none,
Xaa in position 14 is Ser, Ala, Leu or none,
Xaa in position 15 is Tyr, Glu or Asp,
Xaa in position 16 is Gly or Asp,
Xaa in position 17 is Ala or Leu,
Xaa in position 18 is Thr, Ile, Val, Leu or Asn,
Xaa in position 19 is Pro, Thr or Ser,
Xaa in position 20 is Tyr, Phe, Nleu, His or Gln,
Xaa in position 21 is Asp, Asn, Leu or Ala,
Xaa in position 22 is Leu, Ile, Val or Asn,
Xaa in position 23 is Asn, Tyr, Cys or Gly,
Xaa in position 24 is Thr, Met, Ile, Ala, Val or none,
Xaa in position 25 is Gly or none,
n = 1, 2 or 3 and m = 0, 1, 2 or 3 independent of each other,

the terminal ends of each HIV specific peptide may be free carboxyl- or amino groups, amides, acyls, acetyls or salts thereof.

2. The method according to embodiment 1, wherein two or more of the Cys residues of said HIV-specific peptide may form part of an intrachain- or interchain disulphide binding, a $-S-(CH_2)_p-S-$ or a $-(CH_2)_p-$ bridge wherein $p = 1-8$ optionally intervened by one or more heteroatoms such as O, N and S and/or the said peptide sequences are immobilized to a solid support.

3. The method according to any one of embodiments 1 or 2, wherein the amino acid sequence of SEQ ID NO: 47 is selected from the groups of SEQ ID NO: 48 and SEQ ID NO: 49.

4. The method according to any one of the preceding embodiments, wherein the amino acid sequence of SEQ ID NO: 50 is selected from the groups of SEQ ID NO: 51, SEQ ID NO: 52, SEQ ID NO: 53 and SEQ ID NO: 54.

5. The method according to any one of the preceding embodiments, wherein the amino acid sequence of SEQ ID NO: 55 is selected from the groups of SEQ ID NO: 56 SEQ ID NO: 57, SEQ ID NO: 58, SEQ ID NO: 59 and SEQ ID NO: 60.

6. The method according to any one of the preceding embodiments, wherein the amino acid sequence of SEQ ID NO: 61 is selected from the groups of SEQ ID NO: 62, SEQ ID NO: 63, SEQ ID NO: 64, SEQ ID NO: 65 and SEQ ID NO: 66.

7. The method according to any one of the preceding embodiments, wherein at least one HIV-specific peptide comprises at least , two, three, or four peptides selected from each of the groups of SEQ ID NO: 47, SEQ ID NO: 50, SEQ ID NO: 55 and SEQ ID NO: 61.

8. The method according to any one of the preceding embodiments, wherein at least one HIV-specific peptide consist of or comprises the peptides of the SEQ ID NO: 49, SEQ ID NO: 52, SEQ ID NO: 57 and SEQ ID NO: 64.

9. The method according to any one of the preceding embodiments, wherein the at least one agent capable stabilising association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120 is a molecule comprising at least one amino acid sequence selected independently from an amino acid sequence derived from the transmembrane domain of gp41 and an amino acid sequence derived from the C2 domain, wherein the at least one amino acid sequence binds the C5 domain and optionally comprises at least one D-amino acid.

10. The method according to embodiment 9, wherein the molecule is a peptide.

11. The method according to embodiment 10, wherein the peptide consists of at least one amino acid sequence.

12. The method according to embodiment 11, wherein the amino acid sequence derived from the transmembrane domain of gp41 has an amino acid sequence of at most 10 amino acid residues.

13. The method according to any one of the preceding embodiments, wherein the at least one agent capable stabilising association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120 is selected from an antibody, an antibody fragment or an antibody analogue.

14. The method according to embodiment 13, wherein the antibody which is a fully human antibody, a humanized antibody, or a chimeric antibody, or a derivative thereof.

15. The method according to embodiment 14, wherein the antibody is IgA, an IgD, an IgG, an IgE or an IgM.

16. The method according to embodiment 13, wherein the antibody fragment is selected from a Fab fragment, a Fab' fragment, a Fab'-SH fragment, a F(ab)2 fragment, a F(ab')2 fragment, an Fv fragment, a Heavy chain Ig (a llama or camel Ig), a V_{HH} fragment, a single domain FV, and a single-chain antibody fragment.

17. The method according to embodiment 13, wherein the antibody analogue is selected from a scFV, a dsFV, a minibody, a diabody, a triabody, a kappa body, an IgNAR, a tandAb, a BiTE, and a multispecific antibody.

18. The method according to any one of the preceding embodiments, wherein the at least one agent capable stabilising association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120 binds to and stabilises association between one or more amino acid residues in the amino acid stretch $TZ^1AKRRVVZ^2REKR$, where Z^1 is K, R or E and where Z^2 is Q or E, and one or more amino acid residues in an amino acid stretch in the transmembrane domain of gp41 and/or in the constant C2 domain of gp120.

19. A method for reducing and/or delaying pathological effects of human immunodeficiency virus I (HIV) in a human infected with HIV, the method comprising administering (1) an effective amount of at least one immunogen, which induces antibodies that stabilise association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120; in combination with (2) at least one HIV-specific peptide selected from the group of amino acid sequences of SEQ ID NOs: 47, 50, 55 and 61, as defined in embodiment 1, the terminal ends of each HIV specific peptide may be free carboxyl- or amino groups, amides, acyls, acetyls or salts thereof..

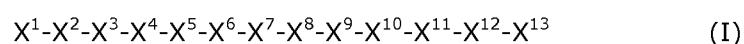
20. The method according to embodiment 19, wherein said at least one HIV-specific peptide is as defined in any one of embodiments 2-8.

21. The method according to embodiments 19 or 20, wherein said immunogen is a peptide multimer comprising

- a first peptide comprising the amino acid sequence of the 13 amino acid residue amino acid sequence of the C5 domain of HIV gp120 including between 0 and 4 amino acid substitutions, a subsequence thereof, or an amino acid sequence comprising the inverso-, retro- or retro-inverso form of said amino acid sequence or subsequence, and
- at least one second peptide comprising an amino acid stretch present in the transmembrane domain of gp41 or present in the constant C2 domain of gp120 or comprising an amino acid stretch present in any one of SEQ ID NOs. 6-13 or comprising a inverso-, retro- or retro-inverso form of an amino acid stretch present in the transmembrane domain of gp41 or present in the constant C2 domain of gp120,

wherein said peptide multimer is capable of inducing an antibody which can bind and stabilise the association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120, and wherein said peptide multimer lacks amino acids N-terminal of C5 in gp120.

22. The method according to any one of embodiments 19-21, wherein said first peptide comprises the amino acid sequence having formula I:



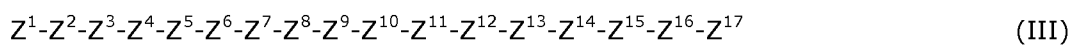
wherein X^1 is Thr, X^2 is selected from Lys, Arg, Har and Glu, X^3 is selected from Ala and Val, X^4 is selected from Arg, Har, Lys and Cit (citrulline), X^5 is selected from Arg, Har, Lys and Cit, X^6 is selected from Arg, Har, Lys and Cit, X^7 is selected from Val, Leu, Ile and Nle (norleucin), X^8 is selected from Val, Leu, Ile and Nle, X^9 is selected from Gln, Glu, Asn and Asp, X^{10} is selected from Arg, Har and Cit, X^{11} is selected from Glu and Asp, X^{12} is Lys, and X^{13} is selected from Arg, Har and Cit,

or comprises a subsequence the amino acid sequence of formula I, or comprising the inverso-, retro- or retro-inverso form of said amino acid sequence or subsequence.

23. The method according to any one of embodiments 19-22, wherein the first peptide further comprises the dipeptide Ala-Pro linked to the N-terminus of the amino acid sequence having formula I.

24. The method according to any one of embodiments 19-23, wherein the first peptide further comprises the dipeptide X^{14} - X^{15} linked to the C-terminus of the amino acid sequence having formula I, wherein X^{14} is selected from Ala and Val, and wherein X^{15} is selected from Val, Leu and Nle.

25. The method according to any one of embodiments 19-24, wherein the at least second peptide includes an amino acid sequence having the formula:



wherein Z^1 is Asp, Z^2 is Arg, Z^3 is Pro, Z^4 is Glu or Gly, Z^5 is Gly or Arg, Z^6 is Ile, Z^7 is Glu, Z^8 is Glu, Z^9 is Glu, Z^{10} is Gly, Z^{11} is Gly, Z^{12} is Glu or is absent, Z^{13} is Arg or Gln, Z^{14} is Asp or Gly, Z^{15} is Arg or Lys, Z^{16} is Asp or Gly and Z^{17} is Arg, or includes a subsequence of formula (III).

26. The method according to any one of embodiments 19-25, wherein the second peptide includes at least 5 consecutive amino acid residues from formula III.

27. The method according to any one of embodiments 19-26, wherein the first peptide and the at least one second peptide are associated via a linker.

28. The method according to any one of embodiments 19-27, wherein the linker is selected from the group consisting of a bis-maleimide linker, a disulfide linker, a polyethylene glycol (PEG) linker, a glycine linker, a lysine linker, and an arginine linker.

29. The method according to any one of embodiments 19-28, where at least one of the first and at least one second peptides comprises an N- or C-terminal modification, such as an amidation, acylation, or acetylation.

30. The method according to any one of embodiments 19-29, wherein said peptide multimer is coupled to a carrier molecule, such as an immunogenic carrier.

31. The method according to any one of embodiments 19-30, wherein the carrier is a virus like particle.

32. The method according to any one of embodiments 19-31, wherein the first peptide is selected from the group consisting of SEQ ID NO: 1, 2, 3, 4, 5, 38, 41 and 44 or a

fragment thereof, or the inverso-, retro- or retro-inverso form of a peptides selected from SEQ ID NO: 1, 2, 3, 4, 5, 38, 41 and 44 or a fragment thereof, and wherein the second peptide is selected from the group consisting of SEQ ID NO: 6, 7, 8, 9, 10, 11, 12, 13, 37, 39, 40, 42, 43, 45, 46 or a fragment thereof, or the inverso-, retro- or retro-inverso form of a peptides selected from SEQ ID NO: 6, 7, 8, 9, 10, 11, 12, 13, 37, 39, 40, 42, 43, 45, 46 or a fragment thereof, and/or wherein the peptide multimer is selected from the peptides having SEQ ID NOs: 1-46.

33. The method according to any one of embodiments 19-32, wherein said peptide multimer comprises at most 70 amino acids.

34. The method according to any one of embodiments 19-33, wherein said peptide multimer comprises at least 6 amino acid residues.

35. The method according to any one of embodiments 19-34, wherein said peptide multimer consist of a number of amino acid residues selected from the group consisting of 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, and 70 amino acid residues.

36. The method according to any one of embodiments 19-35, wherein said peptide multimer is selected from the group consisting of disulphide linked peptides between SEQ ID NO: 28 and any one of SEQ ID NOs: 29, 31, and 33, between SEQ ID NO: 30, and any one of SEQ ID NO: 29, 31, and 33, or between SEQ ID NO: 32 and any one of SEQ ID NO: 29, 31, and 33;

or selected from the group consisting of cysteine-lysine linked peptides between SEQ ID NO: 38 and any one of SEQ ID NO: 39, SEQ ID NO: 40; SEQ ID NO: 42, and SEQ ID NO: 43, or between SEQ ID NO: 41 and any one of SEQ ID NO: 39, SEQ ID NO: 40; SEQ ID NO: 42, and SEQ ID NO: 43.

37. The method according to any one of embodiments 19-36, wherein said peptide multimer is selected from the group consisting of:

CGGAKRRVVGAKRRVVGQREKRAV (SEQ ID NO: 28)
|
CGGGDQQLLGGAEIIIIVGGIEEEGGGERDRDR (SEQ ID NO: 29),

CGGAKRRVVGAKRRVVGQREKR (SEQ ID NO: 30)
|
CGGGDQQLLGGAEIIIIVGGIEEEGG (SEQ ID NO: 31),

CGGAEIIIIVGGDQQLL (SEQ ID NO: 32)
|
CGGAKRRVVGAKRRVV (SEQ ID NO: 33),

GAKRRVVGGCGGAKRRVVQREKRAGEREKRA (SEQ ID NO: 38)
 |
 GKGGIEEEGGRDRDRGGEQDRDR (SEQ ID NO: 39),

GAKRRVVGGCGGAKRRVVQREKRAGEREKRA (SEQ ID NO: 38)
 |
 GKGGIEEEGGERDRDRGGQDRDR (SEQ ID NO: 40),

GAKRRVVGGCGGAKRRVVEREKRAGQREKRA (SEQ ID NO: 41)
 |
 GKGGIEEEGGQDRDRGGDRDRDR (SEQ ID NO: 42),

GAKRRVVGGCGGAKRRVVEREKRAGQREKRA (SEQ ID NO: 41)
 |
 GKGGIEEEGGEQDRDRGGGERDRD (SEQ ID NO: 43) and

GAKRRVVGGCGGAKRRVVQREKRAGEREKRA (SEQ ID NO: 38)
 |
 GKGGIEEEGGRDRDRGGQDRDR (SEQ ID NO: 68).

38. The method according to any one of embodiments 19-37, wherein said peptide multimer is selected (H-Gly-Ala-Lys-Arg-Arg-Val-Val-Gly-Gly-Cys(2-oxo-ethyl)-Gly-Gly-Ala-Lys-Arg-Arg-Val-Val-Gln-Arg-Glu-Lys-Arg-Ala-Gly-Glu-Arg-Glu-Lys-Arg-Ala-NH₂) (H-Gly-Lys-Gly-Gly-Ile-Glu-Glu-Glu-Gly-Gly-Arg-Asp-Arg-Asp-Arg-Gly-Gly-Gln-Asp-Arg-Asp-Arg-NH₂), acetate salt (amide bond between Cys(2-oxo-ethyl)¹⁰ (A-chain) and Lys² (B-chain)).

39. A method of reducing the risk of developing acquired immunodeficiency syndrome (AIDS), the method comprising administering (1) an effective amount of at least one immunogen, which induces an antibody that stabilises association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120; in combination with (2) at least one HIV-specific peptide selected from the group of amino acid sequences of SEQ ID NOs: 47, 50, 55 and 61, as defined in embodiment 1, the terminal ends of each HIV specific peptide may be free carboxyl- or amino groups, amides, acyls, acetyls or salts thereof.

40. The method according to embodiment 39, wherein said at least one HIV-specific peptide is as defined in any one of embodiments 2-8.

41. The method according to embodiments 39 or 40, wherein the at least one immunogen is as defined in any one of embodiments 21-38.

42. A method of reducing the risk of developing acquired immunodeficiency syndrome (AIDS), the method comprising administering (1) an effective amount of at least one agent capable of stabilising association of the C5 domain of HIV gp120 with the

transmembrane domain of gp41 and/or with the constant C2 domain of gp120; in combination with (2) at least one HIV-specific peptide selected from the group of amino acid sequences of SEQ ID NOs: 47, 50, 55 and 61, as defined in embodiment 1, the terminal ends of each HIV specific peptide may be free carboxyl- or amino groups, amides, acyls, acetyls or salts thereof.

43. The method according to embodiment 42, wherein said at least one HIV-specific peptide is as defined in any one of embodiments 2-8.

44. The method according to embodiments 42 or 43, wherein the at least one agent is as defined in any one of embodiments 21-38.

45. The method according to any one of embodiments 42-44, wherein association between the C5 domain and C2 and/or the transmembrane domain of gp41 involves at least one amino acid in the sequence TZ¹AKRRVVZ²REKR, where Z¹ is K, R or E and where Z² is Q or E and an amino acid and involves at least one amino acid in the transmembrane domain of gp41 or at least one amino acid in the constant C2 domain of gp120.

46. A composition comprising (1) a peptide multimer, said multimer comprising

- a first peptide comprising the amino acid sequence of the 13 amino acid residue amino acid sequence of the C5 domain of HIV gp120 including between 0 and 4 amino acid substitutions, a subsequence thereof, or an amino acid sequence comprising the inverso-, retro- or retro-inverso form of said amino acid sequence or subsequence, and
- at least one second peptide comprising an amino acid stretch present in the transmembrane domain of gp41 or present in the constant C2 domain of gp120 or comprising an amino acid stretch present in any one of SEQ ID NOs. 6-13 or comprising a inverso-, retro- or retro-inverso form of an amino acid stretch present in the transmembrane domain of gp41 or present in the constant C2 domain of gp120,

wherein said peptide multimer is capable of inducing an antibody which can bind and stabilise the association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120, and wherein said peptide multimer lacks amino acids N-terminal of C5 in gp120; in combination with (2) at least one HIV-specific peptide selected from the group of amino acid sequences of SEQ ID NOs: 47, 50, 55 and 61, as defined in embodiment 1, the terminal ends of each HIV specific peptide may be free carboxyl- or amino groups, amides, acyls, acetyls or salts thereof.

47. The composition according to embodiment 46, wherein said at least one HIV-specific peptide is as defined in any one of embodiments 2-8.

48. The composition according to embodiments 46 or 47, wherein the at least one peptide multimer is as defined in any one of embodiments 21-38.

49. The composition according to any one of embodiments 46-48, which is an immunogenic composition in combination with a pharmaceutically acceptable diluent or vehicle and optionally one or more immunological adjuvant.

50. The immunogenic composition according to embodiment 48 in the form of a vaccine composition.

51. The immunogenic composition according to embodiment 50 in the form of a vaccine composition where the one or more adjuvant are provided either separately or in combination with the composition.

52. The immunogenic composition according to any one of embodiments 50 or 51 for use as a pharmaceutical.

53. The immunogenic composition according to embodiment 52 for use as a pharmaceutical in the treatment or prophylaxis of AIDS.

PREAMBLE TO EXAMPLES

Overview sequences and abbreviations:

C5-sequences:

APTKAKRRVVQREKRAV (SEQ ID NO: 1)

APTKAKRRVVEREKRAV (SEQ ID NO: 2)

APTRAKRRVVQREKRAV (SEQ ID NO: 3)

APTRAKRRVVEREKRAV (SEQ ID NO: 4)

APTEAKRRVVEREKRAV (SEQ ID NO: 5)

WWGCAKRRVCGGAKRRVVQREKRA (SEQ ID NO: 44)

(underlined amino acid residues in SEQ ID NO: 44 are linked via a disulphide linker; the N-terminal W is preferably a D-amino acid and the C-terminal A may be amidated; the peptide is termed BI450-AdjBT_1, when having these two modifications).

C5-complex forming sequences:

DRPEGIEEEGERDR (where amino acid 4 can be G and/or where amino acid 5 can be R and/or where amino acid 13 can be Q and/or where amino acid 14 can be G and/or where amino acid 15 can be K; SEQ ID NO: 6);

DRPEGIENNGGERDR (SEQ ID NO: 7 where amino acid 4 can be G and/or where amino acid 5 can be R and/or where amino acid 13 can be Q and/or where amino acid 14 can be G and/or where amino acid 15 can be K);

DRPEGIENNGGERDRDR (where amino acid 4 can be G and/or where amino acid 5 can be R and/or where amino acid 13 can be Q and/or where amino acid 14 can be G and/or where amino acid 15 can be K and/or where amino acid 16 can be G); SEQ ID NO: 46).

VERYLKDQQLLG (SEQ ID NO: 8);

VERYLKDEELLG (SEQ ID NO: 9);

VERYLKDNNLLG (SEQ ID NO: 10);

QLLLNGLAEEEEIVI (SEQ ID NO: 11, not yet synthesized)

QLLLNGLAEEVVIV (SEQ ID NO: 12, not yet synthesized)

QLLLNGLAEEVVVI (SEQ ID NO: 13, not yet synthesized)

GGAIVNGSLADDDIVI (SEQ ID NO: 37, also termed 204d herein)

WWGQIEEEGGGIEEEGGGERDR (SEQ ID NO: 45: underlined amino acid residues are linked via a disulphide linker; the N-terminal W is preferably a D-amino acid and the C-terminal R may be amidated; the peptide is termed BI450-AdjBT_2, when having these two modifications).

Polypeptides I:

(Z-SEQ_{c5}-Z-SEQ_{c5})_n

n=1,2,3,4

Polypeptides II:

(Z-SEQ_{cx}-Z-SEQ_{cx})_n

n=1,2,3,4

Peptide complexes:

(Z-SEQ_{c5}-Z-SEQ_{c5})_n

|

Bis-maleimide linker

|

(Z-SEQ_{cx}-Z-SEQ_{cx})_n

n=1,2,3,4

(Z-SEQ_{c5}-Z-SEQ_{c5})_n

|

(Z - SEQ_{cx}-Z-SEQ_{cx})_n

n=1,2,3,4

Examples of polypeptides I can be, but are not restricted to, the following sequences:

APTAKRGGGAPTRAKRGGGAPTEAKR (SEQ ID NO: 14)

RVVEREKGGGAKRRVVGGRVVQREK (SEQ ID NO: 15)

GGAKRRVVGAKRRVVGQREKRAV (SEQ ID NO: 16)

CGGAKRRVVGAKRRVVGQREKRAV (SEQ ID NO: 17)

GGAKRRVVGAKRRVVGQREKR (SEQ ID NO: 18)

CGGAKRRVVGAKRRVVGQREKR (SEQ ID NO: 19)

GGAKRRVVGAKRRVV (SEQ ID NO: 20)

GCGAKRRVVGAKRRVV (SEQ ID NO: 21)

Examples of polypeptides II can be, but are not restricted to, the following sequences:

GGGDQQLLGGAEIIIIVGGIEEEGGGERDRDR (SEQ ID NO: 22)

CGGGDQQLLGGAEIIIIVGGIEEEGGGERDRDR (SEQ ID NO: 23)

GGDQQLLGGAEIIIIVGGGERDR (SEQ ID NO: 24)

CGGGDQQLLGGAEIIIIVGGIEEEGG (SEQ ID NO: 25)

GGAEIIIIVGGDQQLL (SEQ ID NO: 26)

CGGAEEIIIIVGGDQQLL (SEQ ID NO: 27)

Examples of disulfide linked constructs can be, but are not restricted to, the following linked peptide sequences:

CGGAKRRVVGAKRRVVGQREKRAV (SEQ ID NO: 28)
 |
 CGGGDQQLLGAAEEIIVGGIEEEGGERDRDR (SEQ ID NO: 29)

CGGAKRRVVGAKRRVVGQREKR (SEQ ID NO: 30)
 |
 CGGGDQQLLGAAEEIIVGGIEEEGG (SEQ ID NO: 31)

CGGAAEEVVGGDQQLL (SEQ ID NO: 32)
 |
 GCGGAKRRVVGAKRRVV (SEQ ID NO: 33)

The above disulfide linked constructs may e.g. be synthesised by titration of 2-pyridinesulfenyl (SPyr)-protected cysteine-containing peptides with thiol-unprotected peptides. This has proven to be a superior procedure to selectively generate disulfide-linked peptide heterodimers preventing the formation of homodimers (Schutz A *et al.*, Tetrahedron, Volume 56, Issue 24, 9 June 2000, Pages 3889-3891). Similar constructs where SEQ ID NO: 28 is disulphide linked to SEQ ID NOs 31 or 33, or where SEQ ID NO: 30 is disulphide linked to SEQ ID NOs: 29 or 33, or where SEQ ID NO: 32 is disulphide linked to SEQ ID NOs: 29 or 31 are also within the scope of the present invention.

Examples of other linked constructs can be, but are not restricted to, the following linked peptide sequences, which have all been obtained from Bachem (UK) Ltd:

GAKRRVVGGCGGAKRRVQREKRAGEREKRA (SEQ ID NO: 38)
 |
 GKGGIEEEGGRDRDRGGEQDRDR (SEQ ID NO: 39)

(the peptides are linked via the underlined Cys and Lys residues; the entire construct is termed BI400-B herein).

GAKRRVVGGCGGAKRRVQREKRAGEREKRA (SEQ ID NO: 38)
 |
 GKGGIEEEGGERDRDRGGQDRDR (SEQ ID NO: 40)

(the peptides are linked via the underlined Cys and Lys residues; the entire construct is termed BI400-Bu1 herein).

GAKRRVVGGCGGAKRRVVEREKRAGQREKRA (SEQ ID NO: 41)
 |
 GKGGIEEEGGQDRDRGGRDRDR (SEQ ID NO: 42)

(the peptides are linked via the underlined Cys and Lys residues; the entire construct is termed BI400-Bu2 herein).

GAKRRVVGGCGGAKRRVVEREKRAGQREKRA (SEQ ID NO: 41)

|
GKGGIEEEGGEQDRDRGGERDRD (SEQ ID NO: 43)

(the peptides are linked via the underlined Cys and Lys residues; the entire construct is termed BI400-Bu3 herein).

The Cys-Lys linker is typically established in the form of an amide bond between (2-oxo-ethyl) derivatized cysteine in one peptide and lysine in the other peptide.

Similar constructs where SEQ ID NO: 38 is Cys-Lys linked to SEQ ID NOs: 42 or 43, or where SEQ ID NO: 41 is Cys-Lys linked to SEQ ID NOs: 39 or 40 are also within the scope of the present invention.

Small molecule inhibitors:

DQQLL (SEQ ID NO: 34)

AKRRVV (SEQ ID NO: 35)

AEEEVV (SEQ ID NO: 36)

SEQ ID NOs 34-36 are preferably composed partly or completely of D-amino acids.

One preferred immunogen which induces antibodies that stabilise association of the C5 domain of HIV gp120 with the transmembrane domain of gp41 and/or with the constant C2 domain of gp120 is a compound of the following structure:

(H-Glycyl-L-alanyl-L-lysyl-L-arginyl-L-arginyl-L-valyl-L-valyl-glycyl-glycyl-**L-cysteiny****(2-oxo-ethyl)**-glycyl-glycyl-L-alanyl-L-lysyl-L-arginyl-L-arginyl-L-valyl-L-valyl-L-glutaminy-L-arginyl-L-glutamyl-L-lysyl-L-arginyl-L-alanyl-glycyl-L-glutamyl-L-arginyl-L-glutamyl-L-lysyl-L-arginyl-L-alanyl-NH₂) (H-Glycyl-**L-lysyl**-glycyl-glycyl-L-isoleucyl-L-glutamyl-L-glutamyl-L-glutamyl-glycyl-glycyl-L-arginyl-L-aspartyl-L-arginyl-L-aspartyl-L-arginyl-glycyl-glycyl-L-glutaminy-L-aspartyl-L-arginyl-L-aspartyl-L-arginyl-NH₂), acetate salt (amide bond between Cys(2-oxo-ethyl)¹⁰ (A-chain) and Lys² (B-chain))

This compound may also be referred to as:

(H-Gly-Ala-Lys-Arg-Arg-Val-Val-Gly-Gly-**Cys(2-oxo-ethyl)**-Gly-Gly-Ala-Lys-Arg-Arg-Val-Val-Gln-Arg-Glu-Lys-Arg-Ala-Gly-Glu-Arg-Glu-Lys-Arg-Ala-NH₂) (H-Gly-**Lys**-Gly-Gly-Ile-Glu-Glu-Glu-Gly-Gly-Arg-Asp-Arg-Asp-Arg-Gly-Gly-Gln-Asp-Arg-Asp-Arg-NH₂), acetate salt (amide bond between Cys(2-oxo-ethyl)¹⁰ (A-chain) and Lys² (B-chain))

This preferred C5 compound consists of two linear peptide amide chains with 31 amino acids (A-chain) and 22 amino acids (B-chain). Each chain has a free amino group at the N-terminus and an amide group at the C-terminus. The chains are covalently linked via an amide bond between Cys(2-oxo-ethyl)¹⁰ of the A-chain and Lys² of the B-chain. All amino acid

residues except the achiral Gly are in the L-configuration.

H-Gly-Ala-Lys-Arg-Arg-Val-Val-Gly-Gly-Cys-Gly-Gly-Ala-Lys-Arg-Arg-Val-Val-Gln-Arg-Glu-Lys-Arg-Ala-Gly-Glu-Arg-Glu-Lys-Arg-Ala-NH₂



The preferred C5 compound may be provided as an acetate salt (also referred to in the examples as Vacc-C5). The counter ion acetate is bound in ionic form to basic groups of the peptide molecule.

HIV-SPECIFIC PEPTIDES FOR USE ACCORDING TO THE INVENTION

The present invention involves the use of HIV-specific peptides based on conserved regions of HIV gag p24, antigens in free or carrier-bound form comprising at least one of the said peptides.

The HIV-specific peptides for use according to the invention originate from the four different conserved areas of the HIV-1 core protein p24, having the properties of maintaining the uniqueness (sensitivity and specificity) of the HIV-1-epitope. Further these peptides possess no recognized cytotoxic T lymphocyte (CTL) antagonistic effect and have at least one potential CTL epitope.

The HIV-specific peptides, for use according to the invention, which have met the above criteria are selected from the group of amino acid sequences of SEQ ID NOs: 47, 50, 55 and 61, as defined above;

wherein the terminal ends of each HIV specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls; or salts of any of the HIV specific peptides.

The HIV-specific peptide sequences have the potential to serve as a particularly good antigen wherein the antigen comprises at least one peptide selected from the group of sequences of SEQ ID NO : 1, SEQ ID NO : 4, SEQ ID NO : 9 or SEQ ID NO : 15 . The antigenicity may be adapted through adjusting the ratio or concentration of different peptides or size of the peptides by for instance dimerisation or polymerisation and/or immobilisation to a solid phase. The antigen may comprise two or more polypeptide sequences which are either linked by a bridge for instance a disulphide bridge between the Cys residues of the chains or bridges like C₁-C₈ alkylene possibly intervened by one or more heteroatoms like O, S, or N or preferably they are unlinked. The chains may be immobilized to a solid phase in monomeric,

dimeric or oligomeric forms. Further amino acids may be added to the ends in order to achieve an «arm» to facilitate immobilization.

All amino acids in the HIV-specific peptides of the invention can be in both D- or L-form, although the naturally occurring L-form is preferred.

The C- and N-terminal ends of the HIV-specific peptide sequences could deviate from the natural sequences by modification of the terminal NH₂-group and/or COOH-group, they may for instance be acylated, acetylated, amidated or salts thereof; or modified to provide a binding site for a carrier or another molecule. When the C-terminal end of a peptide is an amide, suitable amides included those having the formula -C(O)-NR^xR^y, wherein R^x and R^y are independently selected from hydrogen and C₁₋₆ alkyl, which alkyl group may be substituted with one or more fluoro atoms, for example -CH₃, -CH₂CH₃ and -CF₃, a particular amide group which may be mentioned is -C(O)NH₂. When the N-terminal end of the peptide is acetylated, suitable acetylated N-terminal ends include those of formula -NH-C(O)R^z, wherein R^z is hydrogen, C₁₋₆ alkyl, which alkyl group may be substituted with one or more fluoro atoms, for example -CH₃, -CH₂CH₃ and -CF₃, or phenyl.

The HIV-specific peptides for use according to the invention consist of 6 to 50 amino acids, preferably between 10 and 30 amino acids. They cover all natural variation of amino acids in the identified positions.

The polypeptide antigen for use according to the invention is either in a free or in a carrier-bound form. The carrier or solid phase to which the peptide is optionally bound can be selected from a wide variety of known carriers. It should be selected with regard to the intended use of the immobilized polypeptide as a diagnostic antigen or as an immunizing component in a vaccine.

Examples of carriers that can be used for e.g. diagnostic purposes are magnetic beads or latex of co-polymers such as styrene-divinyl benzene, hydroxylated styrene-divinyl benzene, polystyrene, carboxylated polystyrene, beads of carbon black, non-activated or polystyrene or polyvinyl chloride activated glass, epoxy-activated porous magnetic glass, gelatine or polysaccharide particles or other protein particles, red blood cells, mono- or polyclonal antibodies or fab fragments of such antibodies.

In a preferred embodiment the HIV specific peptides for use according to the present invention comprises antigens containing the peptides of the SEQ ID NOs: 1, 4, 9 and 15, more preferably the peptides occur in the ratio 1:1:1:1 w/w.

In a further preferred embodiment the HIV specific peptides for use according to the invention comprise the following:

RALGPAATLQTPWTASLGVG (SEQ ID NO: 49)

RWLLLGLNPLVGGGRLYSPTSILG (SEQ ID NO: 52)

RAIPIAGTLLSGGGRAIYKRTAILG (SEQ ID NO: 57)

and

Experimental molecular weight: 1742.8

Preparation of VERYLKDQQLG

The peptide was synthesized in amide form, from the corresponding starting point according to the general description of synthesis.

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 1460.7

Experimental molecular weight: 1460.1

Preparation of VERYLKDEELG

The peptide was synthesized in amide form, from the corresponding starting point according to the general description of synthesis.

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 1462.6

Experimental molecular weight: 1463.0

Preparation of VERYLKDNNLLG

The peptide was synthesized in amide form, from the corresponding starting point according to the general description of synthesis.

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 1432.6

Preparation of QLLNGSLAEEEEIVI

The peptide was synthesized in amide form, from the corresponding starting point according to the general description of synthesis.

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 1639.9

Preparation of QLLNGSLAEEEEVVI

The peptide was synthesized in amide form, from the corresponding starting point according to the general description of synthesis.

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 1625.9

Preparation of QLLNSLAEEEEVVI

The peptide was synthesized in amide form, from the corresponding starting point according to the general description of synthesis.

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 1568.8

Preparation of GGAKRRVVGAKRRVV

The peptide was synthesized in amide form, from the corresponding starting point according to the general description of synthesis.

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 1665.0

Preparation of GCGAKRRVVGAKRRVV

The peptide was synthesized in amide form, from the corresponding starting point according to the general description of synthesis.

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 1768.1

Preparation of GGGDQQLLGGAEIIIIVGGIEEEGGGERDRDR

The peptide was synthesized in amide form, from the corresponding starting point according to the general description of synthesis.

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 3127.2

Preparation of CGGGDQQLLGGAEIIIIVGGIEEEGGGERDRDR

The peptide was synthesized in amide form, from the corresponding starting point according to the general description of synthesis.

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 3230.4

Preparation of GGDQQLLGGAEIIIIVGGGERDR

The peptide was synthesized in amide form, from the corresponding starting point according to the general description of synthesis.

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 2242.4

Preparation of CGGGDQQLLGGAEIIIIVGGIEEEGG

The peptide was synthesized in amide form, from the corresponding starting point according to the general description of synthesis.

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 2402.5

Preparation of GGAEIIIIVGGDQQLL

The peptide was synthesized in amide form, from the corresponding starting point according to the general description of synthesis.

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 1499.6

Preparation of CGGAEEEEVGGDQQLL

The peptide was synthesized in amide form, from the corresponding starting point according to the general description of synthesis.

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 1602.7

EXAMPLE 2:

Synthesis of complexed peptides

Preparation of

CGGAKRRVVGGAKRRVVGQREKRAV
CGGGDQQLLGGAEIIIIVGGIEEEGGGERDRD

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 5750.4

Preparation of

CGGAKRRVVGGAKRRVVGQREKR
CGGGDQQLLGGAEIIIIVGGIEEEGG

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 4965.6

Preparation of

CGGAEEEEVGGDQQLL
GCGGAKRRVVGGAKRRVV

Purity (HPLC): more than 90 %.

Mass spectral analysis: Theoretical molecular weight: 3410.9

Experimental molecular weight:

Example 3

Recognition of SEQ ID NO: 1 alone and in combination with SEQ ID NOs: 6, 8 and 9 by pooled human sera from HIV chronically infected individuals, LTNP and non-infected blood donors

Seroreactivity to SEQ ID NO: 1 alone or in combination with SEQ ID NOs. 6 (with the sequence DRPEGIEEEGGGERDR), 8 and 9 was determined according to a general ELISA principle either using magnetic particles as a solid support or attachment of peptides to a 96-well tray.

Methods:

In the system described below, peptide was coated on to magnetic particles using generally

accepted techniques. 300 µg was coated onto particles for all peptides with the exception of SEQ1 where 600 µg was used. SEQ ID NO: 1 (from C5) and SEQ ID NO: 6, 8 and 9 (from gp41) were preincubated overnight at 4 degrees C to allow interactions to form between C5 and gp41 sequences respectively and all combined. Sera were then incubated with the peptide coated beads according to established protocols. Visualisation of antibody binding to C5 peptides was achieved using protein G that can bind immunoglobulins from different species coupled to alkaline phosphatase. The positive control was commercially available serum from a sheep immunised with the C5 derived sequence APTKAKRRVVQREKR (SEQ ID NO: 1).

Pooled sera from 25 LTNP were tested for seroreactivity to SEQ ID NO: 1 alone and SEQ ID NO: 1 when in combination with SEQ ID NOs: 6 (DRPEGIEEEGGGERDR), 8 and 9 respectively and all combined. Pooled sera were also tested from 12 HIV positive, chronically infected individuals and 20 sera from blood donors. The results are shown in Table A:

Table A: Results of seroreactivity of pooled sera to SEQ ID NO: 1 and SEQ ID NO: 1 combined with sequences to gp41. Positivity is determined visually.

Peptide	Blood-donors pool	HIV chronically infected pool	LTNP-pool	Pos. Control
APTKAKRRVVQREKR (= SEQ ID NO: 1) (600µg/ml)	+	2+	4+	>4+
APTKAKRRVVQREKE (SEQ ID NO: 1) 300µg /ml + DRPEGIEEEGGGERDR (SEQ ID NO: 6) 300 µg /ml +VERYLKDQQLLG (SEQ ID NO: 8) 300 µg /ml + VERYLKDEELLG (SEQ ID NO: 9) 300µg/ml	(-)	Neg	3+	4+
APTKAKRRVVQREKE (SEQ ID NO: 1) 300 µg /ml + DRPEGIEEEGGGERDR (SEQ ID NO: 6) 300 µg /ml	+	+	2+	4+
APTKAKRRVVQREKE (SEQ ID NO: 1) 300 µg /ml + VERYLKDQQLLG (SEQ ID NO: 8) 300 µg /ml	(-)	Neg	2+	4+
APTKAKRRVVQREKE (SEQ ID NO: 1) 300 µg /ml + VERYLKDEELLG (SEQ ID NO: 9) 300 µg /ml	+	Neg	+	4+

Results/Discussion points: The results in Table A show that pooled LTNP sera generally provide strong reactivity to SEQ ID NO: 1 from HIV-1 when compared to pooled sera from patients chronically infected with HIV - this has been reported previously. However, combining SEQ ID NO: 1 with other peptides derived from gp41 (e.g. all combined or only

SEQ ID NO: 8) reduced the level of background observed in blood donors as well as responses in pooled sera from chronically infected individuals. The response in LTNP remains strong.

EXAMPLE 4

Recognition of SEQ ID NO: 1 and SEQ ID NO: 1 in combination with SEQ ID NO: 6 by individual human sera from HIV chronically infected, LTNP, Blood donors

Seroreactivities of individual LTNP patient sera to SEQ ID NO: 1 (16 µg) alone and in combination with SEQ ID NO: 6 (16 µg) were determined using an ELISA plate as a solid support. Sheep anti-C5 antibodies were used as a positive control. Optical density (OD) at 280 nm was used as a read out following the enzymatic reaction from protein G coupled to alkaline phosphatase. Fig. 1 shows the proportion of LTNP patients and their OD values following subtraction of background (medium alone in the absence of peptide).

Fig. 1 shows that a greater proportion of LTNP sera (n=8, 2 most right-hand, grey bars) have reactivity to SEQ ID NO: 1 when it is in combination (i.e. >80% ratio) with SEQ ID NO: 6 (DRPEGIEEEGGGERDR) when compared to the reactivity against SEQ ID NO: 1 alone (n=6, most left-hand hatched bar, <0% ratio). For LTNP sera that only had a low response to SEQ ID NO: 1, this effect was enhanced when SEQ ID NOs: 1 and 6 were combined. This demonstrates that the C5:gp41 complex has the ability to capture and increase the response dramatically, even when the response from C5 alone is low; Fig. 1 shows that OD was high in the serum samples that only showed binding to SEQ ID NO: 1. However, when combined with the gp41 sequence, the responses to C5 alone were reduced since antibodies now preferably bound the combination.

Fig. 2 shows the magnitude of responses in individual sera from LTNP, chronically infected patients and blood donors to SEQ ID NO: 1 alone and SEQ ID NO: 1 in combination with SEQ ID NO: 6 (DRPEGIEEEGGGERDR). There was a greater response to SEQ ID NO: 1 alone and SEQ ID NO: 1 combined with SEQ ID NO: 6 (DRPEGIEEEGGGERDR) amongst LTNP patients compared to patients chronically infected with HIV. The median OD value for binding to SEQ ID NO: 1 and SEQ ID NO: 6 in combination is higher than binding to SEQ ID NO: 1 alone for both LTNP and patients chronically infected with HIV, showing that combination with SEQ ID NO: 6 improved seroreactivity. Responses in blood donors are consistently low, there is a very tight interquartile range and no difference in seroreactivity to C5 alone or in combination with SEQ ID NO: 6 (DRPEGIEEEGGGERDR) in this negative control.

A Wilcoxon rank-test performed on the OD-values derived from SEQ ID NOs: 1 and 6 combined on LTNP-sera and the OD-values derived from SEQ ID NOs: 1 and 6 combined on HIV-sera, gives that the true median differs within a 25 % confidence-interval.

EXAMPLE 5

Immunological studies

Rabbit immunizations

New Zealand White female rabbits (n=3) were immunized intradermally at weeks 0, 2 & 6

with 1 ml of BI400-B vaccine consisting of 500 µg BI400-B in 50% V/V Freund's adjuvant (i.e. Complete Freund's adjuvant used for priming, followed by boostings with Incomplete Freund's adjuvant). Individual blood serum was isolated for ELISA.

Direct ELISA for human sera

50-100 µl of a mixture of BI400-015 and -201 (pre-incubated in Coating buffer - 0.05M Na₂CO₃ pH9.6; denoted CB - in cold at 16 µg/ml for each peptide 1-3 days prior to coating) or just CB (background control) was used for coating wells in microtiter plates at 4°C overnight. The microtiter plates were then washed 3x with washing buffer (PBS + 1% v/v Triton-X100; denoted WB), followed by 2h blocking at room temperature (RT) with 200 µl/well of blocking buffer (PBS + 1% w/v BSA). Plates were then washed 3x with WB, followed by 1h incubation at 37°C with 50-70 µl/well of added human (serial dilutions ranging from 1:1 – 1:250 in dilution buffer (PBS + 1% v/v Triton-X100 + 1% w/v BSA; denoted DB)). Plates were then washed 6x with WB, followed by 1h incubation at RT with 70 µl/well of Alkaline Phosphatase-conjugated Protein G (3µg/ml in DB; Calbiochem 539305). Plates were then washed 6x with WB, followed by 10-60 min incubation at room temperature with 100 µl/well of 0.3% w/v of Phenolphthalein monophosphate (Sigma P-5758). Plates were finally quenched by adding 100 µl/well of Quench solution (0.1M TRIS + 0.1M EDTA + 0.5M NaOH + 0.01% w/v NaN₃; pH14), followed by ELISA reader (ASYS UVM 340) at 550 nm.

Competitive ELISA for rabbit sera after immunization with BI400-B

50-100 µl of a mixture of BI400-015 and -201 (pre-incubated in Coating buffer - 0.05M Na₂CO₃ pH9.6; denoted CB - in cold at 16 µg/ml for each peptide 1-3 days prior to coating) or just CB (background control) was used for coating wells in microtiter plates at 4°C overnight. Plates were then washed 3x with washing buffer (PBS + 1% v/v Triton-X100; denoted WB), followed by 2h blocking at room temperature (RT) with 200 µl/well of blocking buffer (PBS + 1% w/v BSA). Plates were then washed 3x with WB, followed by 1h incubation at 37°C with 60-100 µl/well of added rabbit serum samples (diluted 1:10 – 1:250 final concentration) preincubated together (4°C overnight) with serial dilutions (ranging from 10-1000 µM final concentration) of 400-SEQ.B, BI400-015, BI400-201, BI400-204d, recombinant gp41 (Shin-Won Scientific, SWO 102 gp41), BI301-23 (irrelevant protein; control), no peptide (i.e. PBS; control), LTNP-sera pools (diluted 1:10 final concentration), or Blood donor sera-pools (diluted 1:10 final concentration; control). Plates were then washed 6x with WB, followed by 1h incubation at RT with 70 µl/well of Alkaline Phosphatase-conjugated Goat-anti-Rabbit-Ig (6µg/ml; Dako D0487). Plates were then washed 6x with WB, followed by 10-60 min incubation at RT with 100 µl/well of Phenolphthalein monophosphate (Sigma P-5758). Plates were finally quenched by adding 100 µl/well of Quench solution (0.1M TRIS + 0.1M EDTA + 0.5M NaOH + 0.01% w/v NaN₃; pH14), followed by ELISA reader (ASYS UVM 340) at 550 nm.

Results

Fig. 3 demonstrates that sera from rabbits immunized with the vaccine antigen 400 SEQ-B

bound to peptides corresponding to C5/gp41 (015/201) in the presence of PBS. This binding could be inhibited by recombinant gp41 as well as by peptides derived from C5 (015), gp41 (201), and C2 (204d) as well as by 400-SEQ-B itself. The binding could not be inhibited using an irrelevant peptide (B301-23).

As evident from Fig. 4, Anti-C5/gp41 sera from BI400-B immunized rabbits is competitively inhibited by LTNP-sera pools, but not with BD control sera.

As shown in Fig. 5, antibodies against C5/gp41 were observed in 26/43 natural virus suppressor HIV patients with viral loads <15000 copies/ml) and in 4/15 HIV patients with viral loads above 15000 copies/ml. Furthermore, significantly ($p=0.018$ when using a Mann-Whitney test) higher anti-C5 IgG responses (i.e. grouped with respect to OD-value measured at same serum dilution) were observed in HIV-1 patients with viral load below 15000 copies/ml ($n=43$) compared to patients with viral load above 15000 copies/ml ($n=15$).

To conclude, the results from the immunization studies with BI400-B demonstrate that it is possible to generate peptides that elicit antibody responses to C5 and gp41/C2 not only as individual components but also as complexes. The specificity of these antibody responses is confirmed in blocking studies using specific peptide antigens (Fig. 3). Furthermore, antibodies generated to these peptides in animal models are comparable with antibodies elicited in natural HIV infection and associated with longterm nonprogression (Fig. 4). These results show that these peptides are suitable for diagnostics as well as the development of a vaccine targeting HIV-induced immune activation. The finding that BI400-B elicits antibodies that bind to the complex between gp41 and C5, and that these antibodies compete with antisera against the same complex epitopes in LTNP HIV patients indicates that it is possible to stimulate immune responses against these epitopes and thereby induce an LTNP-like condition in patients which do not themselves raise antibodies of this type against HIV.

EXAMPLE 6

In the following, a summary of the procedures for the synthesis and purification of C5-Peptide is given. Experience is still limited which may eventually lead to improvements in the manufacture and quality of this product.

The SPPS synthesis was started with 15 mmoles (A-chain) and 30 mmoles (B-chain) of the resin. After purification of a part of the crude C5-Peptide, 16.6 g of final product were obtained.

Stage 1: Solid phase peptide synthesis

The amino acid sequences of the A-chain (H-Gly-Ala-Lys-Arg-Arg-Val-Val-Gly-Gly-Cys-Gly-Gly-Ala-Lys-Arg-Arg-Val-Val-Gln-Arg-Glu-Lys-Arg-Ala-Gly-Glu-Arg-Glu-Lys-Arg-Ala-NH₂) and the B-chain (H-Gly-Lys-Gly-Gly-Ile-Glu-Glu-Glu-Gly-Gly-Arg-Asp-Arg-Asp-Arg-Gly-Gly-Gln-Asp-Arg-Asp-Arg-NH₂) are assembled by standard solid phase peptide synthesis (SPPS) using the Fmoc-strategy. (W.C. Chan and P.D. White; Solid Phase Peptide Synthesis -

A Practical Approach, Oxford University Press Inc., New York, 2000, ISBN 978-0-19-963724-9)

The solid phase is transferred into an SPPS reactor and the synthesis cycle is started with the Fmoc-deprotection. Following the deprotection step, the peptide chain is elongated by the coupling of the following N- α -protected AA derivative or the dipeptide according to the amino acid sequence in the presence of suitable activating agents. To avoid the formation of long peptide sequences as by-products, a systemic acetylation of unreacted peptide chains (capping procedure) can be performed after every coupling step.

For each single step, the solvents and/or reagents are added, and the reaction mixture is stirred and then filtered to remove solvents and/or reagents from the resin. Single steps of the SPPS cycle may be repeated in case the reaction is incomplete. The SPPS cycle is repeated until the solid phase carries the complete amino acid sequence of the A-chain or the B-chain.

For the A-chain, a final Fmoc-deprotection is performed and the SPPS is completed by drying the peptide resin under reduced pressure.

The B-chain is further modified with a bromoacetyl linker at Lys². This procedure consists of selectively cleaving the side-chain protecting group of Lys² and coupling bromoacetic acid to Lys² in the presence of a suitable activating agent. If the coupling reaction is incomplete, recoupling procedures can be performed. The SPPS is then completed by drying the peptide resin under reduced pressure.

Stage 2: Cleavage from the resin including cleavage of the acid labile protecting groups

Cleavage of the peptides from the resin and concomitant cleavage of the acid labile protecting groups is accomplished by treatment with TFA in the presence of water. Scavengers are added as needed to trap reactive cations and to avoid alkylation of side-chain functions. After filtering off and washing the resin with TFA, the products are precipitated in IPE. They are filtered off, washed with IPE, and dried under reduced pressure.

Stage 3: Purification of the intermediates by preparative HPLC (TFA system)

The A-chain and the B-chain obtained in the previous stage are purified by preparative HPLC on reversed phase columns with ACN gradient elution (TFA system) and UV detection at $\lambda = 220$ nm.

Portions of the peptides are dissolved in water or a mixture of water and acetic acid and loaded onto the column. Subsequently, the ACN gradient of the TFA system is started. The collected fractions are checked by analytical HPLC and pooled accordingly.

Side fractions can be repurified with the TFA system. Finally, the pooled fractions with adequate purity are lyophilized.

Stage 4: Coupling of A-chain and B-chain

The coupling of the two peptide chains is performed by the addition of a solution of the B-chain (1 equivalent) in aqueous TFA to a solution of the A-chain (1 equivalent) in TRIS buffer (adjusted to pH 8.5 by the addition of hydrochloric acid). Additional TRIS buffer is added to maintain a pH > 8 in the reaction mixture. The reaction mixture is then stirred and the reaction progress is monitored by analytical HPLC. Upon completion, the pH of the reaction mixture is lowered to approx. pH 3 by the addition of TFA.

Stage 5: Purification by preparative HPLC (TFA system)

The C5-peptide obtained in the previous stage is purified by preparative HPLC on reversed phase columns with ACN gradient elution (TFA system) and UV detection at $\lambda = 220$ nm.

Portions of the C5-peptide are directly loaded onto the column. Subsequently, the ACN gradient of the TFA system is started. The collected fractions are checked by analytical HPLC and pooled accordingly.

Side fractions can be repurified with the TFA system. Finally, the pooled fractions with adequate purity are lyophilized.

Stage 6: Ion exchange, microfiltration, and lyophilization

The last stage of the manufacture of C5-Peptide is the ion exchange from the TFA salt, obtained in the previous stage, into the acetate salt.

The lyophilized material from the TFA purification is dissolved in 5% acetic acid and the solution loaded onto the ion exchange resin (acetate form). The elution is performed with 5% acetic acid and checked by TLC. The product solution is filtered through a 0.2 μm membrane filter and lyophilized to yield the final product as a white to off-white material.

EXAMPLE 7

DESCRIPTION OF THE PREPARATION OF THE PEPTIDES

The peptides of the invention can be produced by any known method of producing a linear amino acid sequence, such as recombinant DNA techniques. A nucleic acid sequence which encodes a peptide of the invention or a multimer of the said peptides, is introduced into an expression vector. Suitable expression vectors are for instance plasmids, cosmids, viruses and YAC (yeast artificial chromosome) which comprise necessary control regions for replication and expression. The expression vector may be stimulated to expression in a host cell. Suitable host cells are for example bacteria, yeast cells and mammal cells. Such techniques are well known in the art and described for instance by Sambrook et al., *Molecular Cloning: A Laboratory Manual*, Cold Spring Harbor Laboratory Press, Cold Spring Harbor, 1989. Other well-known techniques are degradation or synthesis by coupling of one amino acid residue to the next one in liquid phase or preferably on a solid phase (resin) for instance by the so-called Merrifield synthesis. See for instance Barany and Merrifield in the *Peptides, Analysis, Synthesis, Biology*, Vol.2, E. Gross and Meinhofer, Ed. (Acad.Press, N.Y., 1980), Kneib-

Coronier and Mullen Int. J. Peptide Protein Res.,30, p.705-739 (1987) and Fields and Noble Int.J.Peptide Protein Res., 35, p.161-214 (1990).

In case a linked or cyclic peptide is desired, the amino acid sequence is subjected to a chemical oxidation step in order to cyclize or link the two cysteine residues within one or between two peptide sequences, when the appropriate linear amino acid sequences are synthesized, see Akaji et al., Tetrahedron Letter, 33, 8, p.1073-1076, 1992.

GENERAL DESCRIPTION OF SYNTHESIS

All peptide derivatives prepared in the Examples given below were synthesized on a Milligen 9050 Peptide Synthesizer using a standard program. The resin used was Tenta Gel P RAM with a theoretical loading of 0.20 meq/g (RAPP POLYMERE GmbH, Tübingen). The final product of the synthesis was dried *in vacuo* overnight. The peptide was then cleaved from the resin by treatment with 90% trifluoroacetic acid in the presence of ethandithiol (5%) and water (5%) as scavengers (1.5 hours at RT). Then the resin was filtered and washed on filter with additional trifluoroacetic acid (100%) (2 x 20 ml). The combined filtrates were evaporated *in vacuo* (water bath at RT) and the residue was triturated with ethyl ether (200 ml) and the precipitated product filtered off. The solid was promptly dissolved on filter with glacial acetic acid (100 ml) and added to 1.5 l of 20% acetic acid in methanol and treated with 0,1 M solution of iodine in methanol until a faint brown colour remained. Then Dowex 1 x 8 ion exchange in acetate form (15g) (Bio-Rad, Richmond, CA) was added and the mixture filtered. The filtrate was evaporated and the residue freeze-dried from acetic acid. The product was then purified by reversed phase liquid chromatography on a column filled with Kromasil® 100 - 5 C8 (EKA Nobel, Surte, Sweden) in a suitable system containing acetonitrile in 0.1 % trifluoroacetic acid water solution. The samples collected from the column were analyzed by analytical high performance liquid chromatography (HPLC) (Beckman System Gold, USA) equipped with a Kromasil® 100 - 5 C8 Column (EKA Nobel, Surte, Sweden). Fractions containing pure substance were pooled, the solvent was evaporated and the product freeze-dried from acetic acid. The final HPLC analysis was performed on final product, and the structure of the peptide was confirmed by amino acid analysis and mass spectrometry (LDI-MS).

All amino acids used during the synthesis were L-amino acids and they were protected with a fluorenylmethoxy-carbonyl group at the α -amino function. The side chains were protected as follows:

Cys (Trt), Gln(Trt), Glu(OtBu), Thr(tBu).

The abbreviations, within the brackets are :

Trt = triphenylmethyl

t-Bu = tert. Butyl

OtBu = tert. Butylester

The amino acid derivatives was supplied by Bachem AG, Switzerland.

EXAMPLE 8

Preparation of K A L G P G A T L Q T P W T A C Q G V G - NH₂ (SEQ ID NO: 48).

The peptide was synthesized in amide form, from corresponding starting materials according to the general description of synthesis. The purity was determined by HPLC analysis and the structure was confirmed by amino acid analysis and mass spectrometry (LDI-MS).

Purity (HPLC): 87 %

EXAMPLE 9

Preparation of R A L G P A A T L Q T P W T A S L G V G (SEQ ID NO: 49).

The peptide was synthesized in amide form, from corresponding starting materials according to the general description of synthesis. The purity was determined by HPLC analysis and the structure was confirmed by amino acid analysis and mass spectrometry (LDI-MS).

Purity (HPLC): more than 95%

Molecular weight (free base): 1966

Molecular formula : C₈₈H₁₄₄O₂₅N₂₆

EXAMPLE 10

Preparation of W I I P G L N P L V G G G K L Y S P T S I L C G - NH₂ (SEQ ID NO: 51).

The peptide was synthesized in amide form, from the corresponding starting materials according to the general description of synthesis. The purity was determined by HPLC analysis and the structure was confirmed by amino acid analysis and mass spectrometry (LDI-MS).

Purity (HPLC) : 95%

Mass spectral analysis : Theoretical molecular weight : 2454.9

Experimental molecular weight : 2454.8 ES+

EXAMPLE 11

Preparation of R W L L L G L N P L V G G G R L Y S P T S I L G (SEQ ID NO: 52).

The peptide was synthesized in amide form, from the corresponding starting materials according to the general description of synthesis. The purity was determined by HPLC analysis and the structure was confirmed by amino acid analysis and mass spectrometry (LDI-MS).

Purity (HPLC) : more than 95 %

Molecular weight (free base) : 2552

Molecular formula : C₁₁₉H₁₉₅O₂₉N₃₃

EXAMPLE 12

Preparation of K I L L G L N P L V G G G R L Y S P T S I L G (SEQ ID NO: 53) , R L L L G L N P L V G G G R L Y S P T T I L G (SEQ ID NO: 54) and N I P I P V G D I Y G G G D I Y K R W Q A L C L (SEQ ID NO: 70).

The peptides are synthesized in amide form, from the corresponding starting materials according to the general description of synthesis. The purity are determined by HPLC analysis and the structures are confirmed by amino acid analysis and mass spectrometry (LDI-MS).

EXAMPLE 13

Preparation of R N I P I P V G D I Y G G G D I Y K R W Q A L C L (SEQ ID NO: 56).

The peptide was synthesized in amide form, from the corresponding starting materials according to the general description of synthesis. The purity was determined by HPLC analysis and the structure was confirmed by amino acid analysis and mass spectrometry (LDI-MS).

Purity (HPLC) : 85 %

Mass spectral analysis : Theoretical molecular weight : 2817.3

Experimental molecular weight : 2813.7 ES+

EXAMPLE 14

Preparation of R A I P I P A G T L L S G G G R A I Y K R W A I L G (SEQ ID NO: 57).

The peptide was synthesized in amide form, from the corresponding starting materials according to the general description of synthesis. The purity was determined by HPLC analysis and the structure was confirmed by amino acid analysis and mass spectrometry (LDI-MS).

Purity (HPLC) : more than 95 %

Molecular weight (free base) : 2707

Molecular formula : C₁₂₅H₂₀₈O₂₉N₃₈

EXAMPLE 15

Preparation of A L P I P A G F I Y G G G R I Y K R W Q A L G (SEQ ID NO: 58), K I P I P V G F I G G G W I Y K R W A I L G (SEQ ID NO : 59) and K I P I P V G T L L S G G G R I Y K R W A I L G (SEQ ID NO : 60). The peptides are synthesized in amide form, from the corresponding starting materials according to the general description of synthesis. The purity are determined by HPLC analysis and the structures are confirmed by amino acid analysis and mass spectrometry (LDI-MS).

EXAMPLE 16

Preparation of K F I I P N I F S A L G G A I S Y D L N T N I L N C I (SEQ ID NO : 62).

The peptide was synthesized in amide form, from the corresponding starting materials according to the general description of synthesis. NI in the sequence is Norleucine. The purity was determined by HPLC analysis and the structure was confirmed by amino acid analysis and mass spectrometry (LDI-MS).

Purity (HPLC) : more than 80 %

Mass spectral analysis : Theoretical molecular weight : 2783.3

Experimental molecular weight : 2783.3 ES+

EXAMPLE 17

Preparation of K F I I P N I F S A L S G G G A I S Y D L N T F L N C I G (SEQ ID NO : 63).

The peptide was synthesized in amide form, from the corresponding starting materials according to the general description of synthesis. NI in the sequence is Norleucine. The purity was determined by HPLC analysis and the structure was confirmed by amino acid analysis and mass spectrometry (LDI-MS).

Purity (HPLC) : more than 80 %

Mass spectral analysis : Theoretical molecular weight : 2932.4

Experimental molecular weight : 2931.8 ES+

EXAMPLE 18

Preparation of R F I I P N I F T A L S G G R R A L L Y G A T P Y A I G (SEQ ID NO : 64).

The peptide was synthesized in amide form, from the corresponding starting materials according to the general description of synthesis. NI in the sequence is Norleucine. The purity was determined by HPLC analysis and the structure was confirmed by amino acid analysis and mass spectrometry (LDI-MS).

Purity (HPLC) : more than 95 %

Molecular weight (free base) : 2894

Molecular formula : C₁₃₇H₂₁₇O₃₂N₃₇

EXAMPLE 19

Preparation of K I I P N I F S A L G G G R L L Y G A T P Y A I G (SEQ ID NO: 65), R I I P N I F T A L S G G G R L L Y G A T P Y A I G (SEQ ID NO: 66) and W I I P N I F S A L G G A I S Y D L N T N I L N C I (SEQ ID NO : 71). The peptides are synthesized in amide form, from the corresponding starting materials according to the general description of synthesis. The purity are determined by HPLC analysis and the structures are confirmed by amino acid analysis and mass spectrometry (LDI-MS).

EXAMPLE 20

Dimerisation via disulphide bridge.

The peptide sequences of the Examples 8 and 10 were linked via an oxidation step to form a dipeptide wherein the cysteine residues formed a disulphide bridge. The bridge was formed in either ways;

A) Oxidation with I₂. Equal amounts of the peptides were dissolved in acetic acid/methanol (1:4) and 0.1 M I₂ in methanol was added yielding a mixture of the dimer.

or

B) Oxidation via [Cys(Spy)¹⁶]-SEQ ID NO:48. 2,3mM of the peptide of SEQ ID NO: 48 dissolved in 2 M AcOH (aq) and 2-propanol (1:1) was treated with 2,2 dithiodipyridine (3 eqv) to yield [Cys(Spy)¹⁶]-SEQ ID NO:48. Equal amounts of [Cys(Spy)¹⁶]-SEQ ID NO:48 and peptide of SEQ ID NO:51 were dissolved in 10 mM NH₄Oac (aq pH=6, 5) and methanol (5:2) to yield the dimer of SEQ ID NO: 67.

The purity of the peptide was determined by HPLC analysis and the peptide structure was confirmed by amino acid analysis. The peptide content (aminoacid free base) was 80%,
Purity (HPLC) : 92%.

EXAMPLE 21

A vaccine comprising the peptides of the SEQ ID NOs: 49, 52, 57 and 64 was prepared. The freeze-dried peptides were dissolved in sterile water at a final concentration of 4 mg/ml. The final salt concentration was 0.9 %. A preparation of a granulocyte-macrophage-colony stimulating factor (GM-CSF) was also prepared, according to the manufacturers directions for use, to a final concentration of 0.3 mg/ml. The two solutions are administered intracutaneously. A typical injection dose is 100 µl.

EXAMPLE 22

An antigen solution or suspension is mixed with equal parts of Freund`s adjuvant of Behring, complete or incomplete, and is then finely emulsified by being drawn up into, and vigourously pressed out of, an injection syringe, or with a homogenator. The emulsion should remain stable for at least 30 minutes. The antigen-adjuvant emulsions is best injected subcutaneously as a depot.

EXAMPLE 23

Toxicity data.

The dipeptide of Example 20 was diluted in 0.9% NaCl to a test solution concentration of 4 mg/ml. The peptide was administered by injection to NMFI female mice in a dose of 100 µg per kg bodyweight. No toxicological effects were observed and the peptide was deemed not toxic.

Toxicity studies were performed in mice and rats on the peptide composition of the vaccine in Example 21. The mouse was selected for the study to provide comparative data

from a second commonly used rodent species. The test substance was a mixture of four peptides supplied as one vial containing lyophilised material for reconstitution with physiological saline, and dose levels were expressed in terms of total peptide load. The individual peptides was present in ratio 1:1:1:1 w/w giving dose levels of each peptide of 0.0075 mg/kg body weight, 0.075 mg/kg body weight and 0.75 mg/kg body weight, which are up to 500 fold the intended human dose. The test animals were divided into four groups of ten animals each (five males and five females); a saline control group and groups for low, intermediate and high doses. The test composition was administered once, by intravenous infusion into a tail vein at a dose rate of 3 ml/minute. The animals were killed at day 15 and 16 by intraperitoneal injection of sodium pentobarbitone.

The results of these studies indicated that the dose levels administered to the mice and rats elicited no adverse reactions and that the no effect level was in excess of 3 mg/kg.

EXAMPLE 24

Immunoassay for detection of antibodies induced by HIV-1.

The magnetic particle reagents are to be prepared according to the manufacturers recommended protocol. Dynal AS, is the manufacturer of the Dynabeads, which are employed. The magnetic particles coated with ligand are called Reagent 1. A peptide according to the invention is covalently coupled to the pre-activated surface of the magnetic particles. It is also possible to physically absorb the peptide to the surface of the magnetic particles. The concentration of particles in Reagent 1 is within the range from 1 mg/ml to 15 mg/ml. The particle size varies between 0.2 μm to 15 μm . The concentration of peptides is within the range from 0.01 mg/mg particle to 1 mg/mg particle.

The anti human Ig Alkaline Phosphatase (AP) conjugated antibody reagent is prepared according to the recommended protocol of Dako AS. This protocol is a standard procedure in this field. This reagent is called Reagent 2.

The substrate solution phenolphthalein-monophosphate is to be prepared according to the recommended protocol of Fluka AG. This protocol is a standard procedure in this field. The substrate solution is called Reagent 3.

The washing and incubation buffer which is used is standard 0,05M tris-base buffer with the following additional compounds; Tween 20 (0.01% to 0.1%), glycerol (0.1% to 10%) and sodium chloride (0.2% to 0.1%).

The assay procedure comprises an incubation step wherein 1 drop of Reagent 1 is mixed with 2 drops of washing buffer in each well. After mixing, 30 μl of sample is added and the solution is incubated for 5 minutes. The magnetic particles can be trapped by a magnet and the liquid removed, before the magnet is separated. Then the wells are washed twice in 4 drops of washing solution, before incubation with Reagent 2. 1 drop of Reagent 2 is added with 2 drops of washing buffer and the solution is incubated for 5 minutes. The magnetic particles can be trapped by a magnet and the liquid removed, before the magnet is separated.

Then the washing step is repeated before incubation with Reagent 3. 2 drops of Reagent 3 is added to each well and the solution is incubated for 3 minutes. The results can be read against a white background. Positive results are red (3+ = strong red) whereas negative results are clearly light yellow/brown solutions as obtained in the negative control.

The immunoassay kit could be used in detection of antibodies, induced either by HIV virus or HIV-specific peptides or proteins, for instance the peptides of the present invention.

The above Examples are only meant as illustrating the invention. It must be understood that a person skilled in the art can modify the peptides, antigens and vaccines herein described without deviating from the concept and scope of this invention as set forth in the claims.

The polypeptides of the invention can be used in a combination of at least one peptide selected from each group of sequences, SEQ ID NOs: 47, 50, 55 and 61 to form antigens and the active principle of a prophylactic or therapeutic vaccine intended to provide protection against the human immunodeficiency virus type 1 (HIV-1). The vaccine may include compounds having beneficial effects in protecting or stimulating the host's immune system (human being or vertebrate animal) for instance interleukins, interferons, granulocyte macrophage growth factors, haematopoietic growth factors or similar. Preferably the vaccine composition further contain an adjuvant or vehicle, more preferably the adjuvant or vehicle is Monophosphoryl Lipid A (MPL ®) possibly with alum, Freund's adjuvant (complete or incomplete) or aluminum hydroxide. The optimal amount of adjuvant/vehicle will depend on the type(s) which is chosen.

The peptide or vaccine formulation can be freeze-dried prior to storage. The vaccine may be stored preferably at low temperature, in ampoules containing one or more dosage units, ready for use. A typical dosage unit of the peptide according to the invention is within the concentration range: 1 µg-1mg per kg bodyweight, preferably within 2 µg-0.15 mg per kg body weight. Persons skilled in the art will appreciate that a suitable dose will depend on the body weight of the patient, the type of disease, severity of condition, administration route and several other factors. The vaccine might be administered up to twelve times and through injection, typically it will be administered about three times. In preparation of an injection solution the peptides are dissolved in sterile sodium chloride solution at a final concentration of 1 mg/ml per peptide and 0,9% sodium chloride. Typically an injection volume is 100 µl to 200 µl (2 x 100 µl). The peptide is preferably co-administered with a suitable adjuvant and/or a granulocyte-macrophage growth factor for instance Leucomax® «Shering Plough». Suitable administration may be intracutane, subcutane, intravenous, peroral, intramuscular, intranasal, mucosal or any other suitable route. Booster administrations may be required in order to maintain protection.

EXAMPLE 25

A clinical study testing the combination of Vacc-4x and Vacc-C5 could be constructed based on pre-existing clinical data. The vaccination regime of Vacc-C5 could be 300µg Vacc-C5 delivered intradermally 10 minutes following an intradermal injection of 0.33×10^6 IU Granulocyte-macrophage colony-stimulating factor (GM-CSF). The vaccination regime could be once weekly in weeks 1, 2, 4, 12, 13, 22 and 23. After period of immunological maturation, a vaccination schedule of Vacc-4x could be 300µg/peptide given intradermally 10 minutes following an intradermal injection of 0.33×10^6 IU GM-CSF. The Vacc-4x could be parentally administered at weeks 27, 28, 29, 30, 42, 44, with clinical and immunological parameters measured throughout the protocol, such as Delayed Hypersensitivity Reaction (DTH), serological parameters such as ELISA for Vacc-C5 antibody response and cellular parameters such as ELISPOT or proliferation for Vacc-4x or corresponding native antigen. Alternatively, the Vacc-4x and Vacc-C5 (for instance 300µg per peptide Vacc-4x and 300µg Vacc-C5) could be combined in the same injection and be administered 10 minutes following intradermal injection of GM-CSF, once weekly at weeks 1, 2, 3, 4, 16 and 18, with clinical and immunological parameters measured throughout the protocol, such as DTH, serological parameters such as ELISA for Vacc-C5 antibody response and cellular parameters such as ELISPOT or proliferation for Vacc-4x or corresponding native antigen. The adjuvant could also be ISA51, ISA720, Provac or other licenced or non-licenced adjuvant instead of GM-CSF, in both clinical studies.

Example 26

Test of peptides together with IMiDs for increased proliferation, polyfunctionality, IL-2 secretion and IFN- γ production.

Expansion of polyfunctional HIV-specific T-cells upon stimulation with Dendritic Cells, pre-incubated with peptides to be used according to the invention, may be studied by methods described by Keersmaecker et al. (J. Virol., 2012 86:9351-9360) and referenced therein, HIV proteins Gag or Nef, they are incubated with peptides to be used according to the invention, before they are used to stimulate T-cells in a co-culture.

Keersmaecker et al. found that the presence of IMiDs (Lenalidomide (IMiD3; CC-5013) and pomalidomide (IMiD1; CC-4047) during in vitro T-cell stimulation with dendritic cells presenting Gag- or Nef-specific peptides, resulted in a number of improvements in the function of the T-cells. Among these were; polyfunctional HIV specific CD8+ T cells with enhanced lytic capacity, more Gag antigen epitopes recognized and at lower antigen peptide concentrations, reduced proliferation of CD4+ T cells with increased number of polyfunctional CD4+ T-cells, increased IL-2 production by CD8 T-cells, detectable IFN- γ production by CD8+ T-cells and CD4 T-cells after antigen stimulation.

"Expansion of Polyfunctional HIV-Specific T Cells upon Stimulation with mRNA Electroporated Dendritic Cells in the Presence of Immunomodulatory Drugs"

Brenda De Keersmaecker, Sabine D. Allard, Patrick Lacor, Rik Schots, Kris Thielemans, and

Joeri L. Aerts

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doi:10.1128/JVI.00472-12

Example 27

Suggested clinical study protocol for the test of Peptide composition comprising 4 peptides in combination with Lenalidomide and HDAC inhibitor

Immunizations (four primary immunizations and two booster immunizations) at Weeks 1, 2, 3 and 4, and booster immunizations at Weeks 12 and 13 with either:

- 1) Peptide composition with GM-CSF as adjuvant and Lenalidomide (CC-5013), or
- 2) Peptide composition with GM-CSF as adjuvant and Placebo for Lenalidomide (CC-5013).
- 3) Placebo

Suggested doses:

Peptide composition: 0.6, 0.9, 1.2 and 1.5 mg (Equimolar amount of each peptide)

Lenalidomide: 5, 10, and 25 mg.

Vacc-C5: 100, 300 and 900 µg.

Subjects randomized to the Lenalidomide (CC-5013) arm will take a single oral dose of Lenalidomide (CC-5013) daily the two preceding days before immunization with the Peptide composition and on the day of each immunization.

The Peptide composition used according to this clinical trial setup consists of SEQ ID NO:49, SEQ ID NO:52, SEQ ID NO:57, and SEQ ID NO:64.

At week 20 subjects in all study arms will receive 20 mg panobinostat (LBH589) orally on days 1, 3, and 5 (i.e. 3 times a week) every other week for a period of 8 weeks (up to week 28) while maintaining background ART. This will be followed by a 24 week follow up period (up to week 52). Upon completion of the study, subjects may be invited to participate in an additional observational study in which ART will be interrupted to evaluate the effect of study treatment on virological control. Enrolment into this part of the study will be optional and determined by the effect of study treatments on the latent HIV-1 reservoir. (Maximum duration of treatment interruption: 16 weeks).

In summary:

Study arm 1: Peptide composition + IMiD + HDAC (panobinostat)

Study arm 2: Peptide composition + HDAC (panobinostat)

Study arm 3: HDAC (panobinostat)

Depletion of the viral reservoir as a result of the combination treatments according to the present invention may be quantified by for instance following the procedures set forth in Lehrman et al. (The Lancet (366), 2005, pp. 549-555) and references there in. In brief, this

includes measuring in samples of patient blood obtained before, during and after treatment; p24 expression from stimulated latently infected cells, plasma HIV RNA concentration (viral load), and integrated HIV DNA by realtime PCR analysis.

Example 28

DC/ T-CELL PROLIFERATION ASSAY

Dendritic cells (DC) were generated from monocytes isolated from buffy coat preparations from healthy blood donors. Briefly, peripheral blood mononuclear cells were separated by a density gradient centrifugation and the monocytes were then negatively isolated using the Dynabeads Untouched Human Monocytes (Invitrogen, Carlsbad, CA) following the manufacturer's instructions. The monocytes were cultured with IL-4 (20 ng/ml; Immunotools, Friesoythe; Germany) and GM-CSF (100 ng/ml; Immunotools) in X-VIVO15 medium (Lonza, Basel, Switzerland) for 5-6 days to generate immature DC. Cytokines were replenished every 2-3 days. The maturation of the cells was performed for 24 hours with IFN- γ (1000 IU/ml), TNF- α (50 ng/ml), IL-1 β (25 ng/ml) IFN- α (3000 IU/ml). After maturation, the DC were pulsed for 2 hours at 37°C with peptides at 10 μ g/ml, before extensive washing and co-culture with Peripheral blood mononuclear cells (PBMC) labelled with a fluorescent dye (VPD450, BD biosciences, Sam Jose, CA). Various ratios with DC:T cell were tested alongside with appropriate controls. IL-2 (50U/ml) and IL-7 (50ng/mL) (Both, Immunotools) and wells with or without IMiDs were added at the start of co-culture. At day 6-10, the level of T cell proliferation was analysed by flow cytometry. The supernatants from the co-culture wells were investigated with Luminex technology to establish any suppressor activity.

Example 29

Immunological studies

Rabbit immunizations

New Zealand White female rabbits were immunized intradermally at weeks 0, 2 & 6 with 1 ml of BI400-B vaccine consisting of 500 μ g BI400-B in 50% V/V Freund's adjuvant (i.e. Complete Freund's adjuvant used for priming, followed by boostings with Incomplete Freund's adjuvant). Animals optionally received a single dose of an immunomodulatory drug (IMiD), for instance daily the two preceding days before immunization and on the day of each immunization Individual blood serum was isolated for ELISA.

Direct ELISA for human sera

50-100 μ l of a mixture of BI400-015 and -201 (pre-incubated in Coating buffer - 0.05M Na₂CO₃ pH9.6; denoted CB - in cold at 16 μ g/ml for each peptide 1-3 days prior to coating) or just CB (background control) was used for coating wells in microtiter plates at 4°C overnight. The microtiter plates were then washed 3x with washing buffer (PBS + 1% v/v Triton-X100; denoted WB), followed by 2h blocking at room temperature (RT) with 200 μ l/well of blocking buffer (PBS + 1% w/v BSA). Plates were then washed 3x with WB, followed by 1h incubation

at 37°C with 50-70 µl/well of added human (serial dilutions ranging from 1:1 – 1:250 in dilution buffer (PBS + 1% v/v Triton-X100 + 1% w/v BSA; denoted DB)). Plates were then washed 6x with WB, followed by 1h incubation at RT with 70 µl/well of Alkaline Phosphatase-conjugated Protein G (3µg/ml in DB; Calbiochem 539305). Plates were then washed 6x with WB, followed by 10-60 min incubation at room temperature with 100 µl/well of 0.3% w/v of Phenophtalein monophosphate (Sigma P-5758). Plates were finally quenched by adding 100 µl/well of Quench solution (0.1M TRIS + 0.1M EDTA + 0.5M NaOH + 0.01% w/v NaN₃; pH14), followed by ELISA reader (ASYS UVM 340) at 550 nm.

Competitive ELISA for rabbit sera after immunization with BI400-B

50-100 µl of a mixture of BI400-015 and -201 (pre-incubated in Coating buffer - 0.05M Na₂CO₃ pH9.6; denoted CB - in cold at 16 µg/ml for each peptide 1-3 days prior to coating) or just CB (background control) was used for coating wells in microtiter plates at 4°C overnight. Plates were then washed 3x with washing buffer (PBS + 1% v/v Triton-X100; denoted WB), followed by 2h blocking at room temperature (RT) with 200 µl/well of blocking buffer (PBS + 1% w/v BSA). Plates were then washed 3x with WB, followed by 1h incubation at 37°C with 60-100 µl/well of added rabbit serum samples (diluted 1:10 – 1:250 final concentration) preincubated together (4°C overnight) with serial dilutions (ranging from 10-1000 µM final concentration) of 400-SEQ.B, BI400-015, BI400-201, BI400-204d, recombinant gp41 (Shin-Won Scientific, SWO 102 gp41), BI301-23 (irrelevant protein; control), no peptide (i.e. PBS; control), LTNP-sera pools (diluted 1:10 final concentration), or Blood donor sera-pools (diluted 1:10 final concentration; control). Plates were then washed 6x with WB, followed by 1h incubation at RT with 70 µl/well of Alkaline Phosphatase-conjugated Goat-anti-Rabbit-Ig (6µg/ml; Dako D0487). Plates were then washed 6x with WB, followed by 10-60 min incubation at RT with 100 µl/well of 0.3% w/v of Phenophtalein monophosphate (Sigma P-5758). Plates were finally quenched by adding 100 µl/well of Quench solution (0.1M TRIS + 0.1M EDTA + 0.5M NaOH + 0.01% w/v NaN₃; pH14), followed by ELISA reader (ASYS UVM 340) at 550 nm.

Example 30

The peptides according to the invention used in the following examples were synthesized by Schafer-N as c-terminal amides using the Fmoc-strategy of Sheppard, (1978) J.Chem.Soc., Chem. Commun., 539.

Cell penetration assay

Intracellular staining for biotinylated peptides

96-well U-bottom polystyrene plates (NUNC, cat no: 163320) were used for staining of human PBMCs. Briefly, 8ul of N- or C-terminally biotinylated peptides according to the invention (i.e. 5mM, 2.5mM & 1.25mM tested for each peptide) were incubated at 37°C for 2h with 40ul of PBMC (12.5 x 10⁶ cells/ml) from blood donors. Cells were then washed 3x with 150ul of Cellwash (BD, cat no: 349524), followed by resuspension of each cell pellet with

100ul of Trypsin-EDTA (Sigma, cat no: T4424), then incubated at 37°C for 5 min. Trypsinated cells were then washed 3x with 150ul of Cellwash (BD, cat no: 349524), followed by resuspension with BD Cytotfix/Cytoperm™ plus (BD, cat no: 554715), then incubated at 4°C for 20 min according to manufacturer. Cells were then washed 2x with 150ul PermWash (BD, cat no: 554715). Cells were then stained with Streptavidin-APC (BD, cat no: 554067) & Anti-hCD11c (eBioscience, cat no: 12-0116) according to manufacturer at 4°C for 30 min aiming to visualize biotinylated peptides & dendritic cells, respectively. Cells were then washed 3x with 150ul PermWash, followed by resuspension in staining buffer (BD, cat no: 554656) before flow cytometry. Dendritic cells were gated as CD11c+ events outside lymphocyte region (i.e. higher FSC & SSC signals than lymphocytes). 200 000 total cells were acquired on a FACSCanto II flow cytometer with HTS loader, and histograms for both total cells & dendritic cells with respect to peptide-fluorescence (i.e. GeoMean) were prepared.

Extracellular staining for biotinylated peptides

96-well U-bottom polystyrene plates (NUNC, cat no: 163320) were used for staining of human PBMCs. Briefly, 8ul of N- or C-terminally biotinylated peptides according to table 1 or table 2 (i.e. 5mM, 2.5mM & 1.25mM tested for each peptide; all peptides manufactured by solid phase synthesis by commercial suppliers) were incubated at 37°C for 2h with 40ul of PBMC (12.5 x 10⁶ cells/ml) from blood donors. Cells were then washed 3x with 150ul of Cellwash (BD, cat no: 349524), then stained with Streptavidin-APC (BD, cat no: 554067) & Anti-hCD11c (eBioscience, cat no: 12-0116) according to manufacturer at 4°C for 30 min aiming to visualize biotinylated peptides & dendritic cells, respectively. Cells were then washed 3x with 150ul of Cellwash (BD, cat no: 349524), followed by resuspension in staining buffer (BD, cat no: 554656) before flow cytometry. Dendritic cells were gated as CD11c+ events outside lymphocyte region (i.e. higher FSC & SSC signals than lymphocytes). 200 000 total cells were acquired on a FACSCanto II flow cytometer with HTS loader, and histograms for both total cells & dendritic cells with respect to peptide-fluorescence (i.e. GeoMean) were prepared.

It was clearly seen that the CMI peptides according to the invention had improved ability to enter the cell compared to its native counterparts

The data are geomean-value of each tested peptide, as calculated by the FACS Duva software. The Geomean values by trypsinating/Cytotfix/Cytoperm.:

Example 31

Positive CTL response may alternatively be assayed by ELISPOT assay.

Human IFN-gamma cytotoxic T-cell (CTL) response by ELISPOT assay

Briefly, at day 1, PBMC samples from HCV patients were incubated in flasks (430 000 PBMCs/cm²) for 2h at 37°C, 5% CO₂ in covering amount of culture media (RPMI 1640 Fisher Scientific; Cat No. PAAE15-039 supplemented with L- Glutamine, (MedProbe Cat. No. 13E17-605E, 10% Foetal Bovine serum (FBS), Fisher Scientific Cat. No. A15-101) and Penicillin/Streptomycin, (Fisher Scientific Cat. No. P11-010) in order to allow adherence of

monocytes. Non-adherent cells were isolated, washed, and frozen in 10% V/V DMSO in FBS until further usage. Adherent cells were carefully washed with culture media, followed by incubation at 37°C until day 3 in culture media containing 2µg/ml final concentration of hrGM-CSF (Xiamen amoytop biotech co, cat no: 3004.9090.90) & 1µg/ml hrIL-4 (Invitrogen, Cat no: PHC0043) and optionally an immunomodulating agent (IMiD), and this procedure was then repeated at day 6. At day 7, cultured dendritic cells (5 000-10 000 per well) were added to ELISPOT (Millipore multiscreen HTS) plates coated with 0.5µg/well anti-human γ Interferon together with thawed autologous non-adherent cells (200 000 per well), antigen samples (1-8µg/ml final concentration for peptide antigens; 5µg/ml final concentration for Concanavalin A (Sigma, Cat no: C7275) or PHA (Sigma, Cat no: L2769)) & anti-Anergy antibodies (0.03-0.05µg/ml final concentration for both anti-PD-1 (eBioscience, cat no: 16-9989-82) & anti-PD-L1 (eBioscience, cat no: 16-5983-82)). Plates were incubated overnight and spots were developed according to manufacturer. Spots were read on ELISPOT reader (CTL-ImmunoSpot® S5 UV Analyzer).

Example 32

ELISPOT assay

At day one, PBMC samples from blood donors were thawed, washed with warm medium and incubated in flasks (250000PBMCs/cm²) for 24 hours at 37°C, 5% CO₂ in covering amount of culture media (RPMI 1640 with ultra-glutamine, Lonza, BE12-702F701; 10% Foetal Bovine serum (FBS), Fisher Scientific Cat. No. A15-101; Penicillin/Streptomycin, Fisher Scientific Cat. No. P11-010) to allow the cells to recover after thawing. At day two, the cells were added to a Falcon Microtest Tissue Culture plate, 96well flat bottom, at 500 000 cells per well in a volume of 200µl total medium. Parallel wells were added the indicated stimuli in duplicate and optionally an immunomodulating agent (IMiD), or left with medium as a control for 6 days at 37°C, 5% CO₂. After the six days of incubation, 100µl of the cell suspension were transferred to an ELISPOT (Millipore multiscreen HTS) plate coated with 1µg/ml native influenza M2e protein. After a 24 hour incubation, the plate was washed four times with PBS + 0,05% Tween20, and a fifth time with PBS, 200µl/well. A mouse Anti-human IgG or IgM biotin (Southern Biotech 9040-08 and 9020-08) was diluted in PBS with 0.5% FBS and incubated for 90 minutes at 37°C. The washing was repeated as described, before 80µl Streptavidin-Alkaline-Phosphatase (Sigma Aldrich, S289) was added each well and incubated at 60 minutes in the dark, at room temperature. The wells were then washed 2 times with PBS + 0.05% Tween20 and 4 times with PBS, 200µl/well, before the substrate, Vector Blue Alkaline Phosphatase Substrate kit III (Vector Blue, SK-5300) was added and let to develop for 7 minutes at room temperature. The reaction was stopped with running water, the plates let dry and the sport enumerated by an ELISPOT reader (CTL-ImmunoSpot® S5 UV Analyzer).

ELISA

100 µl of antigen as indicated (pre-incubated in Coating buffer - 0.05M Na₂CO₃ pH9.6; denoted CB - in cold at 8µg/ml 1-3 days) or just CB (background control) was used for coating wells in microtiter plates at 4°C. The microtiter plates are then washed 3x with washing buffer (PBS + 1% v/v Triton-X100; denoted WB), followed by 2h blocking at room temperature (RT) with 200 µl/well of blocking buffer (PBS + 1% w/v BSA). Plates are then washed 3x with WB, followed by 1h incubation at 37°C with 50-70 µl/well of added human (or rabbit or sheep) sera (serial dilutions ranging from 1:5 – 1:250 in dilution buffer (PBS + 1% v/v Triton-X100 + 1% w/v BSA; denoted DB)). Plates are then washed 6x with WB, followed by 1h incubation at RT with 70 µl/well of Alkaline Phosphatase-conjugated Protein G (3µg/ml in DB; Calbiochem 539305) or goat anti-mouse IgG biotin (1µg/ml, Southern Biotech, 1030-08. In case of the goat anti-mouse IgG biotin, the plates were washed one extra step as described, before addition of 100µl Streptavidin-Alkaline-Phosphatase (1µg/ml, Sigma Aldrich, S289) and incubated 1 hour at RT. Plates are then washed 6x with WB, followed by 10-60 min incubation at room temperature with 100 µl/well of 0.3% w/v of Phenolphthalein monophosphate (Sigma P-5758). Plates are finally quenched by adding 100 µl/well of Quench solution (0.1M TRIS + 0.1M EDTA + 0.5M NaOH + 0.01% w/v NaN₃; pH14), followed by a measurement with a ELISA reader (ASYS UVM 340) at 550 nm. The strength of the sera, i.e. the magnitude of the humoral immune response, is then reported as the dilution of sera that result in the described Optical Density (OD) value, or the OD value at the indicated dilution of sera.

Example 33

Solubility and stability of peptide mix Vacc-HIV, Vacc-4x and Vacc-C5 peptides in solutions containing NaCl.

Vacc-4x is hardly dissolvable in a salt-containing solution, for instance one in which the salt concentration is at or near physiological salt concentrations. By first dissolving the Vacc-C5 peptide and subsequently the Vacc-4x peptide mixture in that specific order according to the below procedure it was found that it was possible to solubilize Vacc-4x in a salt-containing solution. Table 2 shows the result of optical density measurements (OD at 595nm) of Vacc-4x, Vacc-C5 and their mixture Vacc-HIV, demonstrating that Vacc-C5 solubilizes Vacc-4x in a salt containing solution.

The obtained solution of the mixture of Vacc-4x and Vacc-C5 at 0.7% NaCl concentration was shown to be stable over 24h when prepared according to the below procedure, stored refrigerated (2 to 8°C), and analysed by HPLC.

Procedure:

1. Let the peptides reach room temperature.
2. Spin down the tube with Vacc-C5 peptide to collect all the powder in the bottom of the glass.
3. Take out and weigh appropriate amount of Vacc-C5 peptide.
4. Add 0.7% NaCl solution so that the Vacc-C5 is dissolved to a concentration of 9mg/ml.
5. Let solution properly dissolve in Rota mixer at room temperature for 30 minutes.
6. Spin down the tube with Vacc-4x peptides to collect all the powder in the bottom of the glass.
7. Take out and weigh appropriate amount of Vacc-4x peptide.
8. Add the Vacc-C5 0.7% NaCl solution directly to the Vacc-4x peptides so that the Vacc-4x peptides have a concentration of 12mg/ml.
9. Let solution properly dissolve in Rota mixer at room temperature for 30 minutes.

Table 2. Solubility of Vacc-4x, Vacc-C5 peptides separate and in combination (Vacc-HIV) in varying salt concentrations determined by optical density (OD) at 595nm.

Peptide	Dissolved in	Concentration, mg/ml	OD 595nm
Vacc-4x	dH ₂ O	1,2mg/100µl= 12mg/ml	0.002
	0,9%NaCl	1,2mg/100µl= 12mg/ml	2.47
	0,7%NaCl	1,2mg/100µl= 12mg/ml	1.12
	PBS	1,2mg/100µl= 12mg/ml	2.69
Vacc-C5	dH ₂ O	0,9mg/100µl= 9mg/ml	0.001
	0,9%NaCl	0,9mg/100µl= 9mg/ml	0.001
	PBS	0,9mg/100µl= 9mg/ml	-0.004
Vacc-4x	dH ₂ O	2,4mg/100µl= 24mg/ml	0.002
	0,9%NaCl	2,4mg/100µl= 24mg/ml	2.055
	0,7%NaCl	2,4mg/100µl= 24mg/ml	1.25
	PBS	2,4mg/100µl= 24mg/ml	2.64
Vacc-C5	dH ₂ O	1,8mg/100µl= 18mg/ml	0.003
	0,9%NaCl	1,8mg/100µl= 18mg/ml	0.001
	PBS	1,8mg/100µl= 18mg/ml	0.001
Vacc-HIV (Vacc-4x + Vacc-C5)	dH ₂ O	(1,2+0,9)mg/100µl	0
	0,9%NaCl	(1,2+0,9)mg/100µl	1.3
	0,7% NaCl	(1,2+0,9)mg/100µl	0.028

Table 3. Stability of Vacc-4x, Vacc-C5 and Vacc-HIV mixture measured as per cent of nominal concentration by HPLC. Vacc-4x and Vacc-C5 were dissolved in distilled water. The Vacc-4x, Vacc-C5 mixture (Vacc-HIV) was dissolved in 0.7% NaCl solution following the above procedure.

Group 1 (12 mg/mL Vacc-4X):	Results as % nominal concentration			mean %
0 hour	89	94	93	92
24 hours	101	103	105	103
Group 2 (9 mg/mL Vacc-C5):	Results as % nominal concentration			mean %
0 hour	81	81	83	81
24 hours	124	123	124	124
Group 3 (12 mg/mL Vacc-4X and 9 mg/mL Vacc-C5):	Results as % nominal concentration			mean %
Vacc-4X				
0 hour	112	115	115	114
24 hours	123	122	124	123
Vacc-C5				
0 hour	97	97	98	98
24 hours	105	104	105	105

Example 34

Table 4. Delayed Type Hypersensitivity (DTH) in Rabbits

Animal groups, vaccines and doses				
Group number	Group description – vaccine recieved	Dose level (mg/animal / occasion)	All animal	
			Male n=6	Female n=6
1	Vacc-4x #	1.2	1-6	19-24
2	Vacc-C5 #	0.9	7-12	25-30
3	Vacc-HIV (Vacc-4x and Vacc-C5 combined) #	2.1 Vacc-4x (1.2) Vacc-C5 0.9)	13-18	31-36

Vaccination

New Zealand White HsdIf: NZW Rabbits were intradermally injected once in weeks 1, 2, 3, 4, 8, 9, 12, 13, 16

and 17 with the above vaccines, preceded by intradermally injecting the adjuvant huGM-CSF (Molgramostim) (33µg/immunisation) 10 minutes before. The vaccine was injected at the same site as the adjuvant (in the blister, less than 5 mm from the rhuGM-CSF injection site).

Dosing for Delayed Type Hypersensitivity (DTH)

All animals received an intradermal injection of Vacc4x (400ug) during Weeks 5, 10, 14 and 18 following which DTH assessments was made at 24 and 48 hours.

Dose volume for vaccination

Main Study Dosing (Once in Weeks 1, 2, 3, 4, 8, 9, 2, 13, 16 and 17) .2 mg Vacc-4x reconstituted in water and

administered in 0.1mL, or 0.9 mg Vacc-C5 reconstituted in water and administered in 0.1mL, or Vacc-HIV reconstituted in 0.7% NaCl also to be administered in 0.1mL. Adjuvant in all cases 33 µg GM-CSF is reconstituted in water and administered as 0.1mL volume.

Challenge for DTH

400 µg Vacc-4x reconstituted in water and administered in 0.1mL. DTH is scored by erythema and oedema for size and severity (grade 1 to grade 3 (most severe)).

Conclusion

The results of the DTH reaction to Vacc-4x at week 5 (Table 5) show stronger reaction to the Vacc-4x peptides in the group receiving the combination Vacc-HIV where Vacc-4x has been supplemented with Vacc-C5, compared to the group that has received Vacc-4x alone. As expected, the Vacc-C5 group show little or no DTH reaction towards Vacc-4x. This means that the reaction in the Vacc-HIV group is augmented by the presence of Vacc-C5 in the combination of Vacc-4x, however, the reaction is specific towards Vacc-4x.

		24hrs DTH														Median size Erythema (mm ²)
	Vaccine	n	1	2	3	4	5	6	19	20	21	22	23	24		
1	Vacc-4x	Erythema	5* 5			7* 10	5 7	*			15 *2 0	20 *1 5	5* 7		Yes #	32.5
		1 2 Oedema	10 *1 0		5 * 5	12 *1 2							3* 3			
			7	8	9	10	1 1	1 2	25	26	27	28	29	30		
2	Vacc-C5	Erythema		3 * 4		4* 7				4*6			10 *5	4* 4	5*3	6
		1 2 Oedema						3 * 4								
			13	1 4	1 5	16	1 7	1 8	31	32	33	34	35	36		
3	Vacc-4x+ Vacc C5	Erythema	7* 7	8 * 8	5 * 5	5* 5				20 *2 0	7* 10	12* 10	4* 5	10 *5	*1 0	49.5
		1 2 Oedema							10* 12	5* 5						

Table 5. DTH Reactions in Rabbits. Immunogenicity Study in the Rabbit, Intradermal Administration Vacc-4x, Vacc-C5, Vacc-HIV (Vacc-4x+Vacc-C5 combined) with adjuvant

rHuGM-CSF. DTH reaction five weeks after immunization (Bold numbers indicate grade 2, #Size not recorded, grade 2 reaction).

Example 35

5 Sheep ELISA Vacc-4x, Vacc-C5 and Vacc-HIV

Vaccinations

Three sheep per group were vaccinated in Weeks 1, 2, 3, 4, 8, 9, 12, 13, 16 and 17 by subcutaneous administration of vaccines as specified by the below tables. Blood cells and plasma was harvested in week 0, 5, 10, 14 and 18. Individual Vacc-4x peptides were weighed in lyophilised form and mixed 1:1:1:1, 1.2 mg/animal/occasion is taken out and dissolved in water since Vacc-4x is not dissolvable in salt. Vacc-C5 is similarly weighed 0.9mg peptide/animal per occasion. The purity of the peptides were of GMP grade (above 98%).

To account for loss in the homogenisation step with ISA51, 60% surplus vaccine was mixed to ensure correct volume is available for injection.

15 Mixing the Vacc-HIV was done as follows: Vacc-C5 was dissolved in 0.7% NaCl. After 30 minutes on a rotamixer at RT, the Vacc-C5 solution was added to lyophilised Vacc-4x peptides. After additional 30 minutes on a rotamixer at RT, 400µl of the mixed solution, containing 1.2mg Vacc-4x and 0.9mg Vacc-C5, each plus 60% was added to correct volume of adjuvant. For the Provax, the mixing was done by inverting/pipetting of the solution, whereas the ISA51 tubes were mixed on a vortexer at 2000rpm for 10 minutes at RT in a tube containing one ceramic bead to ensure complete homogenisation.

Group design Table 6					
Group number	Group description – vaccine received	Adjuvant	Solvent	Dose level (mg/animal/occasion)	Animal
					Female n=

1	Vacc-4x	ISA51	water	1.2	3
2	Vacc-C5	ISA51	0.7% NaCl	0.9	3
3	Vacc-HIV (Vacc-4x and Vacc-C5 combined)	ISA51	0.7% NaCl	Vacc-4x (1.2) Vacc-C5 0.9)	3
4	Vacc-HIV (Vacc-4x and Vacc-C5 combined)	Provax	0.7% NaCl	Vacc-4x (1.2) Vacc-C5 0.9)	3

Vaccine overview per animal, Table 7					
Group number	Group description – vaccine received	Adjuvant	Water	0.7% NaCl	Excess
1	Vacc-4x	ISA51, 400µl	400µl	-	300µl
2	Vacc-C5	ISA51, 400µl		400µl	300µl
3	Vacc-HIV (Vacc-4x and Vacc-C5 combined)	ISA51, 400µl		400µl	300µl
4	Vacc-HIV (Vacc-4x and Vacc-C5 combined)	Provax, 200µl		400µl	100µl

ELISA

5 100µl of antigen as indicated (pre-incubated in Coating buffer - 0.05M Na₂CO₃ pH9.6; denoted CB - in cold at 8µg/ml 1-3 days) or just CB (background control) was used for coating wells in microtiter plates at 4°C. The microtiter plates are then washed 3x with washing buffer (PBS + 1% v/v Triton-X100; denoted WB), followed by 2h blocking at room temperature (RT) with 200 µl/well of blocking buffer (PBS + 1% w/v BSA). Plates are then

10 washed 3x with WB, followed by 1h incubation at 37°C with 50-70 ul/well of added human (or rabbit or sheep) sera (serial dilutions ranging from 1:5 – 1:250 in dilution buffer (PBS + 1% v/v Triton-X100 + 1% w/v BSA; denoted DB)). Plates are then washed 6x with WB, followed by 1h incubation at RT with 70 µl/well of Alkaline Phosphatase-conjugated Protein G (3µg/ml in DB; Calbiochem 539305) or goat anti-mouse IgG biotin (1µg/ml, Southern

15 Biotech, 1030-08. In case of the goat anti-mouse IgG biotin, the plates were washed one extra step as described, before addition of 100µl Streptavidin-Alkaline-Phosphatase (1µg/ml, Sigma Aldrich, S289) and incubated 1 hour at RT. Plates are then washed 6x with WB, followed by 10-60 min incubation at room temperature with 100 µl/well of 0.3% w/v of Phenophtalein monophosphate (Sigma P-5758). Plates are finally quenched by adding 100

20 µl/well of Quench solution (0.1M TRIS + 0.1M EDTA + 0.5M NaOH + 0.01% w/v NaN₃;

pH14), followed by a measurement with a ELISA reader (ASYS UVM 340) at 550 nm. The strength of the sera, i.e. the magnitude of the humoral immune response, is then reported as the dilution of sera that result in the described Optical Density (OD) value, or the OD value at the indicated dilution of sera.

5 Results

The results of the ELISA for Vacc-4x and Vacc-C5 from sheep immunized with Vacc-4x, Vacc-C5 or Vacc-HIV, a combination of Vacc-4x and Vacc-C5, show that the peptides are immunogenic separately and in combination.

Table 8, Results Vacc-4x ELISA

Immunization Peptides and Adjuvant	Week 0					Week 5					Week 5 responders*	Fold bkgr
	N=3			Mean	St. dev.	N=3			Mean	St. dev.		
												Mean
Vacc-C5 ISA51	0.134	0.017	0.019	0.057	0.055	0.083	0.021	0.075	0.060	0.028	-	
Vacc-4x ISA51	0.015	0.003	0.177	0.065	0.079	0.691*	0.672*	0.410*	0.591	0.128	0.591	10.5
Vacc-HIV ISA51	0.016	0.026	0.028	0.023	0.005	0.702*	1.749*	0.658*	1.036	0.504	1.036	18.5
Vacc-HIV Provax	0.022	0.135	0.081	0.079	0.046	0.06	0.072	0.099	0.077	0.016	-	-
All				0.056	0.057							
Mean+3st.d ev.				0.228								

10 OD values from sera with 5x dilution. *Responders are sheep with a readout greater than mean value plus three standard deviations of the baseline samples (Week 0).

Table 9, Results Vacc-C5 ELISA

Immunization Peptides and Adjuvant	Week 0					Week 5					Week 5 responders*	Fold bkgr
	N=3			Mean	St. dev.	N=3			Mean	St. dev.		
												Mean
Vacc-C5 ISA51	0.178	0.043	0.002	0.080	0.070	1.362*	1.209*	0.902*	1.158	0.191	1.158	15.49
Vacc-4x ISA51	0.042	0.061	0.014	0.082	0.044	0.048	0.117	0.062	0.076	0.030	-	-
Vacc-HIV ISA51	0.021	0.052	0.031	0.035	0.013	0.389*	1.554*	0.809*	0.917	0.482	0.917	12.27
Vacc-HIV Provax	0.06	0.18	0.05	0.02	0.058	1.37*	0.058	1.536*	0.988*	0.661*	1.453	19.44

	2	4	9								
All				0.075	0.057						
Mean+3st.d ev				0.244							

OD values from sera with 5x dilution. *Responders are sheep with a readout greater than mean value plus three standard deviations of the baseline samples (Week 0).

Example 36

Mouse IFN-γ ELISPOT

5 HLA-A2 tg female mice in total (n=5 mice per group) were vaccinated with Vacc-HIV adjuvanted with ISA51 at weeks k 0, 2 and 6, subcutaneous administration (2x50ul; each side of base of tail). Individual sera were collected at week 0, 4 and 8. Spleens were collected and pooled at the termination of the experiment week 8.

10 Table 10

Group	Treatment
1	Vacc-HIV w0, w2, w6 immunizations
2	Naïve mice No imunizations

Table 11

Formulation of Vaccine					
Groups	Antigens (1.2mg/ml Vacc-4x 0.9mg/ml Vacc-C5 in 0.7% NaCl)	Adjuvant, ISA51	Final Volume	100 ul contains:	Excess
1	500µl peptide	500µl	1000µl	120µg of Vacc-4x peptide, 90µg Vacc-C5	500µl
2	No immunizations				

ELISPOT procedure

15 Plates pre-coated with mAb AN18 were washed 4 times with sterile PBS, 200 µl/well. Medium, 200 µl/well, containing 10 % of the same serum as used for the cell suspensions was added and incubated for ≥ 30 minutes at room temperature. The medium was then removed and cell suspension including possible stimulatory agents such as antigen and controls was added (50/75 µl antigen solution and 50/75 µl cell suspension, 2.5x10⁵ cells/well; final volume 100/150 µl/well) and the plate incubated in a 37° C humidified incubator with 5 % CO₂ for 12-48 hours. Cells were removed by emptying the plate and washing 5 times with PBS, 200 µl/well. Detection antibody (R4-6A2-biotin) diluted to 1 µg/ml

20

in PBS containing 0.5 % fetal calf serum (PBS-0.5% FBS) 100 µl/well, was added and incubated for 2 hours at room temperature. The plate was washed four times with sterile PBS, 200 µl/well. Streptavidin-ALP (1:1000) in PBS-0.5% FBS, 100 µl/well was added and incubated for 1 hour at room temperature and the plate washed again. Filtered substrate solution (BCIP/NBT-plus), 100 µl/well was added and developed until distinct spots emerged (usually 20-40 minutes). Color development was stopped by washing extensively in tap water and the plates left to dry. The plates were then inspected and spots counted in a dissection microscope (x40) or in an ELISPOT reader.

Results

The mice immunized with Vacc-HIV had a higher amount of T-cell spots when tested against Vacc-4x, Vacc-4x constituent peptides (Vacc-10, Vacc-11, Vacc-12, Vacc-13) or pools of their corresponding overlapping 15-mer peptides, compared to the control group or No Peptide (Figure 6). This clearly demonstrates that vaccination with Vacc-HIV created a cell mediated immune response towards the Vacc-4x peptides.

Throughout the specification and the claims which follow, unless the context requires otherwise, the word 'comprise', and variations such as 'comprises' and 'comprising', will be understood to imply the inclusion of a stated integer, step, group of integers or group of steps but not to the exclusion of any other integer, step, group of integers or group of steps.

All patents and patent applications referred to herein are incorporated by reference in their entirety.

The application of which this description and claims forms part may be used as a basis for priority in respect of any subsequent application. The claims of such subsequent application may be directed to any feature or combination of features described herein. They may take the form of product, composition, process, or use claims and may include, by way of example and without limitation, the claims.

CLAIMS

1. A method for reducing and/or delaying pathological effects of human immunodeficiency virus I (HIV) in a human infected with HIV, the method comprising administering
5 (1) an effective amount of a peptide multimer being (H-Gly-Ala-Lys-Arg-Arg-Val-Val-Gly-Gly-Cys(2-oxo-ethyl)-Gly-Gly-Ala-Lys-Arg-Arg-Val-Val-Gln-Arg-Glu-Lys-Arg-Ala-Gly-Glu-Arg-Glu-Lys-Arg-Ala-NH₂) (H-Gly-Lys-Gly-Gly-Ile-Glu-Glu-Glu-Gly-Gly-Arg-Asp-Arg-Asp-Arg-Gly-Gly-Gln-Asp-Arg-Asp-Arg-NH₂), acetate salt (amide bond between Cys(2-oxo-ethyl)¹⁰ (A-chain) and Lys² (B-chain)); and
10 (2) at least one HIV-specific peptide selected from the group of amino acid sequences consisting of SEQ ID NO: 49, SEQ ID NO: 52, SEQ ID NO: 57 and SEQ ID NO: 64; wherein the terminal ends of each HIV-specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls or salts of any of the HIV-specific peptides.
2. The method according to claim 1, wherein the at least one HIV-specific peptide
15 comprises at least two, three, or four peptides selected from the group consisting of SEQ ID NO: 49, SEQ ID NO: 52, SEQ ID NO: 57 and SEQ ID NO: 64; wherein the terminal ends of each HIV-specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls or salts of any of the HIV-specific peptides.
3. The method according to either one of claims 1 or 2, wherein said peptide multimer is
20 coupled to a carrier molecule, such as an immunogenic carrier.
4. The method according to claim 3, wherein the carrier is a virus like particle.
5. A method of reducing the risk of developing acquired immunodeficiency syndrome (AIDS), the method comprising administering
25 (1) an effective amount of a peptide multimer being (H-Gly-Ala-Lys-Arg-Arg-Val-Val-Gly-Gly-Cys(2-oxo-ethyl)-Gly-Gly-Ala-Lys-Arg-Arg-Val-Val-Gln-Arg-Glu-Lys-Arg-Ala-Gly-Glu-Arg-Glu-Lys-Arg-Ala-NH₂) (H-Gly-Lys-Gly-Gly-Ile-Glu-Glu-Glu-Gly-Gly-Arg-Asp-Arg-Asp-Arg-Gly-Gly-Gln-Asp-Arg-Asp-Arg-NH₂), acetate salt (amide bond between Cys(2-oxo-ethyl)¹⁰ (A-chain) and Lys² (B-chain)); and
30 (2) at least one HIV-specific peptide selected from the group of amino acid sequences consisting of SEQ ID NO: 49, SEQ ID NO: 52, SEQ ID NO: 57 and SEQ ID NO: 64; wherein the terminal ends of each HIV-specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls or salts of any of the HIV-specific peptides.
6. The method according to claim 5, wherein the at least one HIV-specific peptide
comprises at least two, three, or four peptides selected from the group consisting of SEQ ID

NO: 49, SEQ ID NO: 52, SEQ ID NO: 57 and SEQ ID NO: 64; wherein the terminal ends of each HIV-specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls or salts of any of the HIV-specific peptides.

7. A method for reducing and/or delaying pathological effects of human immunodeficiency virus I (HIV) in a human infected with HIV, or of reducing the risk of developing acquired immunodeficiency syndrome (AIDS), the method comprising administering

(1) an effective amount of a peptide multimer being (H-Gly-Ala-Lys-Arg-Arg-Val-Val-Gly-Gly-Cys(2-oxo-ethyl)-Gly-Gly-Ala-Lys-Arg-Arg-Val-Val-Gln-Arg-Glu-Lys-Arg-Ala-Gly-Glu-Arg-Glu-Lys-Arg-Ala-NH₂) (H-Gly-Lys-Gly-Gly-Ile-Glu-Glu-Glu-Gly-Gly-Arg-Asp-Arg-Asp-Arg-Gly-Gly-Gln-Asp-Arg-Asp-Arg-NH₂), acetate salt (amide bond between Cys(2-oxo-ethyl)¹⁰ (A-chain) and Lys² (B-chain)); and

(2) at least one HIV-specific peptide selected from the group of amino acid sequences consisting of SEQ ID NO: 49, SEQ ID NO: 52, SEQ ID NO: 57 and SEQ ID NO: 64; wherein the terminal ends of each HIV-specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls or salts of any of the HIV-specific peptides.

8. The method according to claim 7, wherein the at least one HIV-specific peptide comprises at least two, three, or four peptides selected from the group consisting of SEQ ID NO: 49, SEQ ID NO: 52, SEQ ID NO: 57 and SEQ ID NO: 64; wherein the terminal ends of each HIV-specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls or salts of any of the HIV-specific peptides.

9. A composition comprising

(1) an effective amount of a peptide multimer being (H-Gly-Ala-Lys-Arg-Arg-Val-Val-Gly-Gly-Cys(2-oxo-ethyl)-Gly-Gly-Ala-Lys-Arg-Arg-Val-Val-Gln-Arg-Glu-Lys-Arg-Ala-Gly-Glu-Arg-Glu-Lys-Arg-Ala-NH₂) (H-Gly-Lys-Gly-Gly-Ile-Glu-Glu-Glu-Gly-Gly-Arg-Asp-Arg-Asp-Arg-Gly-Gly-Gln-Asp-Arg-Asp-Arg-NH₂), acetate salt (amide bond between Cys(2-oxo-ethyl)¹⁰ (A-chain) and Lys² (B-chain)); and

(2) at least one HIV-specific peptide selected from the group of amino acid sequences consisting of SEQ ID NO: 49, SEQ ID NO: 52, SEQ ID NO: 57 and SEQ ID NO: 64; wherein the terminal ends of each HIV-specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls or salts of any of the HIV-specific peptides.

10. The composition according to claim 9, which is an immunogenic composition optionally comprising a pharmaceutically acceptable diluent, vehicle and/or one or more immunological adjuvants.

11. The immunogenic composition according to claim 10 in the form of a vaccine composition.
12. The immunogenic composition according to claim 11 in the form of a vaccine composition where the one or more adjuvants are provided either separately or in combination with the composition.
13. The immunogenic composition according to either one of claims 11 or 12 for use as a pharmaceutical.
14. The immunogenic composition according to claim 13 for use as a pharmaceutical in the treatment or prophylaxis of HIV or AIDS.
15. A method according to any one of claims 1 to 8 or a composition according to any one of claims 9 to 14 wherein
 (1) an effective amount of a peptide multimer being (H-Gly-Ala-Lys-Arg-Arg-Val-Val-Gly-Gly-Cys(2-oxo-ethyl)-Gly-Gly-Ala-Lys-Arg-Arg-Val-Val-Gln-Arg-Glu-Lys-Arg-Ala-Gly-Glu-Arg-Glu-Lys-Arg-Ala-NH₂) (H-Gly-Lys-Gly-Gly-Ile-Glu-Glu-Glu-Gly-Gly-Arg-Asp-Arg-Asp-Arg-Gly-Gly-Gln-Asp-Arg-Asp-Arg-NH₂), acetate salt (amide bond between Cys(2-oxo-ethyl) and Lys₂ (B-chain)) and
 (2) at least one HIV-specific peptide selected from the group of amino acid sequences consisting of SEQ ID NO: 49, SEQ ID NO: 52, SEQ ID NO: 57 and SEQ ID NO: 64; wherein the terminal ends of each HIV-specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls or salts of any of the HIV-specific peptides,
 are administered in combination with one or more further therapeutically active agents, such as agents for the treatment and or prevention of HIV and/or AIDS.
16. The method or composition according to claim 15 wherein the one or more further therapeutically active agents is an immunomodulatory compound and/or a reservoir purging agent, such as a histone deacetylase (HDAC) inhibitor.
17. The method or composition according to claim 15 or 16, wherein the immunomodulatory compound is selected from anti-PD1 antibodies including MDX-1106 (Merck), thalidomide, anti-PD1 antibodies, cyclophosphamide, Levamisole, lenalidomide, CC-4047 (pomalidomide), CC-11006 (Celgene), and CC-10015 (Celgene).
18. The method or composition according to claim 17, wherein the immunomodulatory compound is lenalidomide.

19. The method or composition according to any one of claims 16 to 18, wherein the reservoir purging agent is selected from M344 (4-(dimethylamino)-N-[7-(hydroxyamino)-7-oxoheptyl]benzamide), chidamide (CS055/HBI-800), 4SC-202, (4SC), Resminostat (4SC), hydroxamic acids such as vorinostat (SAHA), belinostat (PXD101), LAQ824, trichostatin A and panobinostat (LBH589); benzamides such as entinostat (MS-275), CI994, and mocetinostat (MGCD0103), cyclic tetrapeptides (such as trapoxin, such as trapoxin B), and the depsipeptides, such as romidepsin (ISTODAX), electrophilic ketones, and the aliphatic acid compounds such as phenylbutyrate, valproic acid, Oxamflatin, ITF2357 (generic givinostat), Apicidin, MC1293, CG05, and CG06; compounds that activate transcription factors including NF-KappaB, Prostratin, auranofin, bryostatin, a nontumorigenic phorbol ester, DPP (12-deoxyphorbol-13-phenylacetate), PMA, and Phorbol 12-myristate 13-acetate (PMA); Compounds that activate HIV mRNA elongation including P-TEF-b kinase and hexamethylbisacetamide (HMBA); IL-7; T-cell stimulating factors including anti-CD3/CD28 - T-cell stimulating Ab's; Kinase inhibitors including Tyrphostin A, Tyrphostin B, and Tyrphostin C; PTEN (phosphatase and tensin homologue) gene inhibitors including SF1670 (Echelon Bioscience), Disulfiram (DSF), an inhibitor of acetaldehyde dehydrogenase, Protein Tyrosine Phosphatase Inhibitors including bpV(HOPic), bpV(phen), and bpV(pic) (Calbiochem; EMD Millipore), Toll-like receptors agonists including Toll-like receptor-9 (TLR9) and Toll-like receptor-7 (TLR9) agonists, quercetin, lipoic acid, sodium butyrate, TNF-alpha, PHA and Tat.

20. The method or composition according to claim 19, wherein the reservoir purging agent is romidepsin.

21. The method according to any one of claims 1 to 8 or 15 to 20 wherein

(1) an effective amount of a peptide multimer being (H-Gly-Ala-Lys-Arg-Arg-Val-Val-Gly-Gly-Cys(2-oxo-ethyl)-Gly-Gly-Ala-Lys-Arg-Arg-Val-Val-Gln-Arg-Glu-Lys-Arg-Ala-Gly-Glu-Arg-Glu-Lys-Arg-Ala-NH₂) (H-Gly-Lys-Gly-Gly-Ile-Glu-Glu-Glu-Gly-Gly-Arg-Asp-Arg-Asp-Arg-Gly-Gly-Gln-Asp-Arg-Asp-Arg-NH₂), acetate salt (amide bond between Cys(2-oxo-ethyl)¹⁰ (A-chain) and Lys² (B-chain)) and

(2) at least one HIV-specific peptide selected from the group of amino acid sequences consisting of SEQ ID NO: 49, SEQ ID NO: 52, SEQ ID NO: 57 and SEQ ID NO: 64; wherein the terminal ends of each HIV-specific peptide may be free carboxyl- or amino- groups, amides, acyls or acetyls or salts of any of the HIV-specific peptides, and/or

3) the one or more further therapeutically active agents,

are administered simultaneously, sequentially or separately in any order.

1/5

Figures

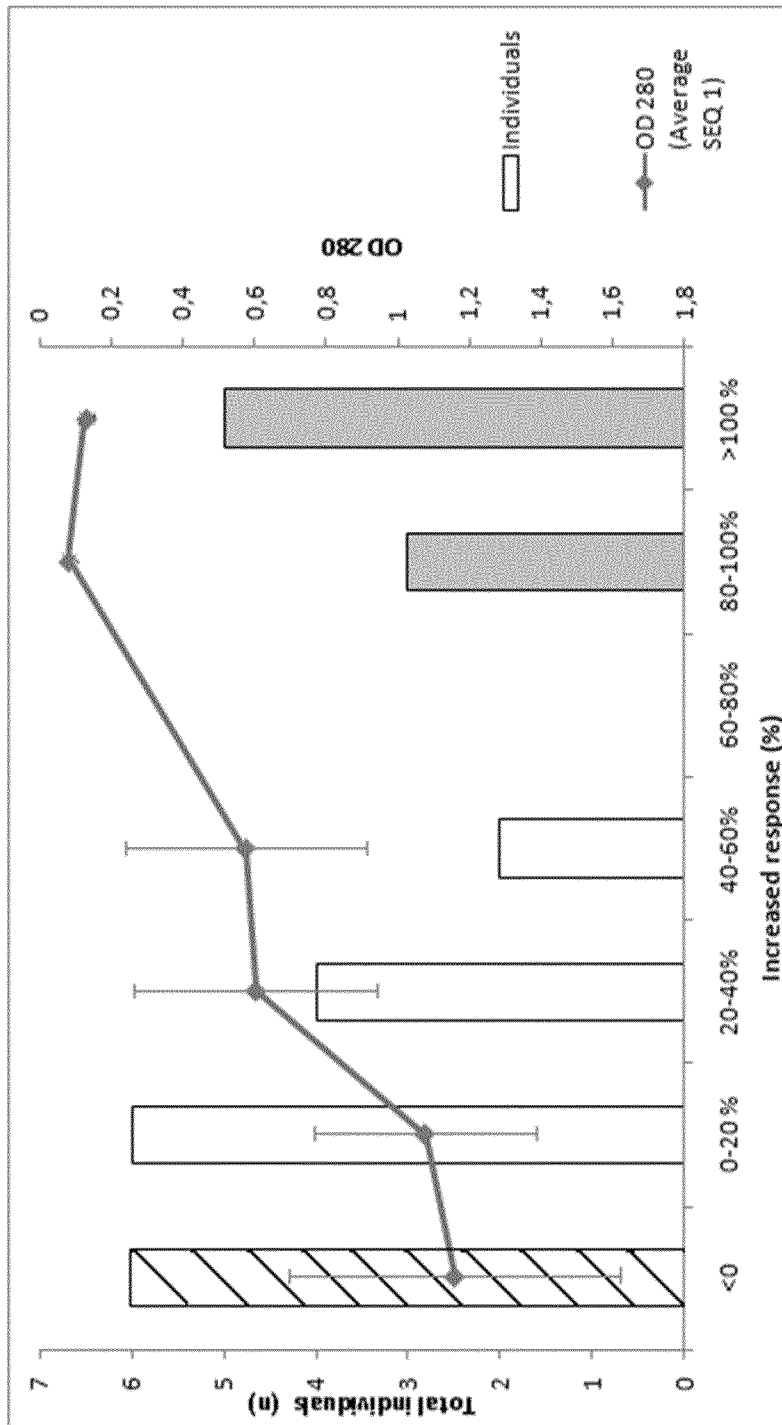
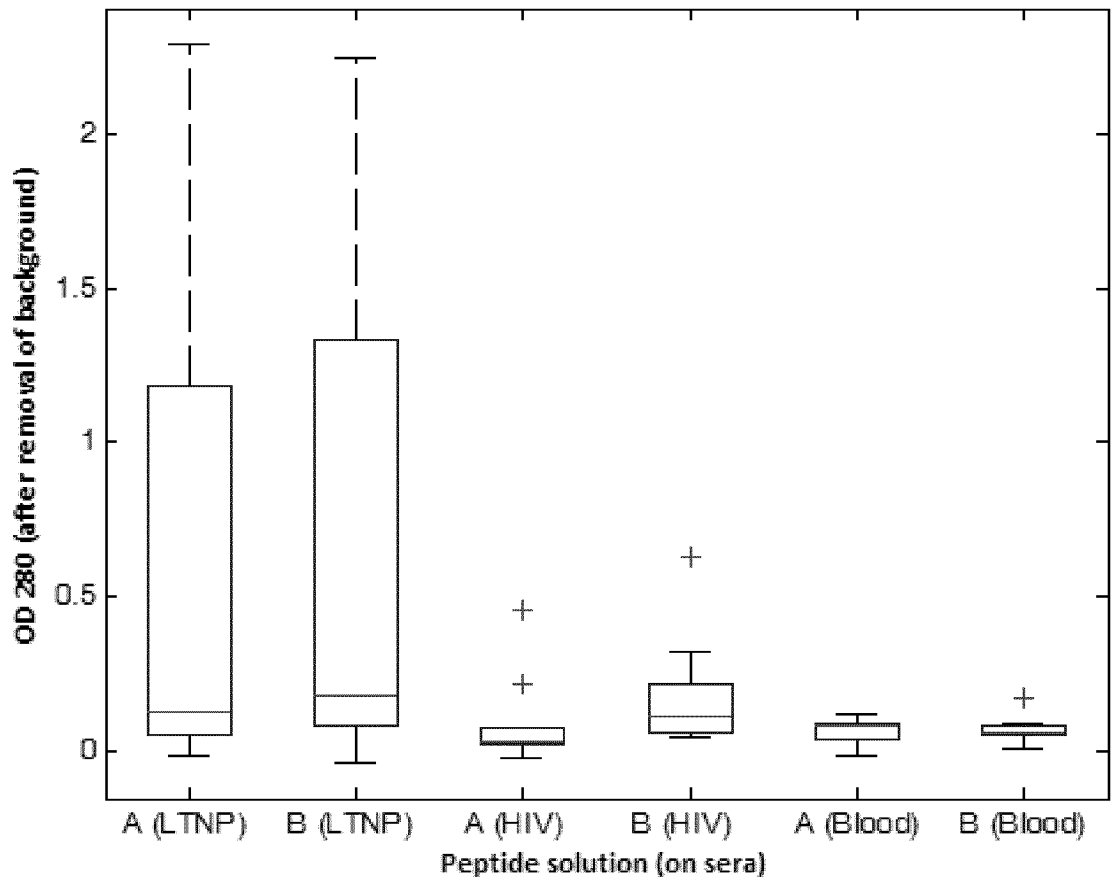


Fig. 1



5

Fig. 2

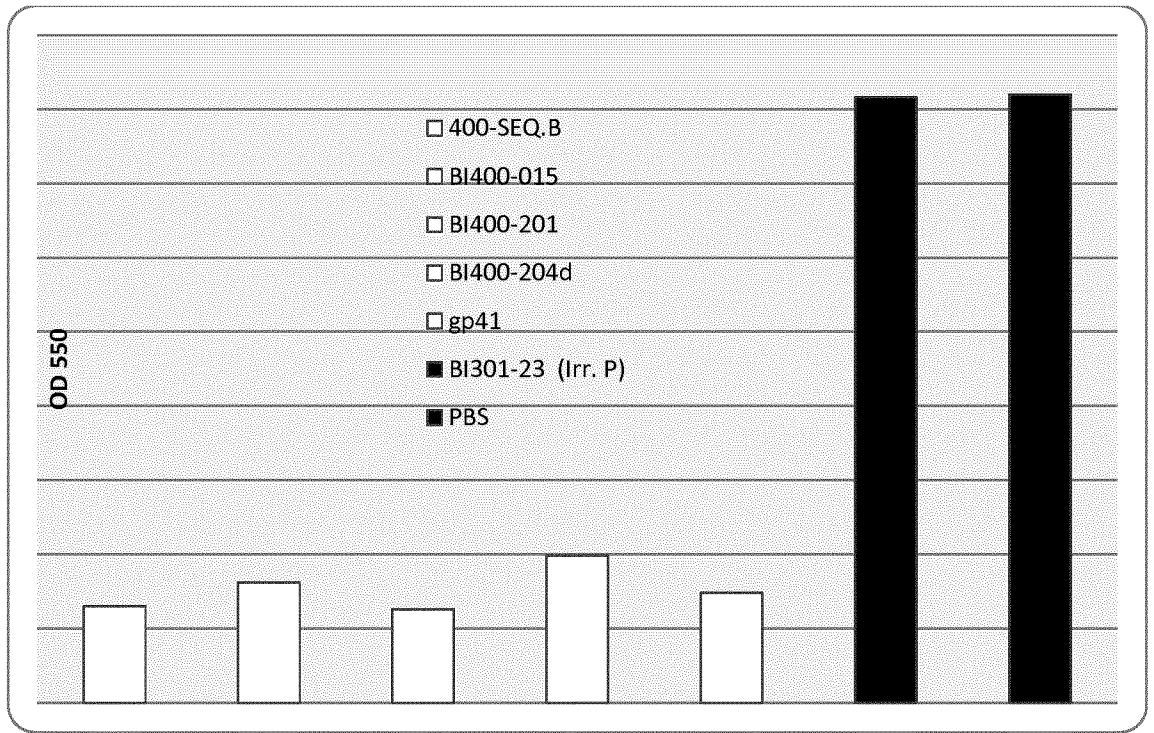


Fig. 3

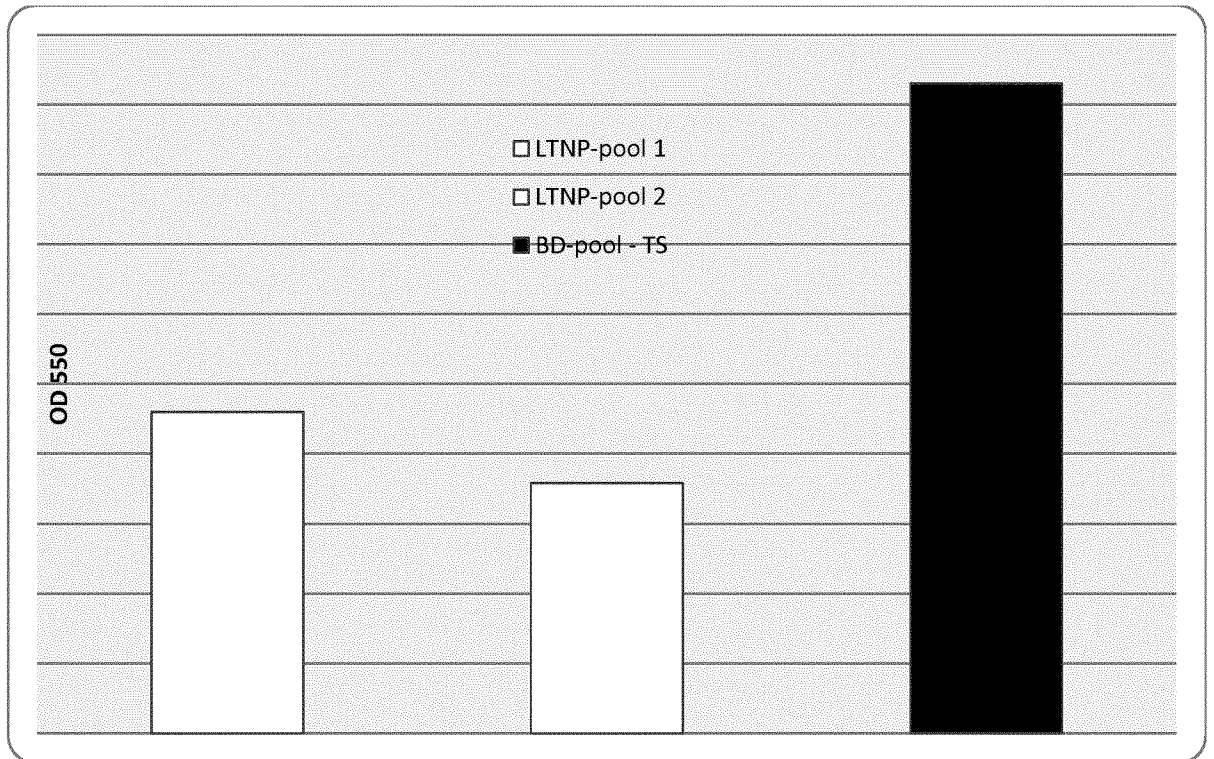


Fig. 4

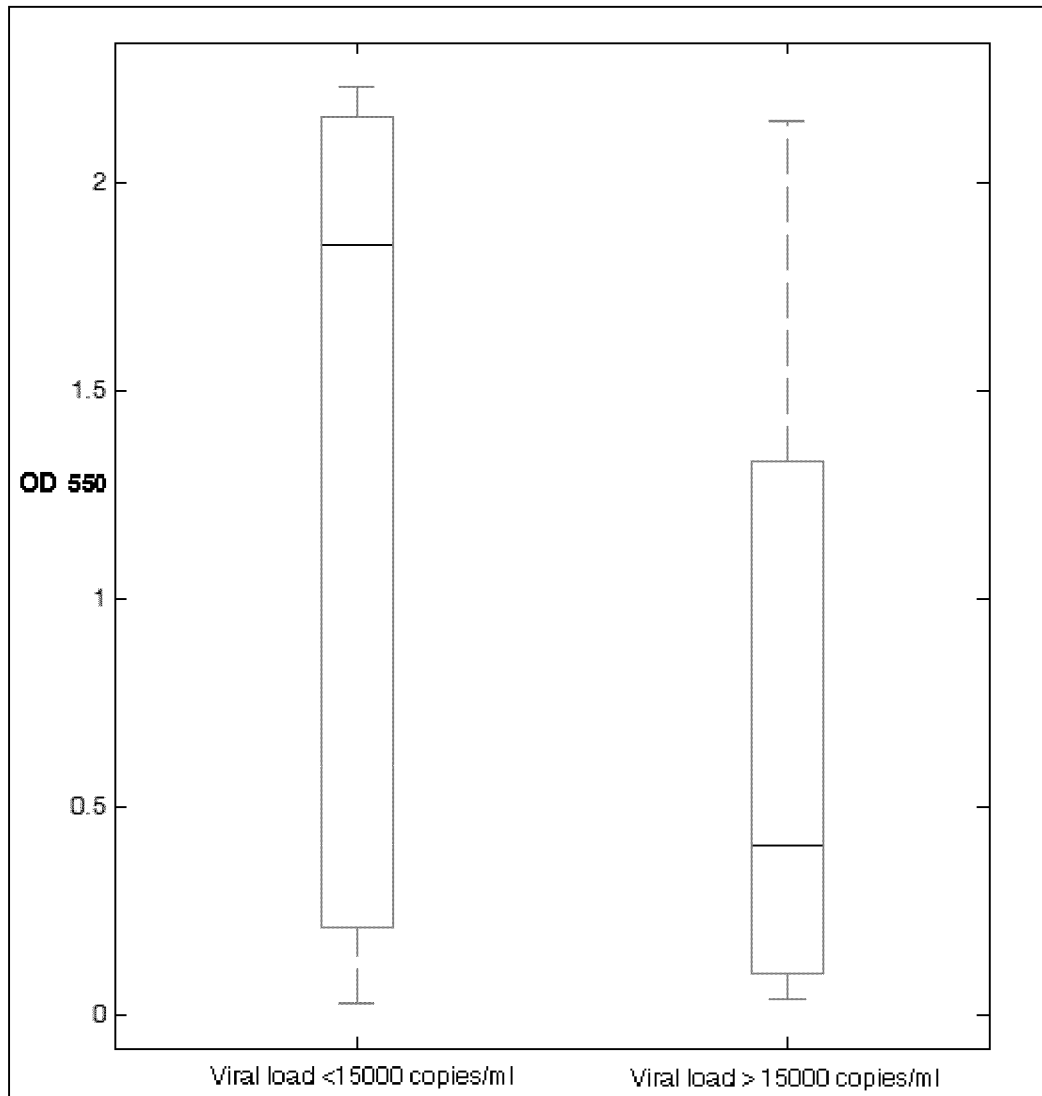


Fig. 5

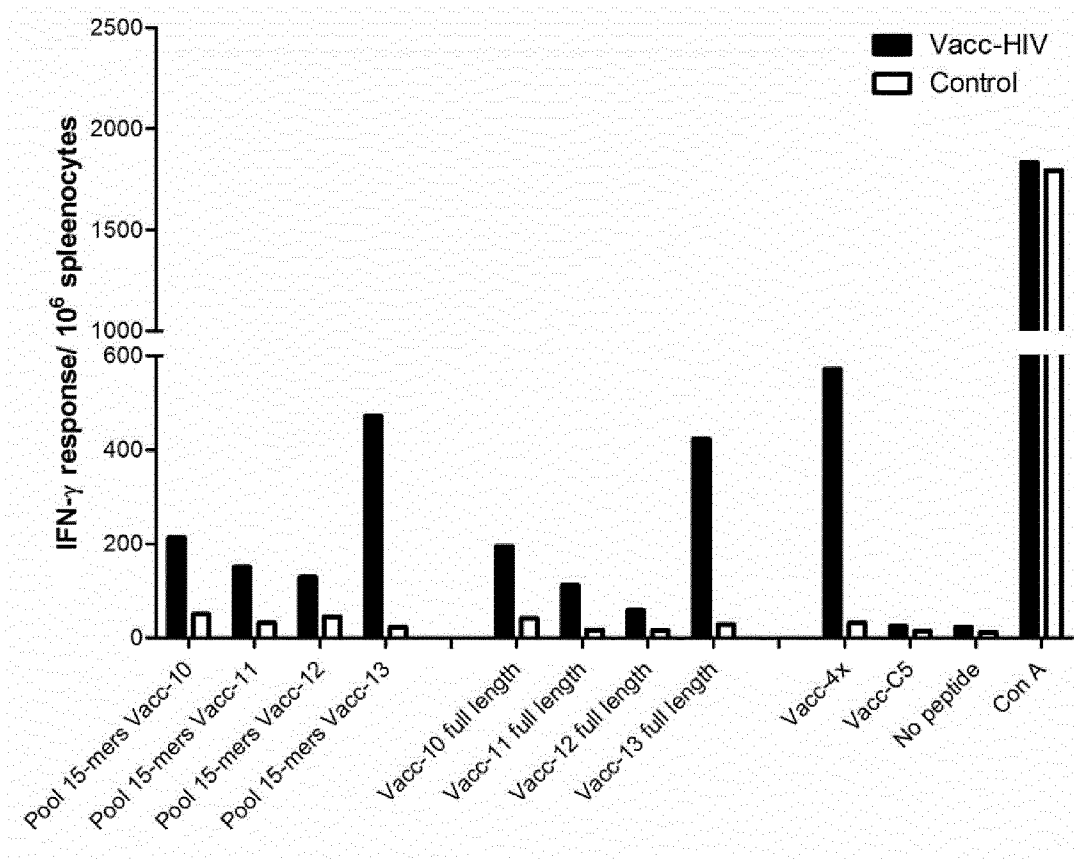


Fig. 6