ADJUVANT COMPOUND

Field of the invention

The present invention relates to a novel compound suited as adjuvant in a vaccine composition, a process to prepare the compound and a composition comprising the compound.

Background of the invention

Vaccination strategies have been used for decades primarily to foster a protective immunity to protect patients from developing a disease after contact with an infectious agent. To this end live attenuated, dead or disrupted pathogens, pathogen preparations, or purified or recombinant components of the pathogens have been administered to patients to elicit a specific immune response to antigenic components of the respective pathogen. The components, which stimulate such an immune response can be, for example, pathogen specific proteins, polysaccharides or lipids. The specific immune response against antigens comprised within pathogens can be further stimulated by the co-administration of adjuvants. Adjuvants are known in the art to accelerate, prolong, or enhance the quality of the specific immune response to the antigen or antigens and are currently employed as part of vaccines. The proposed advantages of adjuvants include their ability to: 1) direct and optimize immune responses that are appropriate for the vaccine; 2) enable mucosal delivery of vaccines; 3) promote cell-mediated immune response; 4) enhance the immunogenicity of weaker immunogens such as highly purified or recombinant antigens; 5) reduce the amount of antigen or the frequency of immunization required to provide protective immunity; 6) improve efficacy of vaccines in individuals with reduced or weakened immune responses such as newborns, the aged, and immunocompromized patients.

Adjuvants have diverse mechanisms of action. One set of adjuvants act through toll-like receptors. Toll-like receptors (TLR) recognize specific patterns of microbial components, especially those from pathogens, and regulate the activation of both innate and adaptive immunity. Immature dendritic cells mature in response to these microbial components. As of yet, 13 members of the TLR-family have been identified. TLR are expressed by phagocytic cells such as monocytes, macrophages and dendritic cells. TLR activation through ligand binding leads to signal transduction events either in a MyD88-dependent pathway (NF-[kappa]β) or MyD88-independent

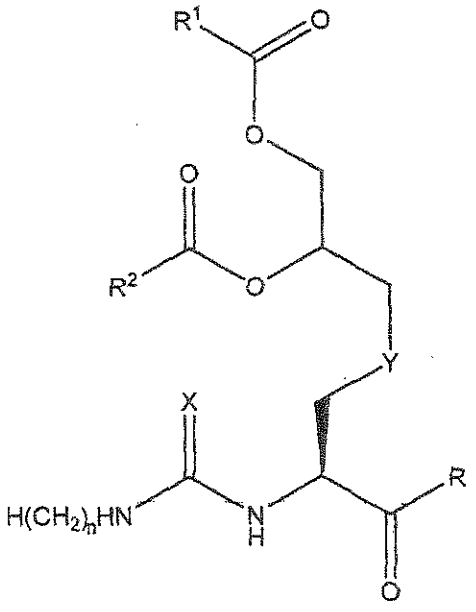
pathway (IFR-3). A known lipopeptide adjuvant which interacts with toll-like receptor 2 (TLR2) is the so-called Pam3Cys-lipopeptide. According to Renate Spohn et al. (Vaccine 22 (2004) 2494-2499), the Pam3Cys-SK4 variant was found to be the most effective additive for electing a cellular immune response in mice. Another advantage of Pam3Cys-SK4 is that it is chemically stable and can be produced in large quantities at high quality. A Pam3Cys-lipopeptide, Pam3Cys—Ser-(Lys)4(Aca-Aca-Biotin).2trifluoroacetate is commercially available from for example Enzo Life Sciences International Inc, Plymouth Meeting, PA, USA for use as an adjuvant.

WO-A-2009/072767 describes the use of a mixture of the Pam3Cys-SK4 and polyinosinic:polycytidylic acid as adjuvant for a vaccine.

The object of the present invention is to improve the immune response of a Pam3Cys-like lipopeptide.

Summary of the invention

The present invention is directed to an improved Pam3Cys-like lipopeptide, inducing a better immune response. The new compound is represented by



(1)

wherein R^1 and R^2 are each independently a branched or straight group having up to 17 atoms selected from carbon, nitrogen, oxygen and sulphur, n is 0 to and including 18, Y is sulphur or selene, X is S or O and R is –OH or an organic group comprising one or more peptides, one or more nucleic acids, one or more antibodies or combinations thereof. Preferably, R^1 and R^2 are each independently branched or straight alkyl groups having up to 17 carbon atoms, preferably 10 tot 17 carbon

atoms. Preferably, R^1 and R^2 are each independently branched or straight alkyl groups having up to 17 carbon atoms, preferably 10 to 17 carbon atoms, and Y is sulphur.

Applicants found that the compound according to the invention is able to induce an improved immune response by functionally stimulating TLR2 as compared to the known Pam3Cys-SK4. Without wishing to be bound to the following theory, applicants believe that the higher stimulation level is achieved by exchanging the bridging $-CH_2-$group in the N-terminal palmitoyl moiety of the known compound into a -NH-bridging group. The fatty chains of the compound fit in the defined pockets in the dimeric receptor and it is believed that by incorporating the bridging –NH- group, a hydrogen bridge is created. This results in a tighter binding of the ligand to the receptor, which in turn is beneficial to achieve the desired adjuvant activity.

Brief description of the Figures.

Figure 1 shows the Pam3Cys-SK4 compound according to the state of the art and two examples of compounds according to the present invention.

Figure 2 shows a synthesis scheme for the preparation of a compound according to the present invention.

Figure 3 shows the test results wherein TRL2-transfected HEK cells and dendritic cells were incubated with the state of the art compounds and compounds according to the invention.

Figure 4 shows the test results for a murine DC cell line which were incubated with the state of the art compounds, compounds according to the invention or left unstimulated.

Figure 5 shows the results of activation of human monocyte-derived dendritic cells (moDC).

Figure 6 shows the in vivo T cell priming capacity of the U-Pam conjugated synthetic long peptide of the OVA antigen (containing the SIINFEKL CTL epitope).

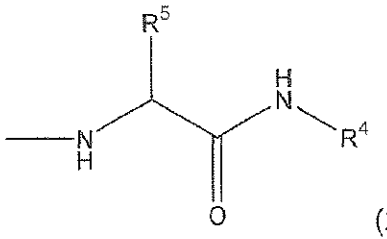
Detailed description of the invention

The compound (1) according to the present invention may have group X which is S or O. The naturally occurring O is preferred for synthetic ease. The S atom is a well known variant for the skilled person. Y is sulphur or selene and preferably sulphur as illustrated in the examples.

R^1 and R^2 are each independently a branched or straight group having up to 17 atoms selected from carbon, nitrogen, oxygen and sulphur, preferably straight alkyl groups having up to 17 carbon atoms, preferably 10 to 17 carbon atoms. In an embodiment, R^1 and R^2 are preferably each independently branched or straight aliphatic groups having up to 17 atoms (i.e. each 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, or 17 atoms) in length containing one or more selected from carbon, nitrogen, oxygen and sulphur. The person skilled in the art knows that the term "up to 17 atoms in length" means in the context of the invention that the backbone of the branched or straight group comprises up to 17 atoms; thus the hydrogen atoms of an aliphatic group are not included in calculating the number of up to 17 atoms. A further preferred group R^1 and R^2 is a straight chain alkyl group with 15 carbon atoms. Groups with fewer carbon atoms, resulting in a less lipophilic version of the compound, may be advantageous because these may have better solubility properties and therefore exhibit more predictable behaviour in solution.

In formula (1) n is 0 to and including 18, preferably at least 4 and more preferably from 11 to and including 15. Applicants found positive results for compounds wherein n is 11 and wherein n is 13.

In a first embodiment, R is an organic group comprising one or more peptides. In this respect, the compound according to the invention is referred to as a peptide-conjugate. These peptides may contain only natural amino acids, but also synthetic amino acids may be comprised in these peptides. Preferably, R is a peptide of up to 60 amino acids. Examples of suitable peptides are SSNASK4, SR8, RPDRY-NH_2 and QPDRY-NH_2. A preferred peptide is SK_m, wherein m is 1, 2, 3, 4 or 5. Preferably m is 4. The SK4 is also known as SerLysLysLysLys. The S part of the SK_m peptide and more preferably the S part of the SK4 peptide may suitably be modified as described below and the SK_m peptide may optionally be further coupled to an antigen. The preferred modified SK_m peptide is presented by:



(2)

in which R^4 represents the K_m peptide part, optionally further coupled to an antigen, and R^5 is hydrogen or a relatively small group comprising one to six atoms chosen from carbon, nitrogen and/or oxygen. m is preferably 4. Examples of possible groups R^5 are hydrogen, C1-C6 alkyl, preferably a C1-C4 alkyl, C2-C6 alkenyl, preferably a C2-C3 alkenyl, C2-C6 alkynyl, preferably a C2-C3 alkynyl, C1-C5 hydroxyalkyl, C1-C5 mercaptoalkyl, C1-C5 aminoalkyl, C1-C4-cyanoalkyl, C1-C3-azidooalkyl, for example a $-CH_2N_3$ group, C1-C6-haloalkyl, for example $-CH_2X$ group (X = F, Cl, Br), aromatic 5 or 6-membered rings containing one or more selected from carbon, nitrogen, oxygen and sulphur, and 3- to 6-membered (hetero)cyclic rings containing one or more selected from carbon, nitrogen, oxygen and sulphur. R^5 is preferably hydrogen, a $-CH_2$-OH group, $-CH_2-CH_3$ group, $-(CH_2)_2-CH_3$ group, $-(CH_2)_3-CH_3$ group, $-CH_2C\equiv CH$ group, $-CH_2CH=CH_2$, $-(CH_2)_2NH_2$ group, $-CH_2$-SH group, $-CH_2$-2-thiophene group, 2-thiophene group or a $-CH_2$-CN group, and more preferably R^5 is a $-CH_2$-OH group, $-CH_2-CH_3$ group, $-(CH_2)_2-CH_3$ group, $-(CH_2)_3-CH_3$ group, $-CH_2C\equiv CH$ group, $-CH_2CH=CH_2$ or a $-(CH_2)_2NH_2$ group. The configuration of the asymmetric carbon to which R^5 is attached can be L or D, and preferably the configuration is L.

Group R may comprise an antigen and more preferably group R^4 in formula (2) comprises an antigen. The antigen may be coupled to the peptide, in particular to the K_m peptide part, either directly or via a spacer molecule: a linker. A "linker" in the context of the invention is understood to mean a low molecular weight moiety with at least two attachment points for moieties. In this respect, a divalent linker has two such attachment points and a multivalent linker has at least three such attachment points. Via one of these attachment points, the linker is attached to the peptide moiety of R, and each of the one or more remaining attachment points are/is attached to a antigen as defined above. These attachment points originate from functional groups in the precursor of the linker and allow at least one antigen to be attached to the adjuvant compound according to the invention. A linker preferably has a molecular weight of at most 800 Da. This is all conventional chemistry.

Examples of suitable chemical linkages in which the antigen is attached to the linker and/or in which the linker is attached to the R-group of the adjuvant compound

according to the invention are organic molecules containing an aliphatic chain and optionally including single or repetitive thioether, amide, amine, oxime, disulfide, thiazolidine, thiourea, ester, thioester, ether, carbamate, thiocarbamate, carbonate, thiocarbonate, hydrazone, sulfate, sulfamidate, sulfone, sulfonamide, phosphate, phosphorothioate, glyoxylic-oxime, or a bond obtained via Diels-Alder cycloaddition, Staudinger ligation, native ligation or Huisgen 1,3-dipolar cycloaddition. Methods of coupling are i.a. described in Chem. Soc. Rev. 2010, 39, 2054, which is incorporated herein by reference.

Examples of suitable linkers are Unylinker-type linkers, α,ω-dihydroxyalkanes, and oligo- or polyethyleneglycol derivatives. The linker may include natural and non-natural amino acid residues, alicyclic compounds such as cyclohexane and cyclopentane derivatives and (hetero) aromatic rings, such as substituted phenyl and substituted triazole.

When no linker is used, the antigen is coupled to directly to the remainder of the compound according to the invention, preferably to the Km peptide part of group R. Examples of suitable bonds between the Km peptide part and the antigen are thioether, disulphide, amide or ester bonds.

Instead of the covalent incorporation of the antigen in the adjuvant compound according to the invention, optionally via a linker, the coupling may also occur via an ionic bond. An example of a suitable ionic bond is the coulombic interaction between a positively charged amine group of a lysine side chain in the Km peptide part and a negatively charged amino acid residue of the antigen. In further embodiments, the adjuvant compound according to the invention, preferably the compound according to formula (1), may be coupled to an antigen but may also be coupled to another compound, using the techniques described herein, such an antibody, a nucleic acid such as a polynucleotide and an oligonucleotide. The other compound may preferably be coupled to the group R and more preferably to group R^4 in formula (2). The other compound may be coupled to the peptide in formula (2), in particular to the K_m peptide part.

In a second embodiment, R is an organic group comprising one or more nucleic acids, such as one or more oligonucleotides or one or more polynucleotides, preferably one or more oligonucleotides. An oligonucleotide may be a sense or an antisense oligonucleotide. In this respect, the compound according to the invention is

referred to as a nucleic acid-conjugate. Such a nucleic acid may be directly coupled to the compound of formula (1), or via a linker. When no linker is used, the nucleic acid is preferably coupled via an oxygen atom or a phosphorus atom of the phosphodiester group at the 3'-terminus or the 5'-terminus of the nucleic acid to the compound according to formula (1), via the carbonyl carbon atom to which R is attached. Preferably, a linker as described above is used. One end of such a linker is attached to the compound according to formula (1) via the carbonyl carbon atom to which R is attached, and the other end of the linker is attached to the nucleic acid, preferably via an oxygen atom or a phosphorus atom of the phosphodiester group at the 3'-terminus or the 5'-terminus of the oligonucleotide.

In the context of this invention, a "nucleic acid" preferably has a length of 5 to 60 nucleotides (i.e. 5, 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, or 60 nucleotides). A nucleic acid such as a polynucleotide and an oligonucleotide may be any nucleic acid known to the person skilled in the art, such as a DNA, RNA, PNA or combinations thereof. Thus, a nucleic acid may comprise naturally occurring nucleotides, or nucleotides analogues, which have one or more modifications with respect to naturally occurring nucleotides. In this respect, naturally occurring nucleotides are those which are comprised in DNA or RNA. Nucleotides analogues comprise at least one modification selected from a modified nucleobase, a modified sugar moiety, a modified internucleoside linkage, and combinations thereof. Exemplary of modifications is a modified backbone, comprising a modified sugar moiety and/or a modified internucleoside linkage. Thus, the backbone and nucleobases of the nucleic acid may be modified according to techniques commonly known to the person skilled in the art, in order to enhance or reduce specificity and/or to enhance or decrease stability. Accordingly, a nucleic acid may contain a RNA residue, a DNA residue, a nucleotide analogue or equivalent as will be further detailed herein below.

It is preferred that a nucleic acid comprises a or at least one residue that is modified to increase nuclease resistance, and/or to increase the affinity of an (antisense) nucleotide for a target sequence. Therefore, in a preferred embodiment, a nucleic acid comprises a or at least one nucleotide analogue or equivalent, wherein a nucleotide analogue or equivalent is defined as a residue having a

modified base, and/or a modified backbone, and/or a non-natural internucleoside linkage, or a combination of these modifications.

In a preferred embodiment, a nucleotide analogue or equivalent comprises a modified backbone. Examples of such backbones are provided by morpholino backbones, carbamate backbones, siloxane backbones, sulfide, sulfoxide and sulfone backbones, formacetyl and thioformacetyl backbones, methyleneformacetyl backbones, riboacetyl backbones, alkene containing backbones, sulfamate, sulfonate and sulfonamide backbones, methyleneimino and methylenehydrazino backbones, and amide backbones. Phosphorodiamidate morpholino oligomers are modified backbone oligonucleotides that have previously been investigated as antisense agents. Morpholino oligonucleotides have an uncharged backbone in which the deoxyribose sugar of DNA is replaced by a six membered ring and the phosphodiester linkage is replaced by a phosphorodiamidate linkage. Morpholino oligonucleotides are resistant to enzymatic degradation and appear to function as antisense agents by arresting translation or interfering with pre-mRNA splicing rather than by activating RNase H. Morpholino oligonucleotides have been successfully delivered to tissue culture cells by methods that physically disrupt the cell membrane, and one study comparing several of these methods found that scrape loading was the most efficient method of delivery; however, because the morpholino backbone is uncharged, cationic lipids are not effective mediators of morpholino oligonucleotide uptake in cells.

It is further preferred that the linkage between a residue in a backbone does not include a phosphorus atom, such as a linkage that is formed by short chain alkyl or cycloalkyl internucleoside linkages, mixed heteroatom and alkyl or cycloalkyl internucleoside linkages, or one or more short chain heteroatomic or heterocyclic internucleoside linkages.

A preferred nucleotide analogue or equivalent comprises a Peptide Nucleic Acid (PNA), having a modified polyamide backbone (Nielsen, et al. (1991) Science 254, 1497-1500). PNA-based molecules are true mimics of DNA molecules in terms of base-pair recognition. The backbone of the PNA is composed of N-(2-aminoethyl)-glycine units linked by peptide bonds, wherein the nucleobases are linked to the backbone by methylene carbonyl bonds. An alternative backbone comprises a one-carbon extended pyrrolidine PNA monomer (Govindaraju and Kumar (2005) Chem. Commun, 495–497). Since the backbone of a PNA molecule contains no charged

phosphate groups, PNA-RNA hybrids are usually more stable than RNA-RNA or RNA-DNA hybrids, respectively (Egholm et al (1993) Nature 365, 566-568).

A further preferred backbone comprises a morpholino nucleotide analog or equivalent, in which the ribose or deoxyribose sugar is replaced by a 6-membered morpholino ring. A most preferred nucleotide analog or equivalent comprises a phosphorodiamidate morpholino oligomer (PMO), in which the ribose or deoxyribose sugar is replaced by a 6-membered morpholino ring, and the anionic phosphodiester linkage between adjacent morpholino rings is replaced by a non-ionic phosphorodiamidate linkage.

In yet a further embodiment, a nucleotide analogue or equivalent of the invention comprises a substitution of at least one of the non-bridging oxygens in the phosphodiester linkage. This modification slightly destabilizes base-pairing but adds significant resistance to nuclease degradation. A preferred nucleotide analogue or equivalent comprises phosphorothioate, chiral phosphorothioate, phosphorodithioate, phosphotriester, aminoalkylphosphotriester, H-phosphonate, methyl and other alkyl phosphonate including 3'-alkylene phosphonate, 5'-alkylene phosphonate and chiral phosphonate, phosphinate, phosphoramidate including 3'-amino phosphoramidate and aminoalkylphosphoramidate, thionophosphoramidate, thionoalkylphosphonate, thionoalkylphosphotriester, selenophosphate or boranophosphate.

A further preferred nucleotide analogue or equivalent of the invention comprises one or more sugar moieties that are mono- or disubstituted at the 2', 3' and/or 5' position such as a -OH; -F; substituted or unsubstituted, linear or branched lower (C1-C10) alkyl, alkenyl, alkynyl, alkaryl, allyl, aryl, or aralkyl, that may be interrupted by one or more heteroatoms; O-, S-, or N-alkyl; O-, S-, or N-alkenyl; O-, S-or N-alkynyl; O-, S-, or N-allyl; O-alkyl-O-alkyl, -methoxy, -aminopropoxy; aminoxy, methoxyethoxy; -dimethylaminooxyethoxy; and -dimethylaminoethoxyethoxy. The sugar moiety can be a pyranose or derivative thereof, or a deoxypyranose or derivative thereof, preferably a ribose or a derivative thereof, or deoxyribose or derivative thereof. Such preferred derivatized sugar moieties comprise Locked Nucleic Acid (LNA), in which the 2'-carbon atom is linked to the 3' or 4' carbon atom of the sugar ring thereby forming a bicyclic sugar moiety. A preferred LNA comprises 2'-O,4'-C-ethylene-bridged nucleic acid (Morita et al. 2001. Nucleic Acid Res Supplement No. 1: 241-242). These substitutions render the nucleotide analogue or

equivalent RNase H and nuclease resistant and increase the affinity for the target RNA.

It is understood by a skilled person that it is not necessary for all positions in an (antisense) oligonucleotide to be modified uniformly. In addition, more than one of the aforementioned analogues or equivalents may be incorporated in a single (antisense) oligonucleotide or even at a single position within an (antisense) oligonucleotide. In certain embodiments, an (antisense) oligonucleotide of the invention has at least two different types of analogues or equivalents. In a preferred embodiment, the modification occurs over the full length of the oligonucleotide.

A preferred oligonucleotide is an immunomodulating oligonucleotide that may occur naturally or be a synthetic oligonucleotide. Preferably, such oligonucleotide immunimodulates by acting on a Toll-like receptor, preferably Toll-like receptor 9 (TLR9). Preferably, such oligonucleotide comprises one or more, such as 1, 2, 3, 4, 5, 6, 7 or more, CpG (unmethylated cytidine-phosphate-guanosine (CpG) dinucleotides), more preferably one or more, class B CpG. A preferred class B CpG comprising oligonucleotide is CpG 7909 with the sequence 5'-TCGTCGTTTTGTCGTTTTGTCGTT-3' (SEQ ID NO: 10) such as described in Drugs R D. 2006;7(5):312-6, which is herein incorporated by reference. Class B CpG comprising oligonucleotides are strong stimulators of human B cell and monocyte maturation. A preferred class B CpG oligonucleotide comprises one or more, preferably three, of the 6mer CpG motif 5'-Pu Py C G Py Pu-3', a partly or fully phosphorothioated backbone, and is preferably 18 to 28 nucleotides, such as 18, 19, 20, 21, 22, 23, 24, 25, 26, 27 or 28 nucleotides, in length. Another preferred CpG comprising oligonucleotide comprises one or more, such as 1, 2, 3, 4, 5, 6, 7 or more, class A CpG. Class A CpG stimulate the production of large amounts of Type I interferons, especially IFNα, induce the maturation of pDCs, and/or are strong activators of NK cells through indirect cytokine signaling.

A preferred class A CpG oligonucleotide comprises one or more of a poly G sequence at the 5' end, the 3' end, or both, an internal palindrome sequence, one or more GC dinucleotides within the internal palindrome, and a partially phosphorothioated backbone, preferably 7 to 10 phosphorothioated bases at one or both ends.

In a preferred embodiment, R is organic group comprising a peptide and a nucleic acid , preferably a peptide and an oligonucleotide as described above. In this

third aspect of the invention, the compound according to the invention is referred to as a peptide/nucleic acid-conjugate, preferable a peptide/oligonucleotide-conjugate. In this respect, the nucleic acid is coupled to the peptide, either directly or via a linker as described herein, which is in turn coupled to the compound according to formula (1). In a preferred embodiment, the nucleic acid is coupled to R^4 or R^5, preferably to R^4 of the (modified) SK_m peptide represented by formula (2), either directly or via a linker as described herein. Alternatively, the nucleic acid may be coupled to the K_m part of the SK_m peptide, preferably the SK_4 peptide, either directly or via a linker as described herein.

In an especially preferred embodiment, the nucleic acid is coupled to the terminal lysine residue of the SK_m peptide, preferably the SK_4 peptide, either directly or via a linker as described herein. In this respect, the linker is preferably a linker containing six carbon atoms.

The preparation of peptide/nucleic acid-conjugates is well-known in the art, for example from Carter and LeBean, *J. Nucleic Acids*, 2011 (doi:10.4061/2011/926595), which is incorporated by reference in its entirety.

In a fourth embodiment, R is organic group comprising one or more antibodies. In this respect, the compound according to the invention is referred to as a antibody-conjugate. The antibody may be any antibody known to the person skilled in the art. Preferred antibodies are selected from the list consisting of 1)antibodies directed against specific target molecules on the surface of cancer cells: differentiation antigens such as CD19, CD20, CD30, overexpressed antigens such as HER-2/Neu, *epidermal growth factor receptor* (EGFR); 2) *antibodies directed against surface* molecules of T cells such as IL-2 receptor, IL-7 receptor, IL-15 receptor with the aim to delete a subset of T cells causing autoimmune disease or involved in immunoregulation such as non-activated regulatory T cells.

The antibody may be coupled to the compound according to formula (1) as described above for nucleic acids. As such, the antibody may be coupled directly or via a linker as described herein.

Alternatively, the antibody may be coupled to a peptide-conjugate as described above, preferably to R^4 of the (modified) SK_m peptide represented by formula (2), either directly or via a linker as described herein. In such a fifth embodiment, R is

organic group comprising a peptide and an antibody. In this respect, the compound according to the invention is referred to as a peptide/antibody-conjugate. In this respect, the antibody is coupled to the peptide, either directly or via a linker as described herein, which is in turn coupled to the compound according to formula (1). In a preferred embodiment, the antibody is coupled to R^4 or R^5, preferably to R^4 of the (modified) SK_m peptide represented by formula (2), either directly or via a linker as described herein. Alternatively, the antibody may be coupled to the K_m part of the SK_m peptide, preferably the SK_4 peptide, either directly or via a linker as described herein.

In an especially preferred embodiment, the antibody is coupled to the terminal lysine residue of the SK_m peptide, preferably the SK_4 peptide, either directly or via a linker as described herein. In this respect, the linker is preferably a linker containing six carbon atoms.

In a sixth embodiment, R is hydroxyl or OH. The compound according to this aspect may be used in combination with peptides, nucleic acids or antibodies for the applications as described below, such as for co-administration.

Preferred compounds according to the invention are represented by formula (1), wherein R^1 and R^2 are each independently branched or straight groups having up to 17 atoms selected from carbon, nitrogen, oxygen and sulphur, n is 0 to and including 18, X is S or O and R is an organic group comprising one or more peptides, one or more nucleic acids, one or more antibodies or combinations thereof. In other words, preferred compounds according to the invention are the peptide-conjugates, the nucleic acid-conjugates, the peptide/nucleic acid-conjugates, the antibody-conjugates or the peptide/antibody-conjugates as described above. Especially preferred are the peptide-conjugates, the peptide/nucleic acid-conjugates or the peptide/antibody-conjugates as described above. Accordingly, it is especially preferred that R is an organic group comprising one or more peptides, and optionally one or more nucleic acids or one or more antibodies.

The compound according to the invention may be a mixture of R- and S-epimers or suitably the R-epimer at the C-2 of the 2-(OC(O)R2)-3-(OC(O)R1)propyl group.

The invention is also directed to a process to prepare the novel compounds by standard solid phase peptide synthesis protocol, comprising the steps:

(a) providing R-H, which is optionally immobilized and/or side-chain protected;

(b) coupling of the substituted cysteine building block Fmoc-(S-(2-(OC(O)R^2)-3-(OC(O)R^1))propyl)-Cys-OH to R-H;

(c) cleavage of the Fmoc-group from the N-terminus; and

(d) treatment of the resulting peptide with alkylisocyanate or alkylisothiocyanate H-$(CH_2)_n$-N=C=X.

In this process, R, R^1, R^2, X and n are defined as described above. Preferably, the substituted cysteine building block is Fmoc-Pam_2-Cys-OH, thus with R^1 and R^2 being straight alkyl groups having 15 carbon atoms. In a preferred embodiment, the process is for preparing the peptide-conjugates according to the invention and involves the following steps:

(a) Solid-phase peptide synthesis, thereby obtaining an immobilized and side-chain protected peptide R-H,

(b) coupling of Fmoc-(S-(2-(OC(O)R^2)-3-(OC(O)R^1))propyl)-Cys-OH, preferably Fmoc-Pam_2-Cys-OH with the immobilized and side-chain protected peptide R-H obtained in step (a),

(c) cleavage of the N-terminal Fmoc-group from the Pam_2Cys-moiety

(d) reacting Fmoc-liberated product of step (c) with an alkylisocyanate or alkylisothiocyanate H-$(CH_2)_n$-N=C=X, preferably alkylisocyanate H-$(CH_2)_n$-N=C=O,

(e) performing an acid-mediated deprotection and cleavage from the solid phase of the product of step (d), and

(f) performing a RP HPLC purification.

The above process is illustrated by Figure 2 and below for the synthesis of U-Pam-14 and U-Pam-12. Figure 2 describes the solid-phase synthesis of target compounds U-Pam-14 and U-Pam-12, wherein the following terms are defined as:

TentaGel S RAM is functionalized copolymer of polystyrene and polyethylene glycole provided with Rink-amide linker (a common solid phase for peptide synthesis)

NHBoc is tert-butyloxycarbonyl protected amino group

tBu is tert-butyl

Fmoc-Pam_2Cys-OH is Fluorenylmethyloxycarbonyl-S-[2,3-bis(palmitoyloxy)propyl]-L-cysteine.

PyBOP, is (benzotriazol-1-yl-oxytripyrrolidinophosphonium hexafluorophosphate; a phosphonium activating reagent commonly used in peptide chemistry

DIPEA is diisopropylethylamine, an organic base commonly used in peptide chemistry

TFA is trifluoroacetic acid

NMP is N-methylpirrolidone, a solvent

DCM is dichloromethane, a solvent

The solid-phase peptide synthesis of step (a) is known and for example described in Dick, F. Peptide Synthesis Protocols. *In:* M.W. Pennington and B. M. Dunn (eds.) Methods in Molecular Biology, Vol. 35, pp. 63-72. Totowa: Humana Press Inc., 1994, which is hereby incorporated by reference. In step (a) immobilized and side chain protected peptide **1** is assembled starting from TentaGel S resin equipped with Rink amide linker (Tentagel S RAM in Scheme 1). The synthesis as illustrated is suitably performed in a fully automated fashion on ABI 433A peptide synthesizer applying Fmoc/OtBu chemistry with HCTU as the coupling reagent and DIPEA as the base. It should be understood that other peptide synthesizers known in the art may also be used. Upon the final Fmoc-cleavage using for example a 20% piperidine in NMP the peptide resin (**1**) is suitably removed from the instrument, washed with DCM and dried. In step (b) the Fmoc-Pam_2Cys-OH is suitably coupled manually to the peptide resin **1** to give fully protected peptide resin **2**. Phosphonium coupling reagent PyBOP is used in this coupling step and the base (DIPEA) is suitably added in two portions to prevent base-catalyzed side reactions. After piperidine-mediated cleavage of Fmoc-group in step (c), the resin is suitably washed with NMP and the resulting immobilized N-lipohexapeptide with free N-terminal amino group was treated in step (d) with tetradecyl isocyanate in DCM/NMP mixture overnight to give immobilized and fully protected UPam-14 (**3**). The product was cleaved in step (e) from the resin with concomitant removal of the side chain protecting groups by acidolysis with suitably 95 % TFA in the presence of H_2O and TIS as cation scavengers. Subsequent in step (f) RP HPLC purification on C_4 phase and lyophylization furnished pure UPam-14 (**5**) as a white solid. The same protocol starting from resin **2** may be employed for the preparation of UPam-12 (**6**) except that dodecyl isocyanate is used instead of tetradecyl isocyanate on the stage of the

introduction of urea connected N-terminal lipophilic chain to immobilized lipohexapeptide.

The above-described synthesis for the peptide-conjugate may be adapted to provide the other conjugates according to the invention, as known in the art. As such, the peptide R–H may be replaced by R–H, wherein R is an organic group comprising one or more nucleic acids, one or more antibodies or combinations thereof with peptides. In another embodiment, the peptide-conjugates are prepared as described above, and are subsequently conjugated with one or more nucleic acids or one or more antibodies, as such obtaining peptide/nucleic acid-conjugates or peptide/antibody-conjugates. Such conjugation methods are well-known in the art, and are for example described in Carter and LeBean, *J. Nucleic Acids*, **2011** (doi:10.4061/2011/926595), which is incorporated by reference in its entirety.

The compounds according to the invention as described above are suitably used as part of a medicament or vaccine. The invention is thus directed to said compound or a composition comprising a compound according to the invention for use as a medicament, preferably a medicament to treat a disease or condition as defined herein. More preferably the invention is directed to a compound or a composition comprising a compound according to the invention to enhance a TLR2 mediated innate immune reaction in a patient, preferably a mammal, more preferably a human. The compound may be used in a so-called mono-therapy wherein in a stand-alone treatment the existing immune system is stimulated, for example for local administration in the lymphoid drainage area of a tumor. Other standalone applications of the compound according to the invention as described above are the treatment of damage or disease of the central nervous system such as axon regeneration of (optic) nerves preferably by injection into the eye and treatment of ischemia such as ischemia of the heart or brain or other organs preferably by systemic injection. A further standalone application is the treatment of infections such viral, bacterial, fungal, protozoa and parasite infections such as visceral leishmanias and visceral endophtalmitis.

In stand-alone applications, the compound according to the invention may be applied in the form of a solution in liquid form, a suspension or emulsion, a cream, spray, or any other formulation known to the person skilled in the art. For treatment of ischemia and axon regeneration, the compound according to the invention is preferably in a pharmaceutically acceptable injectable formulation.

In an aspect of the invention, a compound according to the invention is used in a method for treatment of a disease or condition as defined herein.

A compound may already comprise an antigen and/or another compound such an antibody, a nucleic acid such as a polynucleotide and an oligonucleotide, as defined herein. Alternatively or in combination with a previous embodiment, a composition comprising a compound as identified herein may further comprise an antigen and/or another compound such an antibody, a nucleic acid such as a polynucleotide and an oligonucleotide, as defined herein as a separate molecule. The invention is therefore also directed to a compound comprising an antigen and/or another compound such an antibody, a nucleic acid such as a polynucleotide and an oligonucleotide, and/or a composition comprising said compound or a composition comprising a compound and an antigen and/or another compound such an antibody, a nucleic acid such as a polynucleotide and an oligonucleotide, as a separate molecule for use as a medicament, preferably as a preventive or therapeutic vaccine composition. In particular, the invention is directed to a vaccine composition comprising the compound according to the invention as an adjuvant and at least one antigen and/or another compound such an antibody, a nucleic acid such as a polynucleotide and an oligonucleotide, wherein the antigen or other compound may be present as a separate compound or coupled to the compound according to the invention as described above. Preferably the antigen or other compound is part of the compound according to the invention, wherein the antigen or other compound is coupled to the adjuvant compound described above. Such a linkage has the advantage that, in use, an enhanced immune response by simultaneous stimulation of antigen presenting cells, in particular dendritic cells, that internalize, metabolize and display antigen is achieved.

Accordingly in an aspect of the invention, there is provided a method for the induction, maintenance and/or enhancement (boost) of an immune response in a subject against an antigen and/or for the prevention, delay and/or treatment of a disease or condition associated with said antigen in a subject wherein a compound or a composition as defined herein is administrated to said subject. Each feature of said method is identified herein.

The antigen may be any material that can induce, maintain or enhance an immune response by the immune system of a subject. A preferred subject is an animal. Preferably an animal is a mammal, preferably a human. It is to be

understood that said induced or enhanced immune response is specific for said antigen. An antigen-specific immune response is preferably a T cell response or cellular immune response. Such antigen therefore preferably comprises a T cell epitope: a T helper and/or a CTL epitope.

An antigen can be a full length biomacromolecule or a fragment thereof. The antigen can for example be synthetic material, purified subunits of a protein, a protein fragment, a digest of a protein, a peptide, a DNA molecule, a cDNA molecule, a RNA molecule, an oligonucleotide, an oligosaccharide, a crude composition, preferably of biological origin such as a whole microbe, a bacterial, yeast or fungal lysate, sonicate or fixate or a mixture thereof. In an embodiment, when an antigen is a peptide, said peptide may be from 6 to 60 amino acids, or 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 or 60 amino acids or more. In said embodiment, said peptide is therefore distinct from the protein it derives from. An antigen may be a tumor antigen, viral antigen, bacterial antigen or parasite antigen. An antigen may be derived from an infectious agent. Such infectious agent may cause cancer and/or a premalignant condition. Preferably the antigen is a chemically synthesized or enzymatically produced peptide, oligonucleotide or oligosaccharide and more preferably it has been obtained after purification. An antigen may also be in the form of a nucleic acid (DNA, or RNA) encoding said antigen or fragment thereof. The RNA or DNA molecules may be 'naked' DNA, preferably comprised in vesicles or liposomes, or they may be comprised in a vector. The vector may be any (recombinant) DNA or RNA vector known in the art, and preferably is a plasmid; wherein said DNA encoding said antigen is operably linked to regulatory sequences conferring expression and translation of the encoded messengers. The vector may also be any DNA or RNA virus, such as, but not limited to, Adenovirus, Adeno-Associated Virus (AAV), a retrovirus, a lentivirus, modified Vaccinia Ankara virus (MVA) or Fowl Pox virus, or any other viral vector capable of conferring expression of polypeptides into a chosen subject. DNA vectors may be non-integrating, such as episomally replicating vectors, or may be vectors integrating in the host genome by random integration or by homologous recombination.

The antigen is preferably selected as a single or multiple component from the group consisting of a protein of a pathogen, a recombinant protein, a peptide, a

hapten, a polysaccharide, a glycoprotein, a lipopolysaccharide, a DNA molecule, a cDNA molecule, an RNA molecule (all polynucleotides), a cancer cell and a micro-organism.A preferred composition comprises a compound according to the invention as adjuvant and at least one viral antigen or bacterial antigen, for example TBC; tetanus and Helicobacter Pylori, or parasite antigen or tumor antigen suitable for treating or preventing viral or parasitic or bacterial infections or treating or preventing cancer or comprises a compound according to the invention, wherein group R comprises a viral antigen or bacterial antigen, for example TBC and tetanus, or parasite antigen or tumor antigen suitable for treating or preventing viral or parasitic or bacterial infection or treating or preventing cancer.

Suitable viral antigens are influenza virus antigen, such as for example HA: haemaglutinin or neuraminidase antigen; human papilloma virus (HPV) antigen, such as E2, E6, E7; human immunodeficiency virus (HIV) antigen, such as for example GP120, GP140, GP160; vesicular stomatitis virus antigen, for example vesicular stomatitis virus glycoprotein; cytomegalovirus (CMV) antigen; hepatitis virus antigens, such as for example hepatitis A(HAV), B(HBV), C(HCV), D(HDV) and G(HGV): L-HBsAg, S-HBsAg, M-HBsAg, pre S; respiratory syntytial virus (RSV) antigen; SV40 virus antigen, such as Large T, small T; EBV antigen, such as EBNA, Kaposi Sarcoma Virus (KSV) antigen, Human T-Lymphotropic Virus-1(HTLV-1) antigen, Merkel cell virus (MCV) antigen or herpes simplex virus antigen.

The HPV strains from which the antigen or peptide used derived is preferably a high risk HPV serotype, such as serotypes 16, 18, 31, 33 or 45, more preferably from the serotype 16, 18, 31 or 33, most preferably from serotype 16 or 18, of which 16 is most preferred. The amino acid sequence of the HPV serotype 16 E2, E6 and E7 proteins are depicted in SEQ ID NO 1-3 respectively. The amino acid sequence of the HPV serotype 18 E2, E6 and E7 proteins are depicted in SEQ ID NO 4-6, respectively.

Suitable parasite antigens may be derived from protozoa, nematoda, trematoda or cestoda, such as *Cryptosporidium hominis or parvum*; *Schistosoma* haematobium, mansoni or japonicum; Plasmodium falciparum, malariae, vivax or ovale; Leishmania major, tropica, aethiopica, mexicana, donovani, infantum or braziliensis; Toxoplasma Gondii.

Suitable bacterial antigens may be antigens derived from Mycobacterium Tuberculosis, Streptococcus pneumoniae, Staphylococcus Aureus, Vibrio cholera, Neisseria meningitides.

Tumor antigens are antigens expressed on tumor cells. This group of antigens is preferably said to be associated with cancer in the following illustrating and non-limitative cases: antigens derived from proteins that are expressed solely on tumors and not or only in a limited amount on normal adult cells, antigens derived from proteins that are over-expressed on tumors as compared to normal adult cells, antigens derived from proteins that have been mutated in tumors, antigens that are aberrantly expressed in a given tissue of cancer patients by comparison with the corresponding tissue of a subject not having cancer. An aberrantly expressed antigen may be *de novo* expressed in a tissue wherein it is normally not expressed. A mutated antigen may be a splice variant. A mutated antigen may further be produced as an aberrant fusion protein as a result of a translocation. Examples of antigens that are known to be associated with cancer are p53, MDM-2, HDM2 and other proteins playing a role in p53 pathway, molecules such as survivin, telomerase, cytochrome P450 isoform 1B1, Her-2/neu, and CD19 and all so-called house hold proteins.

Suitable antigens include antigens derived from infectious agents that cause diseases such as cancers and/or premalignant conditions. Examples of such infectious agents are HPV, which causes diseases such as genital warts, a cervical cancer, head and neck cancer, Penile cancer, Vulva cancer, Anal cancer, nasopharyngeal cancer, CIN, VIN, PIN, VAIN and AIN, HCV and HBV, which are involved in liver carcinoma, SV40, which is involved in mesothelioma, HTLV-1, which is involved with T cell leukemia/lymphoma, Merkel cell virus, which is involved with Merkel cell carcinoma and KSV, which is involved with Kaposi sarcoma.

The above vaccine compositions may be used as a preventive (i.e. prophylactic) or therapeutic (i.e. curative) vaccine composition for both acute or persistent infections or disease caused thereby.

The vaccine composition is also preferably used as a preventive or therapeutic vaccine composition designed to elicit specific immune responses against a given disease or condition wherein said antigen is associated or linked with. A preferred disease or condition is a cancer. A cancer may be a non-viral cancer or a viral cancer such as a cancer induced by HPV. A preferred vaccine composition

comprises a compound according to the invention as adjuvant and at least one non viral cancer-associated tumor antigen or comprises a compound according to the invention, wherein group R comprises a non viral cancer-associated tumor antigen. The cancer to be treated or be prevented may be a brain cancer, renal cell carcinoma, a melanoma, a leukemia, a lung cancer, a stomach cancer, an esophageal cancer, a thyroid cancer, a pancreatic cancer, a breast cancer, a prostate cancer, an ovarian cancer, a uterine cancer, a testicular cancer, a cholangioma, a liver cancer, a colon cancer, a gastrointestinal cancer, a bladder cancer, or a rectal cancer. In addition pre-malignant lesions may be treated or prevented by use of the vaccine composition. Pre-malignant lesions are lesions that have undergone genetic changes that predispose cells to become cancer cells. These pre-malignant lesions may evolve into cancers over time. Examples of suitable tumor antigens are gp100, MART-1, MAGE-1, BAGE, GAGE, HAGE, tyrosinase, CEA (cancer embryonic antigen), p53, PSA (prostate specific antigen), PSMA (prostate specific membrane antigen); PRAME, HER2/neu, MAGE-1, MAGE-2, MAGE-3, NY-ESO-1, MUC-1, SART-1 or SART-3, XAGE-1B, Tyrosinase, TERT (telomerase reverse transcriptase), WT1 , Survivin-2B, gp75, MDM2, telomerase, a[rho]h-1 fetoprotein, CA125, CA15-3, CA19-9, G250, HER2, BCR-ABL, Ras, PML-RARα, PR1, SSX-2, HSP70 or a peptide analogue derived from any of the above mentioned viral, non-viral, tumor, bacterial or parasite antigens.

A preferred antigen comprises a peptide comprising a T cell epitope, i.e. a CD4 and/or CD8 T cell epitopes that are derived from any of the abovementioned viral, non-viral, tumor, bacterial or parasite antigens, but preferably from the high risk human papilloma virus (HPV)-specific E6 and E7 oncoproteins as described in WO02/070006 and WO2008/147187, which publications are hereby incorporated by reference.

A preferred peptide originating from HPV serotype 16 E6 as identified above by SEQ ID NO: 2 is selected from the group consisting of a peptide comprising or consisting of or overlapping with:

E6 1-32, E6 19-50, E6 41-65, E6 55-80, E6 71-95, E6 85-109, E6 91-122, E6 109-140 and E6 127-158.

A preferred peptide originating from HPV serotype 16 E7 as identified above by SEQ ID NO: 3 is selected from the group consisting of a peptide comprising or consisting of or overlapping with:

E7 1-35, E7 22-56, E7 43-77 and E7 64-98.

A preferred peptide originating from HPV serotype 16 E6 or E7 as identified above by SEQ ID NO: 2 or 3 is selected from the group consisting of a peptide comprising or consisting of or overlapping with:

E6 1-32, E6 19-50, E6 41-65, E6 55-80, E6 71-95, E6 85-109, E6 91-122, E6 109-140, E6 127-158, E7 1-35, E7 22-56, E7 43-77 and E7 64-98. The invention also encompasses a peptide originating from HPV as identified in these preceding paragraphs and comprising 1, 2, 3, 4, 5, 6 ,7, 8, 9 or more additional amino acids in total derived from the corresponding positions of the corresponding E6 or E7 HPV protein. These additional amino acids may be present at the N and/or at the C terminal of said peptide. However, such peptides are preferably distinct from a full length E6 or E7 protein.

In another embodiment, a peptide originating from HPV has a length of 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 or 50 amino acids and preferably comprises the contiguous amino acid sequence comprising an epitope that is selected from the group consisting of amino acids 11-32 of an HPV E6 protein, amino acids 13-22 of an HPV E6 protein amino acids, amino acids 29-38 of an HPV E6 protein, 37-68 of an HPV E6 protein, amino acids 52-61 of an HPV E6 protein, amino acids 51-72 of an HPV6 protein, amino acids 55-86 of an HPV E6 protein, amino acids 61-82 of an HPV E6 protein, amino acids 71-92 of an HPV E6 protein, amino acids 73-105 of an HPV E6 protein, amino acids 91-112 of an HPV E6 protein, amino acids 101-122 of an HPV E6 protein, amino acids 121-142 of an HPV E6 protein, amino acids 129-138 of an HPV E6 protein, amino acids 137-146 of an HPV E6 protein, amino acids 149-158 of an HPV E6 protein amino acids 1-32 of an HPV E7 protein, amino acids 11-19 of an HPV E7 protein, amino acids 21-42 of an HPV E7 protein, amino acids 51-72 of an HPV E7 protein, amino acids 76-86 of an HPV E7 protein; amino acids 13-22 of an HPV E6 protein, amino acids 29-38 of an HPV E6 protein, amino acids 52-61 of an HPV E6 protein, amino acids 129-138 of an HPV E6 protein, amino acids 137-146 of an HPV E6 protein, amino acids 149-158 of an HPV E6 protein, and amino acids 11-19 of an HPV E7 protein. E6 and E7 proteins being preferably from HPV16 or HPV18 as identified above by SEQ ID NO: 2, 3.

Each of the HPV peptides or epitopes identified herein is identified by providing the corresponding first amino acid and the corresponding last amino acid as identified in the corresponding E6 or E7 protein.

A preferred antigen comprises a peptide comprising a CD4 and/or CD8 T cell epitopes that are derived from the non-viral tumor antigen p53 as described in WO2008/147186, which publication is hereby incorporated by reference.

The amino acid sequence of human p53 is depicted in SEQ ID No.7. Preferably, the length of the contiguous amino acid sequence derived from the protein p53 is no more than 45 amino acids and comprises at least 19 contiguous amino acids derived from the amino acid sequence of p53. The length of the contiguous amino acid sequence derived from p53 comprised within the peptide, preferably is 19-45, 22-45, 22-40, 22-35, 24-43, 26-41, 28-39, 30-40, 30-37, 30-35, 32-35, 33-35, 31-34 amino acids. In another preferred embodiment, a peptide comprises 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, or 45 or more than 45 contiguous amino acid residues of a p53. preferably from human p53 as identified above by SEQ ID NO:7. The skilled person will therefore understand that a peptide of the invention is distinct from a p53 protein, preferably from the human p53 as identified above by SEQ ID NO:7.

In a preferred embodiment, when the protein is human p53, as identified above by SEQ ID NO:7, the peptide is selected from the following peptides, each peptide comprises or consists of or overlaps with any of the following sequences: p53 86-115, p53 102-131, p53 142-171, p53 157-186, p53 190-219, p53 224-248, p53 225-254, p53 257-286, p53 273-302, p53 305-334, p53 353-382 and p53 369-393.

Even more preferably, when the protein is human p53, as identified above by SEQ ID NO:7, the peptide is selected from the following peptides, each peptide comprises or consists of or overlaps with any of the following sequences: p53 142-171, p53 157-186, p53 190-219, p53 224-248, p53 225-254, p53 241-270, p53 257-286 and p53 273-302.

Each of the p53 peptides identified herein is identified by providing the corresponding first amino acid and the corresponding last amino acid as identified in the corresponding human p53 protein as identified above by SEQ ID NO:7.

Preferred antigens include at least two of, or at least three of or the following p53 peptides: p53 142-171, p53 157-186, p53 190-219, p53 224-248, p53 225-254,

p53 241-270, p53 257-286 and p53 273-302, p53 305-334, p53 353-382 and p53 369-393. More preferred antigens further include p53 86-115 and/or p53 102-131.

A preferred antigen comprises a peptide comprising a CD4 and/or CD8 T cell epitopes that are derived from the non-viral tumor antigen PRAME as described in WO2008/118017, which publication is hereby incorporated by reference.

Such peptide may comprise a contiguous amino acid sequence selected from the 509 amino acid sequence of the human PRAME protein, depicted in SEQ ID No. 8, whereby the peptide preferably comprises at least one HLA class II Th cell epitope and preferably also at least one HLA class I cytotoxic T cell epitope. Preferably, the length of the contiguous amino acid sequence from the human PRAME protein, preferably identified by SEQ ID NO:8, comprised within the peptide is 19-45, even more preferably 30-40 amino acids, even more preferably 30-35 and most preferably 33-35 amino acids. More preferred peptides comprise a contiguous amino acid sequence from the human PRAME protein preferably identified by SEQ ID NO:8 and selected from the group consisting of amino acid sequences, aa. 19-53, aa. 47-79, aa. 69-101, aa. 80-114, aa. 94-126, aa. 112-144, aa. 133-166, aa. 173-207, aa. 190-223, aa. 234-268, aa. 247-279, aa. 262-294, aa. 284-316, aa. 295-327, aa. 353-387, aa. 399-431, aa. 417-450, aa. 447-480, aa. 477-509. The invention also encompasses a peptide originating from PRAME as identified in this paragraph and comprising 1, 2, 3, 4, 5, 6, 7, 8, 9 or more additional amino acids in total derived from the corresponding positions of the corresponding PRAME protein. These additional amino acids may be present at the N and/or at the C terminal of said peptide. However, such peptides are preferably distinct from a full length PRAME protein identified by SEQ ID NO:8.

Each of the PRAME peptides identified herein is identified by providing the corresponding first amino acid and the corresponding last amino acid as identified in the corresponding human PRAME protein.

A preferred antigen comprises peptides comprising CD4 and/or CD8 T cell epitopes that are derived from the non-viral tumor antigen NY-ESO-1 as described in WO98/14464, which publication is hereby incorporated by reference.

A preferred antigen comprises peptides comprising CD4 and/or CD8 T cell epitopes that are derived from the non-viral tumor antigen XAGE-1B as described in US6,630,574, US6,504,010, US7,425,607, US6,686,447, which publications are hereby incorporated by reference.

A preferred antigen comprises a peptide comprising a CD4 and/or CD8 T cell epitopes that are derived from the non-viral tumor antigen PSMA as described in EP11172914.1, which publication is hereby incorporated by reference.

Such peptide may comprise a contiguous amino acid sequence selected from the 750 amino acid sequence of the human PSMA protein, depicted in SEQ ID No. 9, whereby the peptide preferably comprises at least one HLA class II Th cell epitope and preferably also at least one HLA class I cytotoxic T cell epitope. Preferably, the length of the contiguous amino acid sequence from the human PSMA protein, preferably identified by SEQ ID NO:9, comprised within the peptide is 19-45, even more preferably 30-40 amino acids, even more preferably 30-35 and most preferably 33-35 amino acids. More preferred peptides comprise a contiguous amino acid sequence from the human PSMA protein preferably identified by SEQ ID NO:9 and selected from the group consisting of amino acid sequences, aa. 3-35, aa. 31-65, aa. 53-88, aa. 94-130, aa. 156-188, aa. 207-242, aa. 253-289, aa. 302-333, aa. 341-371, aa. 393-426, aa. 432-464, aa. 451-485, aa. 469-500, aa. 507-539, aa. 547-579, aa. 565-600, aa. 603-636, aa. 648-681, aa. 679-713, aa. 716-749. The invention also encompasses a peptide originating from PSMA as identified in this paragraph and comprising 1, 2, 3, 4, 5, 6, 7, 8, 9 or more additional amino acids in total derived from the corresponding positions of the corresponding PSMA protein. These additional amino acids may be present at the N and/or at the C terminal of said peptide. However, such peptides are preferably distinct from a full length PSMA protein identified by SEQ ID NO:9.

Each of the PSMA peptides identified herein is identified by providing the corresponding first amino acid and the corresponding last amino acid as identified in the corresponding human PSMA protein.

A preferred antigen comprises peptides comprising CD4 and/or CD8 T cell epitopes that are derived from the non-viral antigens derived from *Mycobacterium tuberculosis* as described in WO06/04389, which publication is hereby incorporated by reference.

An antigen derived from Mycobacterium tuberculosis is preferably selected from the group of polypeptides comprising *Mycobacterium* NRP / dormancy (DosR) regulon encoded proteins that are capable of eliciting an immune response *in vivo* in vertebrates having a *Mycobacterium* infection. More preferably, such antigen is from

the group of polypeptides comprising *Mycobacterium* NRP / dormancy (DosR) regulon encoded proteins that are capable of eliciting an IFN-γ response in human T cell lines, consisting of Rv079, Rv0569, Rv0572c, Rv1733c, Rv1738, Rv1813c, Rv1996, Rv2007c (FdxA), Rv2029c (PfkB), Rv2030c, Rv2031c (HspX, Acr, 16-kDa alpha crystallin homolog), Rv2032, Rv2623, Rv2624c, Rv2626c, Rv2627c, Rv2628, Rv3126c, Rv3127, Rv3129, Rv3130c, Rv3131, Rv3132c, Rv3133c (DosR), Rv3134c, Rv0080, Rv1737c (NarK2), Rv1735c and Rv1736c (NarX). The Rv nomenclature for Mycobacterial antigens and the DNA and protein sequences of the NRP / dormancy (DosR) regulon are well known in the art and may for instance be found at: http://genolist.pasteur.fr/TubercuList/ or or at http://www.ncbi.nlm.nih.gov/entrez (Accession number AL123456). The Rv nomenclature as used herein may refer to either the amino acid sequence of the antigen or the nucleotide sequence encoding the antigen.

The length of the contiguous amino acid sequence derived from the Mycobacterium protein is preferably no more than 45 amino acids and comprises at least 19 contiguous amino acids derived from the amino acid sequence of said Mycobacterium protein. The length of the contiguous amino acid sequence derived from said Mycobacterium protein comprised within the peptide, preferably is 19-45, 22-45, 22-40, 22-35, 24-43, 26-41, 28-39, 30-40, 30-37, 30-35, 32-35 33-35, 31-34 amino acids. In another preferred embodiment, a peptide comprises 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, or 45 or more than 45 contiguous amino acid residues of said Mycobacterium protein. The length of the contiguous amino acid sequence derived from said Mycobacterium protein comprised within the peptide may be the length of said peptide. The skilled person will therefore understand that a peptide of the invention may be distinct from said Mycobacterium protein.

The invention also encompasses a peptide originating from such protein as identified in this paragraph and comprising 1, 2, 3, 4, 5, 6 ,7, 8, 9 or more additional amino acids in total derived from the corresponding positions of the corresponding protein. These additional amino acids may be present at the N and/or at the C terminal of said peptide. However, such peptides are preferably distinct from a full length Mycobacterium protein.

Within the context of the invention, peptide may comprise additional amino acids than the ones originating from an antigen or may entirely be made of or consist of an amino acid sequence originating from such antigen. The length of the contiguous amino acid sequence from one of the above-defined antigens comprised within the peptide, preferably is at least 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 or 45 amino acids and/or preferably no more than 100, 99, 98, 97, 96, 95, 94, 93, 92, 91, 90, 89, 88, 87, 86, 85, 84, 83, 82, 81, 80, 60, 50, 45, 40, 35, 33 or 30 amino acids, more preferably the length of the contiguous amino acid sequence from one of the above-defined antigens comprised within the peptide is 19-45, even more preferably 22-40 amino acids, even more preferably 30-35 and most preferably 33-35 amino acids. In another preferred embodiment, the peptide of the invention consists of any of the contiguous amino acid sequence from the antigen as defined herein, whereby it is understood that no amino acids are appended to either end of the contiguous amino acid sequence from the antigen that are not contiguous with this amino acid sequence in the sequence of the native antigen. These peptides may be easily synthesized and are large enough to be taken up by professional antigen presenting cells, processed by the proteasome and other proteases and peptidases of the intracellular processing system, and have sufficient physical capacity and length to contain at least one HLA class I and/or at least one HLA class II epitope. Optionally a peptide may comprise N- or C-terminal extensions, which may be additional amino acids, modified amino acids or other functional groups that may for instance enhance bio-availability, cellular uptake, targeting to T-cells, processing and/or solubility or comprise or release immune modulating substances that provide adjuvant or (co)stimulatory functions.

The compound of the invention is preferably expected to behave as an adjuvant. An adjuvant is defined herein as a molecule which is able to stimulate the immune system in such a way that an immune response, or an increase thereof, is elicited against said antigen when the antigen is administered in combination with the adjuvant (as a single compound or as two separate molecules as defined herein). To analyze or assess the antigen-specific elicited immune response, said immune response is compared to the immune response induced in presence of the antigen without the adjuvant or in the presence of the antigen with a known adjuvant. A known adjuvant may be another TLR2 adjuvant as identified in the experimental

part as Pam3CysSK4. The induction is assessed in a subject or in cells from a subject.

Without wishing to be bound by any theory, a compound of the invention is believed to act via TLR2.

An immune response induced or elicited may be a B and/or T cell response. An immune response may be a B cell response, i.e. production of an antibody specifically directed against said antigen. An antibody is preferably an IgG antibody. Said immune response may be a T cell response. Said B and/or T cell response may be detected by measuring the production of antibody and/or cytokine using an ELISA as described in the example. Preferred cytokines are IFNγ, IL-2, IL-4, IL-5, TNFα or IL-10.

In a preferred embodiment, the detection of the antigen-specific elicited immune response means that said detection occurs after at least one, ten, eleven, twelve hours or more or after at least one day of administration of said adjuvant and antigen, or at least two days, or at least three days, or at least four days, or at least five days , or at least six days, or at least seven days, or at least two weeks, or at least three weeks, or at least 4 weeks or more. The detection is assessed in a subject or in cells from a subject.

In the context of the invention, the antigen-specific elicited immune response preferably means a detectable increase of an immune response against said antigen. Said detectable increase may be assessed by comparison with the immune response induced or elicited when the antigen is used alone or when said antigen is used with a known adjuvant. A known adjuvant may be another TLR2 adjuvant as identified in the experimental part (Pam3CysSK4). A detectable increase is preferably an increase of at least 5% of the amount of a cytokine as already identified herein, or 10%, 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%, 100%, 150%, 200% or more after at least one, ten, eleven, twelve hours or more or after at least one day of administration of said adjuvant and antigen, or at least two days, or at least three days, or at least four days or more. The detection is assessed in a subject or in cells from a subject.

The functionality of the compound of the invention may also be assessed as described in the experimental part using a cell expressing TLR2.

Surprisingly, it appears that the compound of the invention is able to induce at least a similar or even a more potent immune response against a given antigen using a dose of said compound which is lower than classically used dose of adjuvant. Lower may mean a dose which is at least 1 fold, at least 10 fold, at least 30 fold, at least 50 fold, at least 100 fold, at least 150 fold or at least 200 fold lower than the one of a classical adjuvant as Pam3CysSK4).

The vaccine composition of the present invention can additionally include, in addition to the adjuvant and an antigen, one or more effective ingredients having the same or similar effect with them. For example the vaccine composition according to the invention may comprise one or more adjuvants, in addition to the adjuvant according to the present invention. These other adjuvants may be admixed to the vaccine composition according to the invention or may be administered separately to the mammal or human to be treated. Examples of suitable other adjuvants to be used in combination with the adjuvant compound according to the invention are Montanide adjuvant, such as Montanide ISA-51 or Montanide ISA 720 (Seppic France), Freund's adjuvant or IFA, Resiquimod; imiquimod; Poly IC:LC (Hiltonol); ISCOMS; CpG and GLA;MPL. Another adjuvant is a T cell adhesion inhibitor, more preferably an inhibitor of an endothelin receptor such as BQ-788 (Buckanovich RJ et al,, Ishikawa K, PNAS (1994) 91:4892). BQ-788 is N-cis-2,6-dimethylpiperidinocarbonyl-L-gamma-methylleucyl-D -1-methoxycarbonyltryptophanyl-D-norleucine. However any derivative of BQ-788 or modified BQ-788 compound is also encompassed within the scope of this invention.

The vaccine composition may also comprise compounds like for example detoxified Lipid A, clinical grade CpG or other appropriate immunomodulatory agent or antibody such as CTLA-4 blocking or CD40 agonistic antibodies or agonistic antibodies against other members of the TNF receptor family such as OX40, CD27, 4-1-BB (CD137) or 4-1-BB and/or CD40 ligands, OX40 ligands or functional fragments and derivates thereof, as well as synthetic compounds with similar agonistic activity. These compounds can be mixed or conjugated to either the compound according to the invention and/or to the specific antigen in the vaccine.

The vaccine composition can also include, in addition to the above-mentioned effective ingredients, one or more pharmaceutically acceptable carriers for the administration. The pharmaceutically acceptable carrier can be selected or be prepared by mixing more than one ingredients selected from a group consisting of

saline, sterilized water, Ringer's solution, buffered saline, dextrose solution, maltodextrose solution, glycerol and ethanol. Other general additives such as anti-oxidative agent, buffer solution, bacteriostatic agent, etc., can be added. In order to prepare injectable solutions such as aqueous solution, suspension and emulsion, diluents, dispersing agents, surfactants, binders and lubricants can be additionally added.

The specific formulation of the vaccine composition of the present invention, ways of administration and the use of pharmaceutically acceptable excipients are known in the art and for instance described in Remington; The Science and Practice of Pharmacy, 21st Edition 2005, University of Sciences in Philadelphia. Vaccine compositions and medicaments of the invention are preferably formulated to be suitable for intravenous or subcutaneous, or intramuscular administration, although other administration routes can be envisaged, such as mucosal administration or intradermal and/or intracutaneous administration, e.g. by injection or via a patch. Intradermal administration is preferred herein.

In a preferred embodiment, the vaccine composition is formulated to be suitable for intradermal administration or application. Intradermal is known to the skilled person. In the context of the invention, intradermal is synonymous with intracutaneous and is distinct from subcutaneous. A most superficial application of a substance is epicutaenous (on the skin), then would come an intradermal application (in or into the skin), then a subcutaneous application (in the tissues just under the skin), then an intramuscular application (into the body of the muscle).

The intradermal administration of the vaccine composition is very attractive since the injection of the vaccine is realized at or as close by as possible to the site of the disease resulting in the local activation of the disease draining lymph node, resulting in a stronger local activation of the immune system. In a preferred embodiment, the intradermal administration is carried out directly at the site of the lesion or disease. At the site of the lesion is herein understood to be within less than 5, 2, 1, 0.5, 0.2 or 0.1 cm from the site of the lesion.

In addition, a preferred embodiment comprises delivery of the antigen and adjuvant compound as part of the vaccine composition in a slow release vehicle such as mineral oil (e.g. Montanide ISA 51) ,PLGA based particles or scaffolds, dextran based particles or scaffolds, poly active based particles or scaffolds, liposomes, virosomes. Preferably for intradermal delivery the vaccine composition is

administered in a composition comprising in addition one or more immunologically inert pharmaceutically acceptable carriers, e.g. buffered aqueous solutions at physiological ionic strength and/or osmolarity (such as e.g. PBS).

It is furthermore encompassed by the present invention that the administration of at least one vaccine composition of the invention may be carried out as a single administration. It may also be possible that the various active compounds of the vaccine are administered sequentially and/or using different ways or different sites of administration. Alternatively, the administration of at least one vaccine composition may be repeated if needed.

Definitions

In the context of the invention, an antigen may be defined by a peptide. Any peptide overlapping with such initial peptide is also encompassed by the present invention. Overlapping means that the sequence of the peptide partially or completely overlaps with a given sequence. Preferably, overlapping means partially overlapping. Partially preferably means that the overlap is of one or more amino acids at the N-terminus and/or at the C-terminus of the peptide sequence, more preferably of two or more amino acids at the N-terminus and/or at the C-terminus, or more. It is also preferred that the overlap is of one or more amino acids at the N-terminus and/or two or more amino acids at the C-terminus of the peptide sequence or vice versa. The skilled person will understand that all kinds of overlaps are encompassed by the present invention as long as the obtained peptide exhibits the desired activity as earlier defined herein.

In the context of the invention, a peptide is represented by an amino acid sequence.

In the context of the invention, a nucleic acid molecule is represented by a nucleic acid or nucleotide sequence which encodes a peptide. A nucleic acid molecule may comprise a regulatory region.

It is to be understood that each nucleic acid molecule or protein or peptide as identified herein by a given Sequence Identity Number (SEQ ID NO) is not limited to this specific sequence as disclosed.

Throughout this application, each time one refers to a specific amino acid sequence SEQ ID NO of a peptide, one may replace it by a peptide comprising an amino acid sequence that has at least 60%, 65%, 70%, 75%, 80%, 85%, 90%, 95%,

97%, 98%, 99% or 100% sequence identity or similarity with amino acid sequence with a given SEQ ID NO.

In a preferred embodiment, sequence identity or similarity is determined by comparing the whole length of the sequences as identified herein.

"Sequence identity" is herein defined as a relationship between two or more amino acid (polypeptide or protein or peptide) sequences or two or more nucleic acid *(polynucleotide) sequences, as determined by comparing the sequences. In a* preferred embodiment, sequence identity is calculated based on the full length of two given SEQ ID NO or on part thereof. Part thereof preferably means at least 50%, 60%, 70%, 80%, 90%, or 100% of both SEQ ID NO. In the art, "identity" also means *the degree of sequence relatedness between amino acid or nucleic acid sequences,* as the case may be, as determined by the match between strings of such sequences.

"Similarity" between two amino acid sequences is determined by comparing the *amino acid sequence and its conserved amino acid substitutes of one polypeptide to* the sequence of a second polypeptide. "Identity" and "similarity" can be readily calculated by known methods, including but not limited to those described in (Computational Molecular Biology, Lesk, A. M., ed., Oxford University Press, New York, 1988; Biocomputing: Informatics and Genome Projects, Smith, D. W., ed., Academic Press, New York, 1993; Computer Analysis of Sequence Data, Part I, Griffin, A. M., and Griffin, H. G., eds., Humana Press, New Jersey, 1994; Sequence Analysis in Molecular Biology, von Heine, G., Academic Press, 1987; and Sequence Analysis Primer, Gribskov, M. and Devereux, J., eds., M Stockton Press, New York, 1991; and Carillo, H., and Lipman, D., SIAM J. Applied Math., 48:1073 (1988).

Preferred methods to determine identity are designed to give the largest match between the sequences tested. Methods to determine identity and similarity are codified in publicly available computer programs. Preferred computer program methods to determine identity and similarity between two sequences include e.g. the GCG program package (Devereux, J., et al., Nucleic Acids Research 12 (1): 387 *(1984)), BestFit, BLASTP, BLASTN, and FASTA (Altschul, S. F. et al., J. Mol. Biol.* 215:403-410 (1990). The BLAST X program is publicly available from NCBI and other sources (BLAST Manual, Altschul, S., et al., NCBI NLM NIH Bethesda, MD 20894; Altschul, S., et al., J. Mol. Biol. 215:403-410 (1990). The well-known Smith *Waterman algorithm may also be used to determine identity.*

Preferred parameters for polypeptide sequence comparison include the following: Algorithm: Needleman and Wunsch, J. Mol. Biol. 48:443-453 (1970); Comparison matrix: BLOSSUM62 from Hentikoff and Hentikoff, Proc. Natl. Acad. Sci. USA. 89:10915-10919 (1992); Gap Penalty: 12; and Gap Length Penalty: 4. A program useful with these parameters is publicly available as the "Ogap" program from Genetics Computer Group, located in Madison, WI. The aforementioned parameters are the default parameters for amino acid comparisons (along with no penalty for end gaps).

Preferred parameters for nucleic acid comparison include the following: Algorithm: Needleman and Wunsch, J. Mol. Biol. 48:443-453 (1970); Comparison matrix: matches=+10, mismatch=0; Gap Penalty: 50; Gap Length Penalty: 3. Available as the Gap program from Genetics Computer Group, located in Madison, Wis. Given above are the default parameters for nucleic acid comparisons.

Optionally, in determining the degree of amino acid similarity, the skilled person may also take into account so-called "conservative" amino acid substitutions, as will be clear to the skilled person. Conservative amino acid substitutions refer to the interchangeability of residues having similar side chains. For example, a group of amino acids having aliphatic side chains is glycine, alanine, valine, leucine, and isoleucine; a group of amino acids having aliphatic-hydroxyl side chains is serine and threonine; a group of amino acids having amide-containing side chains is asparagine and glutamine; a group of amino acids having aromatic side chains is phenylalanine, tyrosine, and tryptophan; a group of amino acids having basic side chains is lysine, arginine, and histidine; and a group of amino acids having sulphur-containing side chains is cysteine and methionine. Preferred conservative amino acids substitution groups are: valine-leucine-isoleucine, phenylalanine-tyrosine, lysine-arginine, alanine-valine, and asparagine-glutamine. Substitutional variants of the amino acid sequence disclosed herein are those in which at least one residue in the disclosed sequences has been removed and a different residue inserted in its place. Preferably, the amino acid change is conservative. Preferred conservative substitutions for each of the naturally occurring amino acids are as follows: Ala to Ser; Arg to Lys; Asn to Gln or His; Asp to Glu; Cys to Ser or Ala; Gln to Asn; Glu to Asp; Gly to Pro; His to Asn or Gln; Ile to Leu or Val; Leu to Ile or Val; Lys to Arg; Gln or Glu; Met to Leu or Ile; Phe to Met, Leu or Tyr; Ser to Thr; Thr to Ser; Trp to Tyr; Tyr to Trp or Phe; and, Val to Ile or Leu.

In this document and in its claims, the verb "to comprise" and its conjugations is used in its non-limiting sense to mean that items following the word are included, but items not specifically mentioned are not excluded. In addition the verb "to consist" may be replaced by "to consist essentially of" meaning that a compound or a composition as defined herein may comprise additional component(s) than the ones specifically identified, said additional component(s) not altering the unique characteristic of the invention.

In addition, reference to an element by the indefinite article "a" or "an" does not exclude the possibility that more than one of the elements is present, unless the context clearly requires that there be one and only one of the elements. The indefinite article "a" or "an" thus usually means "at least one".

All patent and literature references cited in the present specification are hereby incorporated by reference in their entirety.

The invention shall be illustrated by the following non-limiting examples.

Example 1

To illustrate the advantages of the compounds according to the invention two variants of the established TLR2/TLR1 ligand Pam_3CysSK_4 containing the CH_2 to NH substitution were prepared. These two compounds named U-Pam-14 and U-Pam-12 differ in the length of the fatty chain attached to the N-terminus of the Cys residue, U-Pam-14 being an exact isostere of palmitoyl moiety of the natural ligand while UPam-12 contains a shortened chain. Figure 1 shows the state of the art Pam_3CysSK_4 ligand and the U-Pam-14 and U-Pam-12 ligand according to the invention. A circle shows where the $-CH_2-$ bridge has been replaced by the -NH- bridge.

All reagents and solvents used in the solid phase peptide synthesis were purchased from Bachem and Biosolve and used as received. Fmoc-Cys((RS)-2,3-di(palmitoyloxy)-propyl)-OH (herein, (RS) denotes a mixture of R- and S-epimers at C-2 of the dipalmitoyloxypropyl group) was purchased from Bachem, Fmoc-amino acids, HCTU and PyBOP from Novabiochem. Tentagel based resins were ordered from Rapp Polymere. LC/MS was conducted on a JASCO system using a Vidac C4 analytical column (4.6 x 50 mm, 5 µm particle size, flow 1.0 mL/min.) or an Alltima CN analytical column (4.6 x 50 mm, 3 µm particle size, flow 1.0 mL/min.). Absorbance was measured at 214 and 256 nm.

Solvent system:

A: 100% water,

B: 100% acetonitrile,

C: 1% TFA/H2O.

Gradients of B in 10% C were applied over 15 minutes unless stated otherwise. Purifications were conducted on the Gilson preparative HPLC system, supplied with a semi preparative Vidac C4 column (10 x 250 mm, 5 µm particle size, flow 5.0 mL/min.).

Solvent system:

A: 100% water,

B: 100% acetonitrile,

C: 1% TFA/H2O.

Gradients of B in 10% C were applied over 3 CV unless stated otherwise. The UV absorption was measured with 214 and 256 nm. The solid-phase peptide synthesis was performed on an ABI (Applied Biosystems) 433A automated instrument applying Fmoc based protocol starting from Tentagel-RAM resin *according to established methods. The consecutive steps performed in each cycle* applied for Fmoc-Lys(Boc)-OH were:

1) Deprotection of the Fmoc-group with 20% piperidine in NMP for 15 min;

2) NMP wash;

3) Coupling of the appropriate amino acid using a five-fold excess.

Briefly, the Fmoc amino acid (0.25 mmol) was dissolved in 0.25 M HCTU in NMP (1 mL), the resulting solution was transferred to the reaction vessel followed by 0.5 mL of 1.0 M DIPEA in NMP to the initiate the coupling. The reaction vessel was then shaken for 45 min;

4) NMP wash;

5) capping with 0.5 M acetic anhydride in NMP in presence of 0.5 mmol DIPEA;

6) NMP wash;

7) Final Fmoc removal with 20% piperidine in NMP for 15 min;

8) NMP wash;

9) DCM wash.

H-Ser(tBu)-Lys(Boc)-Lys(Boc)-Lys(Boc)-Lys(Boc)-Rink-Tentagel (1)

Peptide synthesis was performed on a 1 mmol scale using an ABI 433A automated instrument applying Fmoc based protocol starting form Rink Amide S Tentagel (loading 0.26 mmol/g). The resin, after final Fmoc deprotection, was washed with NMP and DCM and dried. The resulting resin 1 was used in the next step.

General procedure coupling Fmoc-Cys((RS)-2,3-di(palmitoyloxy)-propyl)-OH

The Tentagel S Ram resin 1 loaded with H-Ser(tBu)-Lys(Boc)-Lys(Boc)-Lys(Boc)-Lys(Boc)-Rink-Tentagel was treated with a 0.5 mL stock solution of 0.18 M Fmoc-Cys((RS)-2,3-di(palmitoyloxy)-propyl)-OH in 0.22 M PyBop in DCM:NMP (2:1). The resulting mixture was activated with 2 x 44 µmol Dipea over 15 min. and reacted by shaking for 18h followed by NMP and DCM wash. The resin was swelled in DCM:NMP again and divided in portions of 10 µmol.

General procedure for isocyanate addition

The 10 µmol resin loaded with Fmoc-Cys((RS)-2,3-di(palmitoyloxy)-propyl)-Ser(tBu)-Lys(Boc)-Lys(Boc)-Lys(Boc)-Lys(Boc) 2 was swelled in DCM:NMP (1:1) and treated with 3 x 3 min 20% piperidine in NMP for Fmoc-deprotection. After a thorough NMP wash the resin was suspended in 1 mL DCM:NMP (1:1) and treated with tetradecyl isocyanate or dodecyl isocyanate (25 µL) . The mixture was shaken for 18 h, washed with NMP and DCM and air dried. The resin was treated for 104 minutes with a cleavage cocktail TFA/TIS/H_2O (95/2.5/2.5). The solution was filtered and precipitated with Et_2O (50 mL) and stored at -200 °C for 18h. The Et_2O was centrifuged, removed and the precipitated was dissolved by sonification in 1 ml MeCN : H_2O : tBuOH (1:1:1). Of each 50µL product was diluted with 50µL MeCN : H_2O : tBuOH (1:1:1) for LCMS analysis (Vidac C4 column). Obtained sequences were diluted with another 0.5 mL MeCN : H_2O : tBuOH (1:1:1) and were purified on a semipreparative Vidac C4 column (10 x 250 mm, 5 µm particle size, flow 5.0 mL/min, 60-100% B.).

The thus obtained compounds according to the invention had the following properties:

Upam-14:
1-tetradecyl-urea-Cys((RS)-2,3-di(palmitoyloxy)-propyl)-Ser-Lys-Lys-Lys-Lys-NH_2 (*) was obtained:
0.89 mg (0.59 µmol, 6%),
LCMS: 50-90% B,
rt 8.23 min.
Bruto formula $C_{80}H_{156}N_{12}O_{12}S$ calculated 1509.17, found ESI-MS: [M+H]+: 1510.6 (calculated 1510.2), [M+H]2+: 756.0 (calculated 755.8). HRMS [M+H+] calcd for $C_{80}H_{156}N_{12}O_{12}S$ 1510.17592, found 1510.17670.

(*) RS denotes a mixture of epimers at C-2 of the dipalmitoyloxypropyl group.

Upam-12
1-dodecadecyl-urea-Cys((RS)-2,3-di(palmitoyloxy)-propyl)-Ser-Lys-Lys-Lys-Lys-NH_2 (*)
0.89 mg (0.59 µmol, 6%),
LCMS: 50-90% B
rt 8.06 min.
Bruto formula $C_{79}H_{154}N_{12}O_{12}S$ calculated 1495.15, found ESI-MS: [M+H]+: 1496.3 (calculated 1496.16).

(*) RS denotes a mixture of epimers at C-2 of the dipalmitoyloxypropyl group.

Example 2

The two compounds U-Pam-12 and U-Pam-14 as obtained in Example 1 were tested in comparison to unmodified Pam3CysSK4 for their functional capacity to activate a human TLR2 expressing reporter cell line HEK-TLR2 (Figure 3A) and a murine dendritic cell line (Figure 3B).

In the test live TLR2-transfected HEK cells and dendritic cells ($5x10^4$ cells/well) were incubated with titrating concentrations of the respective Pam compounds in culture medium and incubated at 37 °C. After 24 hours, supernatants were harvested and the presence of IL-8 or IL-12 cytokines respectively, was measured by specific sandwich ELISA assays.

Both cell types were significantly more stimulated by the U-Pam compounds than the unmodified Pam3CysSK4. Both compounds increased the maximal stimulation level at least twofold and were calculated to be at least 100-fold more effective as based on the concentration of the compound needed to reach similar stimulation levels.

It was found that the compound according to the invention can functionally stimulate TLR2 from both human and mouse origin in low (pM to nM) concentrations. The active concentrations are lower than those of the unmodified TLR2 ligand. Additionally, the physiologically important dendritic cells can be activated to produce the immunologically relevant cytokine IL-12. This cytokine is crucially important to facilitate efficient priming of specific T lymphocytes to viruses and/or tumor-antigens. Therefore, a composition comprising said compound as adjuvant can effectively be used to increase the immunogenicity of antigen and thereby improving the efficacy of a vaccine.

It is believed that the use of a compound according to the invention will result in an improved immune response, meaning a more robust innate immune system activation as well as a more robust adaptive immune system activation, expressed in a higher T cell response and/or a higher antibody response, in comparison to immune stimulation with the known Pam3Cys-SK4.

Example 3

This example illustrates the synthesis of a UPam-14 derivative in which R^5 group (CH_2-OH) is replaced by CH_2-CH_3. This compound named here Upam-14-Abu.

H-Abu-Lys(Boc)-Lys(Boc)-Lys(Boc)-Lys(Boc)-Rink-Tentagel (2)

Peptide synthesis was performed as described in Example 1 for H-Ser(OtBu)-Lys(Boc)-Lys(Boc)-Lys(Boc)-Lys(Boc)-Rink-Tentagel (1) with the only difference that Fmoc-Abu-OH was applied instead of Fmoc-Ser(OtBu)-OH to introduce 2-

aminobutyric acid residue instead of serine residue of Upam-14. Subsequent synthetic and purification steps were identical to those described in Example 1.

The thus obtained compound according to the invention had the following properties:

Upam-14-Abu
1-tetradecyl-urea-Cys((RS)-2,3-di(palmitoyloxy)-propyl)-Abu-Lys-Lys-Lys-Lys-NH2
3.22 mg (2.13 µmol, 21%),
LCMS: 50-90% B
rt 8.31 min.
Bruto formula C81H158N12O11S calculated 1507.19, found ESI-MS: [M+H]+: 1508.5 (calculate 1508.2), [M+H]2+: 755.1 (calculated 754.6). HRMS [M+H+] calcd for C81H158N12O11S 1508.19665, found 1508.19725.

Example 4

The U-Pam compound was further functionally tested in dendritic cells (Figures 4 and 5) and in vivo in mice (Figure 6).

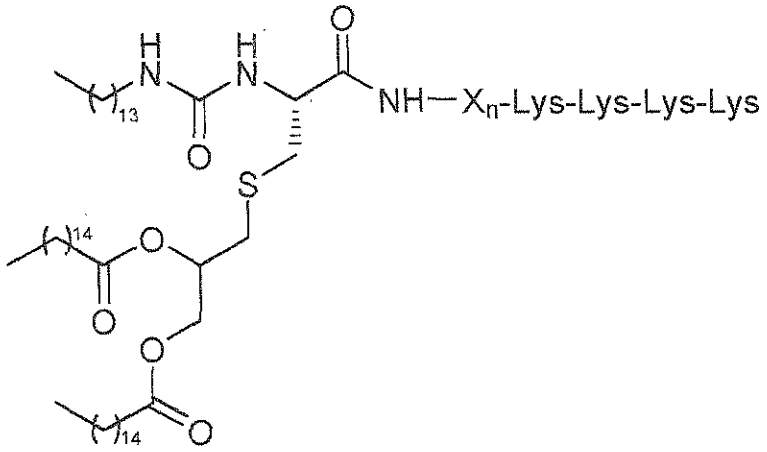
Figure 4 shows a murine DC cell line which was incubated for 48 hours with 30 nM of either U-Pam3CSK4 (U-Pam14) or Pam3CSK4, or left unstimulated. The DCs were subsequently stained with antibodies directed against CD40, CD86 and MHC class II molecules. Mean fluorescence intensity was determined FACS analysis. These data show that U-Pam is superior to wt Pam not only in IL-12 cytokine production (see example 2) but also in expression of cell surface molecules which are hallmarks for optimal DC maturation related to optimal T cell priming capacity.

In figure 5 shows the analysis of U-Pam activation of human monocyte-derived dendritic cells (moDC). On day 5 of culturing the CD14+ fraction of donor PBMC in growth medium with IL-4 and GM-CSF, these moDC were incubated with either wt Pam3CSK4, U-Pam14, Pam3CSK4-conjugated or U-Pam14-conjugated synthetic long peptide (Pam-SLP or uPam14-SLP), or left unstimulated. After 48 hours of

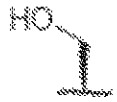
incubation, the supernatant of the moDC cultures was taken, which was subjected to IL12p40 (Fig 5A) and IL12p70 (Fig 5B) ELISA analysis. After 48 hours of incubation, the moDCs were stained with antibodies directed against CD86 (Fig 5C). This analysis shows that the U-Pam compound also improves activation of human dendritic cells. Importantly, not only the free compound but also the U-Pam conjugated to long peptide antigen improved DC activity.

In vivo T cell priming capacity of the U-Pam conjugated synthetic long peptide of the OVA antigen (containing the SIINFEKL CTL epitope) is shown in Figure 6. C57BL/6 mice were vaccinated subcutaneously with either 5 nmol U-Pam14-SLP conjugate, 5 nmol of Pam3CSK4-SLP conjugate, 5 nmol of free U-Pam14 mixed with 5 nmol of SLP, 5 nmol of free Pam3CSK4 mixed with 5 nmol of SLP, or with PBS only. After 14 days, mice were sacrificed and spleens were harvested and a single cell suspension was made. The splenocytes were intracellularly stained with fluorescently labeled antibodies directed against interferon-γ, and with antibodies directed against cell-surface markers CD3 and CD8β. The percentage of IFNγ producing OVA peptide-specific CD8 T cells is shown (Fig 6A). In another independent experiment C57BL/6 were vaccinated as described above and again after 14 days spleens were harvested. A fraction of the splenocytes was restimulated for 7 days with irradiated OVA-expressing EG7 lymphoma cells. The cultured splenocytes were stained with MHC class I Kb-SIINFEKL-APC tetramers, and with antibodies directed against cell surface markers CD3 and CD8β. The percentage of OVA-specific CD8 T cells is shown in (Fig 6B). Both in vivo experiments show enhanced priming of antigen-specific CD8 T cells by conjugation of Upam14 to SLP which harbors a T cell epitope.

Example 5

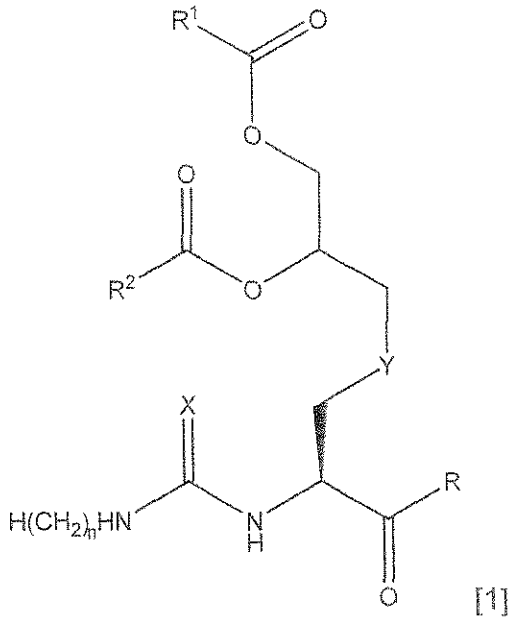


The UPam variants wherein X_n was varied were compared by measuring IL-12 production and the up-regulation of the cell surface markers CD40, CD86 and MHC Class II at 3 μM and 30 nM. Herein, X_n takes the place of serine in the SK_4 peptide part according to formula (2), containing different groups for R^5. Compounds X1 up to X8 containing these different groups R^5, which were studied are listed in the table below, wherein X1 is the UPam-14 as prepared in Example 1 and X2 is the UPam-14-Abu as prepared in Example 3. The potency of the compounds to upregulate CD40 followed the trend as observed in the DC maturation assay. The compounds X1, X2, X3, X4, X5, X6, X7 or X8 showed an increased amount of up-regulation as compared to the results obtained with the state of the art Pam_3Cys-SK_4. In the up-regulation of the cell surface marker CD86 and MHC class II a corroborated trend was observed.

Compound	R^5
X1	
X2	
X3	
X4	
X5	
X6	
X7	
X8	

CLAIMS

1. Compound represented by



[1]

the above formula [1] wherein R^1 and R^2 are each independently a branched or straight chain alkyl group having up to 17 carbon atoms, n is 0 to and including 18, Y is sulphur or selene, X is S or O and R is an organic group comprising one or more peptides, one or more nucleic acids, one or more antibodies or combinations thereof

2. Compound according to claim 1, wherein X is O.

3. Compound according to any one of claims 1-2, wherein Y is sulphur.

4. Compound according to any one of claims 1-3, wherein R^1 and R^2 are each independently a straight chain alkyl group having 10 to 17 carbon atoms.

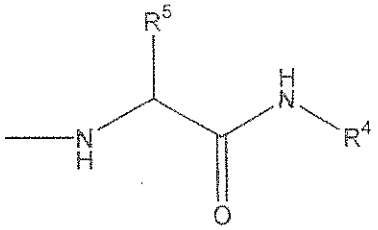
5. Compound according to claim 4, wherein R^1 and R^2 are straight chain alkyl groups having 15 carbon atoms.

6. Compound according to any one of claims 1-5, wherein n is 11 to and including 15.

7. Compound according to any one of claims 1-6, wherein R is SK_m, wherein m is 1, 2, 3, 4 or 5, and wherein R is optionally coupled to an antigen.

8. The compound according to claim 7, wherein R^1 and R^2 are straight chain alkyl groups having 15 carbon atoms, m is 4, n is 12 or 14, X is O, and Y is sulphur.

9 Compound according to claim 1, wherein group R is represented by



in which R^4 a K_m peptide part, wherein m is 0, 1, 2, 3, 4 or 5, and wherein R^4 is optionally coupled to an antigen and in which R^5 is hydrogen or a group comprising one to six atoms chosen from carbon, nitrogen and oxygen.

10. Compound according to claim 9, wherein R^5 is a $-CH_2$-OH group, a $-CH_2$-CH_3 group, a $-(CH_2)_3$-CH_3 group, a $-CH_2C{\equiv}CH$ group, a $-CH_2CH{=}CH_2$ group or a $-(CH_2)_2NH_2$ group.

11. Compound according to claim 9 or 10, wherein R^5 is not hydrogen and the asymmetric carbon to which R^5 is attached has the L configuration.

12. Compound according to any one of claims 7-11, wherein the K_m peptide part is coupled to an antigen, a nucleic acid and/or an antibody.

13. Solid phase peptide synthesis process to prepare a compound according to any one of claims 1-12, comprising

(a)providing R-H, which is optionally immobilized and/or side-chain protected;

(b) coupling of substituted cysteine building block Fmoc-(Y-(2-($OC(O)R^2$)-3-($OC(O)R^1$))propyl)-Cys-OH to R-H; and

(c) cleavage of the Fmoc-group from the N-terminus of the resulting peptide; and

(d) treatment of the Fmoc-liberated peptide with H-$(CH_2)_n$-N=C=X,

wherein R, R^1, R^2, X, Y and n are as defined in any one of claims 1-11.

14. Process according to claim 13, wherein R-H is immobilized and/or side-chain protected.

15. Process according to claim 14, further comprising:

(e) conjugating an antibody or a nucleic acid to the H-$(CH_2)_n$-N=C=X-treated peptide.

16. Composition comprising the compound according to any one of claims 1-12 and an antigen either as separate compound or as part of the compound according to any one of claims 1-12.

17. Use of the compound according to any one of claims 1 to 12 or a composition according to claim 16 for the manufacture of a medicament.

18. Use of a composition according to claim 17, wherein the medicament is for the induction, maintenance and/or enhancement of an immune response in a subject against an antigen.

19. Use of a compound according to any one of claims 1-12 and an antigen, either as separate compound or as part of the compound according to any one of claims 1-12, for the manufacture of a vaccine composition for the prevention, delay and/or treatment of an infection, a cancer or pre-malignant lesion associated with the antigen in a subject, wherein the antigen is derived from any one of selected from the group consisting of influenza virus antigen, haemaglutinin or neuraminidase antigen; human papilloma virus antigen, human immunodeficiency virus antigen, hepatitis virus antigen, respiratory syntytial virus antigen; SV40 virus antigen, EBV antigen, Kaposi Sarcoma Virus (KSV) antigen, Human T-Lymphotropic Virus-1 antigen, Merkel cell virus antigen and herpes simplex virus antigen, Cryptosporidium hominis, Cryptosporidium parvum, Schistosoma haematobium, Schistosoma , mansoni Schistosoma japonicum, Plasmodium falciparum, Plasmodium malariae,

Plasmodium vivax, Plasmodium ovale, Leishmania major, Leishmania tropica, Leishmania aethiopica, Leishmania mexicana, Leishmania donovani, Leishmania infantum, Leishmania braziliensis, Toxoplasma Gondii, Mycobacterium Tuberculosis, Streptococcus pneumoniae, Staphylococcus Aureus, Vibrio cholera, Neisseria meningitides, p53, MDM-2, HDM2, survivin, telomerase, cytochrome P450 isoform 1B1, Her-2/neu and CD19.