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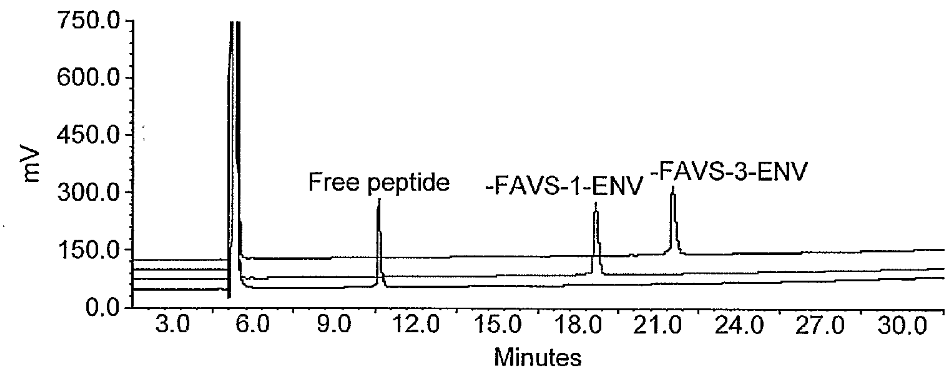
(54) Title: ANTIGEN DELIVERY VECTORS AND CONSTRUCTS



(57) Abstract: The present invention relates to fluorocarbon vectors for the delivery of antigens to immunoresponsive target cells. It further relates to fluorocarbon vector-antigen constructs and the use of such vectors associated with antigens as vaccines and immunotherapeutics in animals.

WO 2005/099752 A2

Antigen delivery vectors and constructs

The present invention relates to novel antigen delivery constructs and their use in immunisation methods. In particular, the invention relates to constructs useful in immunising against human immunodeficiency virus.

Background of the invention

Recent advances in our comprehension of mammalian immunological responses have led to the prevention of certain diseases in man through prophylactic vaccination and the control and treatment of diseases by the use of immunotherapeutics. The types of diseases which may be addressed through immunological intervention include those caused by infectious agents, cancers, allergies and autoimmune diseases. In these cases, most commonly, the premise of the medical treatment is the efficient delivery of antigens to appropriate immune recognition cells. For example, prophylactic vaccination has successfully eradicated smallpox worldwide through the administration of a live attenuated strain of the virus bearing all the antigens of the wild type virus. Similarly infections due to the *Haemophilus influenzae* serotype b bacterium have been significantly reduced in Western countries following the development of a vaccine based upon the polysaccharide antigen from the bacterial cell wall. . Moreover, some cancers such as human melanoma respond to immunotherapy using autologous dendritic cells (DC) as a cellular adjuvant and defined peptides derived from the melanosomal protein gp100 as the source of tumour–specific antigen to generate a cell-mediated immune response.

Self-tolerance to autoantigen can be restored in the treatment of experimental autoimmune encephalomyelitis by injection of a specific neuroantigen that is the target of the destructive immune response. Hence specificity can be afforded by such treatment without the need for long-term immunosuppression.

For infectious diseases, the most rapid progress in disease control has occurred where antibody raised to the administered antigen is capable of neutralising the infectious agent or toxin secreted therefrom, whether this be mediated through IgM, IgG or IgA. Likewise, autoimmune diseases have been treated with antigens that can ameliorate the action of auto-antibodies. However, for the eradication of virus-infected cells, cancer cells and cells harbouring intracellular bacteria, cellular immune responses are also required. For example, intracellular viruses (e.g. retroviruses, oncornaviruses, orthomyxoviruses, paramyxoviruses, togaviruses, rhabdoviruses, arenaviruses, adenoviruses, herpesviruses, poxviruses, papovaviruses and rubella viruses) are able to replicate and spread to adjacent cells without becoming exposed to antibody. The importance of cell-mediated immunity is emphasised by the inability of children with primary T-cell deficiency to clear these viruses, whilst patients with immunoglobulin deficiency but intact cell-mediated immunity do not suffer this handicap. A small, but important, number of bacteria, fungi, protozoa and parasites survive and replicate inside host cells. These organisms include Mycobacteria (tuberculosis and leprosy), Legionella (Legionnaires Disease), Rickettsiae (Rocky Mountain spotted fever), Chlamydiae, *Listeria monocytogenes*, Brucella, *Toxoplasma gondii*, Leishmania, Trypanosoma, *Candida albicans*, Cryptococcus, Rhodotorula and Pneumocystis. By living inside cells, these organisms are inaccessible to circulating antibodies. Innate immune responses are also ineffective. The major immune defense against these organisms is cell-mediated immunity; involving both CD8+ cytolytic T Lymphocytes and CD4 helper T Lymphocytes.

The development of vaccines and immunotherapeutics capable of eliciting an effective and sustained cell-mediated immune response remains one of the greatest challenges in vaccinology. In particular the development of a safe and efficacious vaccine for the prevention and treatment of Human Immunodeficiency Virus (HIV) infection has been hindered by the inability of vaccine candidates to stimulate robust, durable and disease-relevant cellular immunity.

The host cell-mediated immune response responsible for eradicating intracellular pathogens or cancer cells is termed the Th1 response. This is characterised by the induction of cytotoxic T-lymphocytes (CTL) and T-helper lymphocytes (HTL) leading to the activation of immune effector mechanisms as well as immunostimulatory cytokines such as IFN-gamma and IL-2. The importance of Th1 responses in the control of viral infection has recently been shown by Lu *et al.* (Nature Medicine (2004)). This clinical study with chronically HIV-1 infected individuals demonstrated a positive correlation between the suppression of viral load and both the HIV-1-specific IL-2- or IFN-gamma-expressing CD4+ T cells and specific HIV-1 CD8+ effector cell responses. Current immunological strategies to improve the cellular immunity induced by vaccines and immunotherapeutics include the development of live attenuated versions of the pathogen and the use of live vectors to deliver appropriate antigens or DNA coding for such antigens. Such approaches are limited by safety considerations within an increasingly stringent regulatory environment. Furthermore, issues arising from the scalability of manufacturing processes and cost often limit the commercial viability of products of biological origin.

In this context, rationally defined synthetic vaccines based on the use of peptides have received considerable attention as potential candidates for the development of novel prophylactic vaccines and immunotherapeutics. T cell and B cell epitopes represent the only active part of an immunogen that are recognized by the adaptive immune system. Small peptides covering T or B cell epitope regions can be used as immunogens to induce an immune response that is ultimately cross-reactive with the native antigen from which the sequence was derived. Peptides are very attractive antigens as they are chemically well-defined, highly stable and can be designed to contain T and B cell epitopes. T cell epitopes, including CTL and T helper epitopes, can be selected on the basis of their ability to bind MHC molecules in such a way that broad population coverage can be achieved (The HLA Factsbook, Marsh, S., Academic Press. 2000). Moreover, the ability to select appropriate T and B cell epitopes enable the immune response to be directed to multiple conserved epitopes of pathogens which are characterised by high sequence variability (such as HIV, hepatitis C virus (HCV), and malaria).

In order to stimulate T lymphocyte responses, synthetic peptides contained in a vaccine or an immunotherapeutic product should preferably be internalized by antigen presenting cells and especially dendritic cells. Dendritic cells (DCs) play a crucial role in the initiation of primary T-cell mediated immune responses. These cells exist in two major stages of maturation associated with different functions. Immature dendritic cells (iDCs) are located in most tissues or in the circulation and are recruited into inflamed sites. They are highly specialised antigen-capturing cells, expressing large amounts of receptors involved in antigen uptake and phagocytosis. Following antigen capture and processing, iDCs move to local T-cell locations in the lymph nodes or spleen. During this process, DCs lose their antigen-capturing capacity turning into immunostimulatory mature Dcs (mDCs).

Dendritic cells are efficient presenting cells that initiate the host's immune response to peptide antigen associated with class I and class II MHC molecules. They are able to prime naïve CD4 and CD8 T-cells. According to current models of antigen processing and presentation pathways, exogeneous antigens are internalised into the endocytic compartments of antigen presenting cells where they are degraded into peptides, some of which bind to MHC class II molecules. The mature MHC class II/peptide complexes are then transported to the cell surface for presentation to CD4 T-lymphocytes. In contrast, endogenous antigen is degraded in the cytoplasm by the action of the proteosome before being transported into the cytoplasm where they bind to nascent MHC class I molecules. Stable MHC class I molecules complexed to peptides are then transported to the cell surface to stimulate CD8 CTL. Exogenous antigen may also be presented on MHC class I molecules by professional APCs in a process called cross-presentation. Phagosomes containing extracellular antigen may fuse with reticulum endoplasmic and antigen may gain the machinery necessary to load peptide onto MHC class I molecules. It is well recognised, however, that free peptides are often poor immunogens on their own (Fields Virology, Volume 1, Third Edition, 1996).

To optimise the efficacy of peptide vaccines or therapeutics, various vaccine strategies have been developed to direct the antigens into the antigen-presenting cell in order to target the MHC class I pathway and to elicit cytotoxic T-lymphocyte (CTL) responses. As an example of a synthetic delivery system, fatty acyl chains have been covalently linked to peptides as a means of delivering an epitope into the MHC class I intracellular compartment in order to induce CTL activity. Such lipopeptides, for example with a monopalmitoyl chain linked to a peptide representing an epitope from HIV Env protein are described in the US patent 5,871,746. Other technologies have been delivered that aim to deliver epitopes into the intracellular compartment and thereby induce CTLs. These include vectors such as Penetratin, TAT and its derivatives, DNA, viral vectors, virosomes and liposomes. However, these systems either elicit very weak CTL responses, have associated toxicity issues or are complicated and expensive to manufacture at the commercial scale.

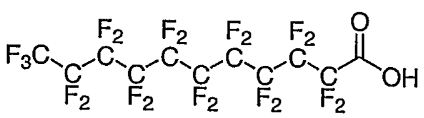
There is therefore a recognised need for improved vectors to direct the intracellular delivery of antigens in the development of vaccines and drugs intended to elicit a cellular immune response. A vector in the context of immunotherapeutics or vaccines is any agent capable of transporting or directing an antigen to immune responsive cells in a host. Fluorinated surfactants have been shown to have lower critical micellar concentrations than their hydrogenated counterparts and thus self-organise into micelle structures at a lower concentration than the equivalent hydrocarbon molecule. This physicochemical property is related to the strong hydrophobic interactions and low Van der Waal's interactions associated with fluorinated chains which dramatically increase the tendency of fluorinated amphiphiles to self-assemble in water and to collect at interfaces. The formation of such macromolecular structures facilitates their endocytic uptake by cells, for example antigen-presenting cells (Reichel F. *et al. J. Am. Chem. Soc.* **1999**, *121*, 7989-7997). Furthermore haemolytic activity is strongly reduced and often suppressed when fluorinated chains are introduced into a surfactant (Riess, J.G.; Pace, S.; Zarif, L. *Adv. Mater.* **1991**, *3*, 249-251) thereby leading to a reduction in cellular toxicity.

This invention seeks to overcome the problem of delivering antigens to immune responsive cells by using a novel fluorocarbon vector in order to enhance the immunogenicity of administered antigens. The fluorocarbon vector may comprise one or more chains derived from perfluorocarbon or mixed fluorocarbon/hydrocarbon radicals, and may be saturated or unsaturated, each chain having from 3 to 30 carbon atoms. In order to link the vector to the antigen through a covalent linkage, a reactive group, or ligand, is incorporated as a component of the vector, for example –CO-, -NH-, S, O or any other suitable group is included; the use of such ligands for achieving covalent linkages are well-known in the art. The reactive group may be located at any position on the fluorocarbon molecule. Coupling of the fluorocarbon vector to the antigen may be achieved through functional groups such as –OH, -SH, -COOH, $-NH_2$ naturally present or introduced onto any site of the antigen. Examples of such linkages include amide, hydrazone, disulphide, thioether and oxime bonds. Alternatively, non-covalent linkages can be used, for example an ionic interaction may be formed via a cation linking together a histidine residue of a peptide antigen and a carboxylic acid on the fluorocarbon vector. Optionally, a spacer element (peptidic or non-peptidic) may be incorporated to permit cleavage of the antigen from the fluorocarbon element for processing within the antigen-presenting cell and to optimise steric presentation of the antigen. The spacer may also be incorporated to assist in the synthesis of the molecule and to improve its stability and/or solubility. Examples of spacers include polyethylene glycol (PEG), amino acids such as lysine or arginine that may be cleaved by proteolytic enzymes and hydrocarbons.

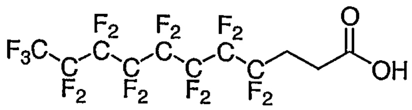
Thus, in a first aspect, the present invention provides a fluorocarbon vector having a chemical structure C_mF_n-C_yH_x-L, or derivatives thereof, where $m = 3$ to 30, $n <= 2m + 1$, $y = 0$ to 15, $x <= 2y$, $(m + y) = 3 - 30$ and L is a ligand to facilitate covalent attachment to an antigen.

In the context of the present invention "derivatives" refers to relatively minor modifications of the fluorocarbon compound such that the compound is still capable of delivering the antigen as described herein. Thus, for example, a number of the fluorine moieties can be replaced with other halogen moieties such as Cl, Br or I. In addition it is possible to replace a number of the fluorine moieties with methyl groups and still retain the properties of the molecule as discussed herein.

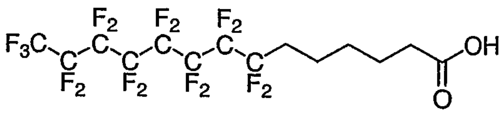
In a particular embodiment of the above formula the vector may be perfluoroundecanoic acid of the following formula (I):



or alternatively 2H, 2H, 3H, 3H-perfluoroundecanoic acid of the following formula (II):



or heptadecafluoro-pentadecanoic acid of the following formula (III):



In a second aspect the invention provides a vector-antigen construct C_mF_{n}-C_yH_x-(**Sp**)-**R** where **Sp** is an optional chemical spacer moiety and **R** is an antigen.

The antigen associated with the vector may be any antigen capable of inducing an immune response in an animal, including humans Preferably the immune response will have a beneficial effect in the host. Antigens may be derived from a virus, bacterium or mycobacterium, parasite, fungus, or any infectious agent or an autologous antigen or allergen.

Examples of viruses include, but are not limited to, Human Immunodeficiency Virus-1 (HIV-1) or -2, influenza virus, Herpes virus HSV-1 and HSV-2), hepatitis A virus (HAV), hepatitis B virus (HBV), or hepatitis C virus (HCV).
Examples of bacteria and mycobacteria include, but are not limited to Mycobacterium tuberculosis, Legionella, Rickettsiae, Chlamydiae, and *Listeria monocytogenes.*
Examples of parasites include, but are not limited to *Plasmodium falciparum* and other species of the Plasmodial family.

Examples of fungi include, but are not limited to *Candida albicans*, Cryptococcus, Rhodotorula and Pneumocystis.

Autologous or self-antigens include, but are not limited to the following antigens associated with cancers, HER-2/neu expressed in breast cancer, gp100 or MAGE-3 expressed in melanoma, P53 expressed in colorectal cancer, and NY-ESO-1 or LAGE-1 expressed by many human cancers.

Allergens include, but are not limited to. phospholipase A_2 (API m1) associated with severe reactions to bee, Derp-2, Der p 2, Der f , Der p 5 and Der p 7 associated with reaction against the house-dust mite *Dermatophagoides pteronyssinus*, the cockroach allergen Bla g 2 and the major birch pollen allergen Bet v 1.

Thus in a embodiment, the present invention provides a vector-antigen construct where the antigen is, or represents, an antigen from a virus, bacterium, mycobacterium, parasite, fungus, autologous protein or allergen.

Antigens may be proteins, protein subunits, peptides, carbohydrates, lipid or combinations thereof, provided they present an immunologically recognisable epitope. Such antigens may be derived by purification from the native protein or produced by recombinant technology or by chemical synthesis. Methods for the preparation of antigens are well-known in the art. Furthermore antigens also include DNA or oligonucleotide encoding an antigenic peptide or protein.

Thus in yet a further embodiment, the present invention provides a vector-antigen construct where the antigen is a protein, protein subunit, peptide, carbohydrate or lipid or combinations thereof.

For the construct to be immunologically active the antigen must comprise one or more epitopes. Peptides or proteins used in the present invention preferably contain a sequence of at least seven, more preferably between 9 and 100 amino-acids and most preferably between around 15 to 35 amino acids. Preferably, the amino acid sequence of the epitope(s) bearing peptide is selected to enhance the solubility of the molecule in aqueous solvents. Furthermore, the terminus of the peptide which does not conjugate to the vector may be altered to promote solubility of the construct via the formation of multimolecular structures such as micelles, lamellae, tubules or liposomes. For example, a positively charged amino acid could be added to the peptide in order to promote the spontaneous assembly of micelles. Either the N-terminus or the C-terminus of the peptide can be coupled to the vector to create the construct. To facilitate large scale synthesis of the construct, the N- or C-terminal amino acid residues of the peptide can be modified. When the desired peptide is particularly sensitive to cleavage by peptidases, the normal peptide bond can be replaced by a noncleavable peptide mimetic; such bonds and methods of synthesis are well known in the art.

As a specific example, the peptide **NNTRKRIRIQRGPGRAFVTIGK-NH_2** represents an epitope from the Env (301-322) protein of HIV-1, which has been shown to be immunologically active. This represents yet another embodiment of the present invention. (Reference http://www.hiv.lanl.gov/content/immunology/index.html).

More than one antigen may be linked together prior to attachment to the ligand. One such example is the use of fusion peptides where a promiscuous T helper epitope can be covalently linked to one or multiple CTL epitopes or one or multiple B cell epitope which can be a peptide, a carbohydrate, or a nucleic acid. As an example, the promiscuous T helper epitope could be the PADRE peptide, tetanus toxoid peptide (830-843) or influenza haemagglutinin, HA(307-319).
In another embodiment therefore, the vector-antigen construct is one where **R** is more than one epitope or antigen linked together. Epitopes may also be linear overlapping thereby creating a cluster of densely packed multi-specific epitopes.

Due to the strong non-covalent molecular interactions characteristic to fluorocarbons, the antigen may also be non-covalently associated with the vector and still achieve the aim of being favourably taken up by antigen-presenting cells

The present invention also provides vaccines and immunotherapeutics comprising one or more fluorocarbon vector- antigen constructs. Multi-component products of this type are desirable since they are likely to be more effective in eliciting appropriate immune responses. For example, the optimal formulation of an HIV immunotherapeutic may comprise a number of epitopes from different HIV proteins. In this case each epitope may be linked to a common fluorocarbon vector or each epitope could be bound to a dedicated vector. Alternatively, multiple epitopes may be incorporated into a formulation in order to confer immunity against a range of pathogens. A multi-component product may contain one or more vector-antigen construct, more preferably 2 to about 20, more preferably 3 to about 8 such constructs.

Compositions of the invention comprise fluorocarbon vectors associated to antigens optionally together with one or more pharmaceutically acceptable carriers and/or adjuvants. Such adjuvants, capable of further potentiating the immune response, may include, but are not limited to, muramyldipeptide (MDP) derivatives, CpG, monophosphoryl lipid A, oil in water adjuvants, water-in-oil adjuvants, aluminium salts, cytokines, immunostimulating complex (ISCOMs), liposomes, microparticules, saponins, cytokines, or bacterial toxins and toxoids. Other useful adjuvants will be well-known to one skilled in the art. The choice of carrier if required is frequently a function of the route of delivery of the composition. Within this invention, compositions may be formulated for any suitable route and means of administration. Pharmaceutically acceptable carriers or diluents include those used in formulations suitable for oral, ocular, rectal, nasal, topical (including buccal and sublingual), vaginal or parenteral (including subcutaneous, intramuscular, intravenous, intradermal) administration.

The formulation may be administered in any suitable form, for example as a liquid, solid, aerosol, or gas. For example, oral formulations may take the form of emulsions, syrups or solutions or tablets or capsules, which may be enterically coated to protect the active component from degradation in the stomach. Nasal formulations may be sprays or solutions. Transdermal formulations may be adapted for their particular delivery system and may comprise patches. Formulations for injection may be solutions or suspensions in distilled water or another pharmaceutically acceptable solvent or suspending agent.

Thus in a further aspect, the present invention provides a prophylactic or therapeutic formulation comprising the vector-antigen construct with or without a suitable carrier and/or adjuvant.

The appropriate dosage of the vaccine or immunotherapeutic to be administered to a patient will be determined in the clinic. However, as a guide, a suitable human dose, which may be dependent upon the preferred route of administration, may be from 1 to 1000μg. Multiple doses may be required to achieve an immunological effect, which, if required, will be typically administered between 2 to 12 weeks apart. Where boosting of the immune response over longer periods is required, repeat doses 3 months to 5 years apart may be applied.

The formulation may combine the vector-antigen construct with another active component to effect the administration of more than one vaccine or drug. A synergistic effect may also be observed through the co-administration of the two or more actives. In the treatment of HIV infection, an example of one such drug is Highly Active Anti-Retroviral Therapy (HAART).

In other aspects the invention provides:

i) Use of the immunogenic construct as described herein in the preparation of a medicament for treatment or prevention of a disease or symptoms thereof.

ii) A method of treatment through the induction of an immune response following administration of the constructs or formulations described herein;

iii) The use of the fluorocarbon vectors and fluorocarbon vector-antigen constructs in medicine.

The examples refer to the figures in which:

Figure 1: shows HPLC chromatograms of various peptides and constructs at T=0;

Figure 2: shows HPLC chromatograms of various peptides and constructs stored at 40°C for 27 days;

Figure 3: shows critical micelle concentration evaluation for two peptides, FAVS-3-ENV and FAVS-1-ENV;

Figure 4: shows particle size analysis by quasi light scattering spectrometry after 20 hours standing for various peptide constructs;

Figure 5: shows cellular immune response assessed by ex vivo IFN-gamma ELISPOT assay in mice after single immunisation (A,B), first boost (C,D) and second boost (E,F);

Figure 6 shows nature of T lymphocytes primed in vivo by various fluorocarbon-peptide constructs;

Figure 7: shows cellular immune response assessed by ex vivo IFN-g ELISPOT assay in mice after three immunisations with FAVS-1-ENV alone or in combination with murabutide;

Figure 8: cytokine measurement after three injections with FAVS-1-ENV alone or in combination with murabutide; and

Figure 9: shows cellular immune response assessed by ex vivo IFN-g ELISPOT assay in mice after two intranasal administrations with FAVS-1-ENV alone or in combination with murabutide.

Example 1

Synthesis of Fluorocarbon-vectored peptides

The following fluorocarbon-vector peptides were synthesised:

FAVS-1-ENV: NNTRKRIRIQRGPGRAFVTIGK- $C_8F_{17}(CH_2)_2CO$ - K-NH_2

FAVS-2-ENV: NNTRKRIRIQRGPGRAFVTIGK- $C_8F_{17}(CH_2)_6CO$ - K-NH_2

FAVS-3-ENV: IRIQRGPGRAFVTIGKK- $CO(CH_2)_2$–$(PEG)_4$ - $C_8F_{17}(CH_2)_6CO$ - K-NH_2

Where the standard amino acid one letter code is utilised and PEG is CH_2-CH_2-O.

NNTRKRIRIQRGPGRAFVTIGK is the ENV(301-322) peptide of the Human Immunodeficiency Virus.

Peptide synthesis was carried out on an ABI 430 or ABI 433 automatic peptide synthesizer, on Rink amide resin (0.38mmol/g loading) using Nsc (2-(4-nitrophenylsulfonyl)ethoxycarbonyl), or Fmoc ((9-fluorenylmethylcarbonyl) amino acids. Coupling was promoted with HOCt (6-Chloro-1-oxybenzotriazole) and DIC (1,3-

diisopropylcarbodiimide) , and Fmoc/Nsc deprotection was carried out using 20% piperidine in DMF (Dimethylformamide) . Uncoupled *N*-termini were capped with acetic anhydride as part of each cycle. Cleavage of the peptide from resin and concomitant side-chain deprotection was achieved using TFA, water and TIS (Diisopropylsilane) (95:3:2), with crude isolation of product by precipitation into cold diethyl ether. Purification was performed by preparative HPLC using Jupiter C5 or Luna C18 (2) columns (250x22mm) and peptide mass was verified by mass spectrometry.

Peptide purity was verified prior to conducting the experiments by HPLC (HP 1050) using a column from Supelco (C5, 250×4.6mm, 300A, 5μm) under gradient elution. Solvent A (90% Water, 10% Acetonitrile, 0.1% TFA), Solvent B (10% Water, 90% Acetonitrile, 0.1% TFA). A gradient 0 to 100% of B in 30 minutes was used and column temperature was 40 °C. The wavelength of the UV detector was set up at 215nm. Purity of the fluorocarbon-vector peptides in each case was greater than 90%.

The chemical stability of hermetically sealed samples containing lyophilised vector-peptides was assessed at 4°C, 20°C and 40°C together with the unvectored peptide as a comparator (NNTRKRIRIQRGPGRAFVTIGK-NH_2). The stability over the time was monitored by HPLC using the conditions described above. The data is shown in figures 1 and 2.

For each peptide conjugate, no sign of degradation was observed after 27 days at 40°C incubation, with a single peak eluting at the same retention time as found at T=0.

Example 2

Physicochemical analysis of Fluorocarbon-vectored peptides

(i) Solubility

The solubility of the fluorocarbon-vector peptides in aqueous solution at concentrations useful for a pharmaceutical formulation was confirmed. Solutions of peptides were prepared at 20°C by dissolving the lyophilised peptide powder with PBS (0.01M, pH 7.2) across a range of concentrations. Preparations were then vortexed for one minute. An aliquot was collected and the remainder of the solution was centrifuged for 10 minutes at 12,000rpm. To a 96-well flat bottom plate containing 25 μl aliquots of serial dilutions of each peptide was added 200 μl of the BCA working reagent (Pierce, UK) containing the solution A (bicichoninic acid, sodium carbonate, sodium tartrate in a sodium hydroxyde 0.1M solution, 50vol,) and B (4% cupric sulphate solution, 1 vol.). After incubating for 45 minutes at 37°C and cooling for 10 minutes, the absorbance was measured at 570 nm. The plates were analysed by a Wallac Victor multilabel counter (Perkin Elmer). For each peptide a calibration curve was plotted and used to determine the peptide concentration in the soluble fraction, expressed in nmol/ml. Data are presented Table 1. All the peptides were found to be fully soluble at the concentration of antigen used for murine immunisation studies.

Peptide	Solubility
Free peptide	>3300 nmol/ml
FAVS-1-ENV	>4000 nmol/ml
FAVS-2-ENV	> 500 nmol/ml
FAVS-3-ENV	>3000 nmol/ml

Table 1: Summary of the solubility assay performed by the protein assay method

(ii) **Critical Micelle Concentration [CMC]**

The Critical Micelle Concentration of the fluorocarbon-vectored peptides in physiological phosphate buffered saline was determined by dye bonding with 8-anilino-1-naphthalene-sulphonic acid (ANS). Starting from 300 μg peptide/ml solutions, serial two-fold dilutions of the peptide and peptide-vector solutions in PBS (0.01M, pH 7.2) were prepared at 20°C, from which 200 μl were added to the wells of a microplate. 40 μl of freshly dissolved ANS in PBS was then added to each well. After two minutes the plate was excited at 355 nm and scanned at 460 nm on a Victor microplate fluorimeter. The ratio (Intensity of fluorescence of the sample/Intensity of fluorescence of the blank) was plotted on a linear scale versus the concentration on a logarithmic scale. Data are presented Figure 3.

(iii) Particle size analysis

Particle size analysis was performed on a Malvern 4700C Quasi Light Scattering spectrometer (Malvern Ltd, UK) equipped with an Argon laser (Uniphase Corp., San Jose, CA) tuned at 488 nm. Samples were maintained at a temperature of 25 °C. The laser has variable detector geometry for angular dependence measurement. Measurements were performed at angles of 90° and 60°. Solutions were prepared by dissolving the peptide in filtered 0.01M phosphate buffered saline to a concentration of 500nmol/ml and vortexing for 1 minute. Solutions were then dispensed into cuvettes (working volume of 1ml). Measurements were taken after 15 minutes at an angle of 90° (Figure 4). The Kcount value output is proportional to the number of particles detected; in all cases the Kcount was >10 in order to ensure that reliable size distribution measurements were obtained.

ITS reference	Standing Time (h)	Kcount	size (nm)		Average size (nm)	Polydispersity
			Population1	Population2		
FAVS-1-ENV	0.25	177	28	-	28.3	0.151
	20	230	32	-	32.7	0.180
FAVS-2-ENV	0.25	190	15	120	28.5	0.450
	20	245	20	300	68.4	0.539
FAVS-3-ENV	0.25	201	70	400	209	0.659
	20	225	105	800	207	0.647

Table 2: Particle size of micellar solution in PBS.

Example 3

(i) Immunogenicity of Fluorocarbon-vectored peptides

Specific-pathogen-free mice (6-8 week female Balb/c) were purchased from Harlan

(UK). Peptides ENV, FAVS-1-ENV, FAVS-2-ENV or FAVS-3-ENV were dissolved in PBS (0.01M, pH 7.2). Each dose was normalised to 50nmol peptide per ml based on the net peptide content obtained from amino-acid analysis. Mice (3 per group) were immunized subcutaneously under the skin of the interscapular area with 50nmol peptide in a volume of 100 μl PBS, pH 7.2. Three doses were administered at ten day intervals. A mouse group receiving a priming dose of free peptide admixed with Complete Freund's adjuvant (50nmol peptide in PBS emulsified in an equal volume of adjuvant) and booster doses of Incomplete Freund's adjuvant served as a positive control. Ten days after the final immunisation mice were sacrificed and spleens removed to assess the cellular immune response to the peptide. To determine the progress of the immune response development, groups of mice receiving a single and two doses of peptide were also set up.

The *in vivo* cellular response primed by the vectored peptides was monitored by IFN-gamma ELISPOT on fresh spleen cells in order to enumerate the *ex-vivo* frequency of peptide-specific IFN-gamma producing cells and more specifically peptide-specific CD8+ T lymphocytes primed following immunisation. Spleen cells were restimulated *in vitro* with the ENV(301-322) NNTRKRIRIQRGPGRAFVTIGK peptide containing a well-known T-helper epitope and ENV(311-320) RGPGRAFVTI a shorter peptide corresponding to the CD8 epitope (MHC class I H-2Dd-restricted known as P18-I10) in order to cover both components of the cellular immune response (T Helper and CD8 T cell activity).

The spleens from each group of mice were pooled and spleen cells isolated. Cells were washed three times in RPMI-1640 before counting. Murine IFN-g Elispot assays were performed using Diaclone Kit (Diaclone, France) according to the manufacturer's instructions with the following modifications. Duplicate culture of spleen cells at cell density of $5x10^5$/well were distributed in anti-IFN-gamma antibody coated PVDF bottomed-wells (96-well multiscreen™-IP microplate - Millipore) with the appropriate concentration of peptide (10, 1, 0 mg/ml of T helper ENV(301-322) or P18-I10 CTL epitope) in culture medium (RPMI-1640), 5 μM β-mercaptoethanol, 5mM glutamine supplemented with 10% Foetal Calf Serum during 18 hours at 37°C under 5% CO_2

atmosphere. The spots were counted using a Carl Zeiss Vision ELIspot reader unit. The results correspond to mean values obtained with each conditions after background subtraction. Results are expressed as spot forming units (SFC) per million input spleen cells (Figure 5).

(ii) Nature of T lymphocytes primed *in vivo* by the fluorocarbon-peptides (CD4 and CD8 T cell separation)

Spleen Cells from immunized mice were distributed in 48-well microplates at cell density of 2.5×10^6 / well with 1μg/ml of T helper ENV(301-322) or P18-I10 CTL peptides. At day 3, 5ng/ml of recombinant murine IL-2 was added to each well. At day 7, pre-stimulated spleen cells were harvested, washed three times in RPMI 1640, counted and separated by magnetic cell sorting using magnetic beads conjugated with monoclonal rat anti-mouse CD8a and CD4 antibodies (MACS, Microbeads Miltenyi Biotec, UK) according to manufacturer's intructions. CD4 and CD8 + T cells were distributed at cell density of 2.5×10^5/well in duplicate in antibody coated PVDF bottomed-wells (96-well multiscreen™-IP microplate, Millipore) with 1 mg/ml of peptide in culture medium (RPMI-1640, 5 μM β-mercaptoethanol, Glutamine, non-essential amino-acids, sodium pyruvate supplemented with 10% Foetal Calf Serum for 12 hours at 37°C under 5% CO_2 atmosphere. The spots were counted using a Carl Zeiss Vision ELIspot reader unit. The results correspond to mean values obtained with each conditions after background subtraction (<10 spots). Results are expressed as spot forming units (SFC) per million input spleen cells.

According to the *ex vivo* IFN-γ ELISPOT assays, the FAVS-peptide constructs were able to prime a strong cellular immune response against both the long (ENV301-322) and the short ENV peptides (P18-I10 CTL epitope) after a single *in vivo* exposure to the antigen (Figure 5 A and B). Figure 6 demonstrates that both CD4+ and CD8 + ENV-specific T cells were efficiently primed *in vivo*.

The intensity of the response after priming with the FAVS-peptides was in the same range as the responses obtained from mice immunized with the native peptide emulsified in Freund's adjuvant. ENV-specific T cell responses are clearly amplified after a first and a second boost with the FAVS-1-ENV formulation (Figure 5C, D, E, F) as summarized in Figure 6.

This clearly demonstrates the ability of the FAVS-peptides to be taken up by antigen presenting cells *in vivo* in order to reach the MHC class I and MHC class II pathways and thereby prime strong cellular immune responses.

Example 4

Immunogenicity of Fluorocarbon-vectored peptides co-administered with synthetic adjuvant

In order to assess the potential impact of a synthetic immunostimulant on the quantitative and qualitative immunogenicity of the FAVS-peptides, FAVS-1-ENV was injected alone and in combination with Murabutide. Murabutide (N-acetyl-muramyl-L-alanyl-D-glutamine-O-n-butyl-ester; a synthetic derivative of muramyl dipeptide and NOD-2 agonist) is a synthetic immune potentiator that activates innate immune mechanisms and is known to enhance both cellular and humoral responses when combined with immunogens ("Immune and antiviral effects of the synthetic immunomodulator murabutide: Molecular basis and clinical potential", G. Bahr, in: "Vaccine adjuvants: Immunological and Clinical Principles", eds Hacket and Harn (2004), Humana Press).

Specific-pathogen-free mice (6-8 week female Balb/c) were purchased from Harlan (UK). The FAVS-1-ENV construct was used at two different dose levels, one group of mice receiving 50nmoles and a second group received 5 nmoles of construct. Mice (3 per group) were immunized subcutaneously under the skin of the interscapular area with FAVS-1-ENV either alone or in combination with 100 μg of Murabutide in a total volume of 100 μl PBS, pH 7.2. Three doses were administered at ten day intervals. A control group receiving murabutide alone was also set up.

Ten days after the final immunisation mice were sacrificed and spleens removed to assess the cellular immune response to the T helper ENV(301-322) or P18-I10 CTL epitope peptides. Interferon-gamma Elispot and Th-1 and Th-2 cytokine measurements were performed on the isolated spleens as described in Example 3. Briefly, spleen cells were cultured with the appropriate concentration of peptide (10 or 0 μg/ml of T helper ENV (301-322) or P18-I10 CTL epitope) in culture medium during 18 hours at 37°C under 5% CO_2 atmosphere. IFN-g Elispot assay was then performed. The spots were counted using a Carl Zeiss Vision Elispot reader unit. The results correspond to mean values obtained with each conditions after background subtraction (<10 spots). Results are expressed as spot forming units (SFC) per million input spleen cells (Figure 7).

Multiplex cytokine measurements (IL-2, IFN-g, IL4, IL5, IL-10, IL-13) were performed on fresh spleen cells re-stimulated with the ENV (301-322) peptide from mice immunised with the 5 nmol dose of FAVS-1-ENV. Supernatants were collected at 24 hours and 48 hours. Levels of cytokines (IL2, IL4, IL-5, IL-10, IL-13, IFN-γ) in cell culture supernatant samples were measured using the Cytokine specific Sandwich ELISA according to the mutiplex format developed by SearchLight™ Proteomic Arrays (Pierce Biotechnology, Woburn, MA). Results were expressed in pg cytokine/ml.

FAVS-1-ENV administered alone was shown to induce predominantly Th-1 cytokine production (i.e. IL-2 and IFN-g) with low levels of Th-2 cytokines also being produced. The inclusion of murabutide within the formulation led to the induction of a more balanced Th-1/Th-2 response with higher levels of Th-2 cytokines such as IL-5, IL-10 and IL-13 (Figure 8).

Example 5

Immunogenicity of Fluorocarbon-vectored peptides administered mucosally

Specific-pathogen-free mice (6-8 week female Balb/c) were purchased from Harlan (UK).

FAVS-1-ENV (50 nmoles per mouse) was administered twice intranasally in 0.01M PBS alone or in combination with 100 μg of Murabutide with 10 days interval between both administration. Mice were slightly anaesthetised with Isoflurane (Isoflo, Solvay, UK). 20μl of soluble peptide solution (10μl/nostril) was administered using a micropipette. A control group received PBS only. Each dosing group comprised six animals. Mice were sacrificed 10 days after the last administration by carbon dioxide asphyxiation. Spleens were removed, pooled for each group of mice and spleen cells were isolated. Cells were washed three times with RPMI-1640 before counting. Counting was performed using a Thomas counting slide. Spleen cells from individual mice were cultured with the appropriate concentration of peptide (10 or 0 μg/ml of T helper ENV (301-322) or P18-I10 CTL epitope) in culture medium during 18 hours at 37°C under 5% CO_2 atmosphere. IFN-g Elispot assay was then performed using the Diaclone Kit as described in Example 3. The spots were counted using a Carl Zeiss Vision Elispot reader unit. The results correspond to mean values obtained with each conditions after background subtraction (<10 spots). Results are expressed as spot forming units (SFC) per million input spleen cells. The data represent the average for 6 mice.

All six mice per group immunised intranasally either with FAVS-1-ENV alone or in combination with murabutide produced a robust systemic T-cell response. Combination with murabutide led to modest increases in the frequency of IFN- gamma producing T cells (Figure 9).

Example 6

Example HIV peptides

Candidate peptides for attachment to the fluorocarbon vector to produce a prophylactic or therapeutic vaccine for HIV may include the following one or more peptides or fragments thereof, or homologues (including the corresponding consensus, ancestral or central tree sequences from HIV-1 representing different clades such as but not limited to clades A, B, C, D, F, G and H as referred to in the 2004 Los Alamos National Laboratory database) or natural and non-natural variants thereof, but not necessarily exclusively. The standard one letter and three-letter amino acid codes have been utilised. Homologues have at least a 50% identity compared to a reference sequence. Preferably a homologue has 80, 85, 90, 95, 98 or 99% identity to a naturally occurring sequence. The sequences provided below are 35 amino acids in length. Fragments of these sequences that contain one or more epitopes are also candidate peptides for attachment to the fluorocarbon vector.

SEQ ID N°1

WKGEGAVVIQDNSDIKVVPRRKAKIIRDYGKQMAG

Trp-Lys-Gly-Glu-Gly-Ala-Val-Val-Ile-Gln-Asp-Asn-Ser-Asp-Ile-Lys-Val-Val-Pro-Arg-Arg-Lys-Ala-Lys-Ile-Ile-Arg-Asp-Tyr-Gly-Lys-Gln-Met-Ala-Gly

SEQ ID N°2

EIYKRWIILGLNKIVRMYSPTSILDIRQGPKEPFR

Glu-Ile-Tyr-Lys-Arg-Trp-Ile-Ile-Leu-Gly-Leu-Asn-Lys-Ile-Val-Arg-Met-Tyr-Ser-Pro-Thr-Ser-Ile-Leu-Asp-Ile-Arg-Gln-Gly-Pro-Lys-Glu-Pro-Phe-Arg

SEQ ID N°3

EHLKTAVQMAVFIHNFKRKGGIGGYSAGERIVDII

Glu-His-Leu-Lys-Thr-Ala-Val-Gln-Met-Ala-Val-Phe-Ile-His-Asn-Phe-Lys-Arg-Lys-Gly-Gly-Ile-Gly-Gly-Tyr-Ser-Ala-Gly-Glu-Arg-Ile-Val-Asp-Ile-Ile

SEQ ID N°4

WEFVNTPPLVKLWYQLEKEPIVGAETFYVDGAANR

Trp-Glu-Phe-Val-Asn-Thr-Pro-Pro-Leu-Val-Lys-Leu-Trp-Tyr-Gln-Leu-Glu-Lys-Glu-Pro-Ile-Val-Gly-Ala-Glu-Thr-Phe-Tyr-Val-Asp-Gly-Ala-Ala-Asn-Arg

SEQ ID N°5

GERIVDIIATDIQTKELQKQITKIQNFRVYYRDSR

Gly-Glu-Arg-Ile-Val-Asp-Ile-Ile-Ala-Thr-Asp-Ile-Gln-Thr-Lys-Glu-Leu-Gln-Lys-Gln-Ile-Thr-Lys-Ile-Gln-Asn-Phe-Arg-Val-Tyr-Tyr-Arg-Asp-Ser-Arg

SEQ ID N°6

FRKYTAFTIPSINNETPGIRYQYNVLPQGWKGSPA

Phe-Arg-Lys-Tyr-Thr-Ala-Phe-Thr-Ile-Pro-Ser-Ile-Asn-Asn-Glu-Thr-Pro-Gly-Ile-Arg-Tyr-Gln-Tyr-Asn-Val-Leu-Pro-Gln-Gly-Trp-Lys-Gly-Ser-Pro-Ala

SEQ ID N°7

NWFDITNWLWYIKIFIMIVGGLIGLRIVFAVLSIV

Asn-Trp-Phe-Asp-Ile-Thr-Asn-Trp-Leu-Trp-Tyr-Ile-Lys-Ile-Phe-Ile-Met-Ile-Val-Gly-Gly-Leu-Ile-Gly-Leu-Arg-Ile-Val-Phe-Ala-Val-Leu-Ser-Ile-Val

SEQ ID N°8

ENPYNTPVFAIKKKDSTKWRKLVDFRELNKRTQDF

Glu-Asn-Pro-Tyr-Asn-Thr-Pro-Val-Phe-Ala-Ile-Lys-Lys-Lys-Asp-Ser-Thr-Lys-Trp-Arg-Lys-Leu-Val-Asp-Phe-Arg-Glu-Leu-Asn-Lys-Arg-Thr-Gln-Asp-Phe

SEQ ID N°9

VASGYIEAEVIPAETGQETAYFLLKLAGRWPVKTI

Val-Ala-Ser-Gly-Tyr-Ile-Glu-Ala-Glu-Val-Ile-Pro-Ala-Glu-Thr-Gly-Gln-Glu-Thr-Ala-Tyr-Phe-Leu-Leu-Lys-Leu-Ala-Gly-Arg-Trp-Pro-Val-Lys-Thr-Ile

SEQ ID N°10

PDKSESELVSQIIEQLIKKEKVYLAWVPAHKGIGG

Pro-Asp-Lys-Ser-Glu-Ser-Glu-Leu-Val-Ser-Gln-Ile-Ile-Glu-Gln-Leu-Ile-Lys-Lys-Glu-Lys-Val-Tyr-Leu-Ala-Trp-Val-Pro-Ala-His-Lys-Gly-Ile-Gly-Gly

SEQ ID N°11

NRWQVMIVWQVDRMRIRTWKSLVKHHMYISRKAKG

Asn-Arg-Trp-Gln-Val-Met-Ile-Val-Trp-Gln-Val-Asp-Arg-Met-Arg-Ile-Arg-Thr-Trp-Lys-Ser-Leu-Val-Lys-His-His-Met-Tyr-Ile-Ser-

Arg-Lys-Ala-Lys-Gly

SEQ ID N°12

HPDKWTVQPIVLPEKDSWTVNDIQKLVGKLNWASQ

His-Pro-Asp-Lys-Trp-Thr-Val-Gln-Pro-Ile-Val-Leu-Pro-Glu-Lys-Asp-Ser-Trp-Thr-Val-Asn-Asp-Ile-Gln-Lys-Leu-Val-Gly-Lys-Leu-Asn-Trp-Ala-Ser-Gln

SEQ ID N°13

PAIFQSSMTKILEPFRKQNPDIVIYQYMDDLYVGS

Pro-Ala-Ile-Phe-Gln-Ser-Ser-Met-Thr-Lys-Ile-Leu-Glu-Pro-Phe-Arg-Lys-Gln-Asn-Pro-Asp-Ile-Val-Ile-Tyr-Gln-Tyr-Met-Asp-Asp-Leu-Tyr-Val-Gly-Ser

SEQ ID N°14

MRGAHTNDVKQLTEAVQKIATESIVIWGKTPKFKL

Met-Arg-Gly-Ala-His-Thr-Asn-Asp-Val-Lys-Gln-Leu-Thr-Glu-Ala-Val-Gln-Lys-Ile-Ala-Thr-Glu-Ser-Ile-Val-Ile-Trp-Gly-Lys-Thr-Pro-Lys-Phe-Lys-Leu

SEQ ID N°15

EKAFSPEVIPMFSALSEGATPQDLNTMLNTVGGHQ

Glu-Lys-Ala-Phe-Ser-Pro-Glu-Val-Ile-Pro-Met-Phe-Ser-Ala-Leu-Ser-Glu-Gly-Ala-Thr-Pro-Gln-Asp-Leu-Asn-Thr-Met-Leu-Asn-Thr-Val-Gly-Gly-His-Gln

SEQ ID N°16

NLLRAIEAQQHLLQLTVWGIKQLQARVLAVERYLK

Asn-Leu-Leu-Arg-Ala-Ile-Glu-Ala-Gln-Gln-His-Leu-Leu-Gln-Leu-Thr-Val-Trp-Gly-Ile-Lys-Gln-Leu-Gln-Ala-Arg-Val-Leu-Ala-Val-

Glu-Arg-Tyr-Leu-Lys

SEQ ID N°17

ASVLSGGELDRWEKIRLRPGGKKKYKLKHIVWASR

Ala-Ser-Val-Leu-Ser-Gly-Gly-Glu-Leu-Asp-Arg-Trp-Glu-Lys-Ile-Arg-Leu-Arg-Pro-Gly-Gly-Lys-Lys-Lys-Tyr-Lys-Leu-Lys-His-Ile-Val-Trp-Ala-Ser-Arg

SEQ ID N°18

ELYKYKVVKIEPLGVAPTKAKRRVVQREKRAVGIG

Glu-Leu-Tyr-Lys-Tyr-Lys-Val-Val-Lys-Ile-Glu-Pro-Leu-Gly-Val-Ala-Pro-Thr-Lys-Ala-Lys-Arg-Arg-Val-Val-Gln-Arg-Glu-Lys-Arg-Ala-Val-Gly-Ile-Gly

SEQ ID N°19

FPISPIETVPVKLKPGMDGPKVKQWPLTEEKIKAL

Phe-Pro-Ile-Ser-Pro-Ile-Glu-Thr-Val-Pro-Val-Lys-Leu-Lys-Pro-Gly-Met-Asp-Gly-Pro-Lys-Val-Lys-Gln-Trp-Pro-Leu-Thr-Glu-Glu-Lys-Ile-Lys-Ala-Leu

SEQ ID N°20

QIYQEPFKNLKTGKYARMRGAHTNDVKQLTEAVQK

Gln-Ile-Tyr-Gln-Glu-Pro-Phe-Lys-Asn-Leu-Lys-Thr-Gly-Lys-Tyr-Ala-Arg-Met-Arg-Gly-Ala-His-Thr-Asn-Asp-Val-Lys-Gln-Leu-Thr-Glu-Ala-Val-Gln-Lys

SEQ ID N°21

NLLRAIEAQQHLLQLTVWGIKQLQARVLAVERYLK

Asn-Leu-Leu-Arg-Ala-Ile-Glu-Ala-Gln-Gln-His-Leu-Leu-Gln-Leu-Thr-Val-Trp-Gly-Ile-Lys-Gln-Leu-Gln-Ala-Arg-Val-Leu-Ala-Val-Glu-Arg-Tyr-Leu-Lys

SEQ ID N°22

AGLKKKKSVTVLDVGDAYFSVPLDKDFRKYTAFTI

Ala-Gly-Leu-Lys-Lys-Lys-Lys-Ser-Val-Thr-Val-Leu-Asp-Val-Gly-Asp-Ala-Tyr-Phe-Ser-Val-Pro-Leu-Asp-Lys-Asp-Phe-Arg-Lys-Tyr-Thr-Ala-Phe-Thr-Ile

SEQ ID N°23

TTNQKTELQAIHLALQDSGLEVNIVTDSQYALGII

Thr-Thr-Asn-Gln-Lys-Thr-Glu-Leu-Gln-Ala-Ile-His-Leu-Ala-Leu-Gln-Asp-Ser-Gly-Leu-Glu-Val-Asn-Ile-Val-Thr-Asp-Ser-Gln-Tyr-Ala-Leu-Gly-Ile-Ile

SEQ ID N°24

VSQNYPIVQNLQGQMVHQAISPRTLNAWVKVVEEK

Val-Ser-Gln-Asn-Tyr-Pro-Ile-Val-Gln-Asn-Leu-Gln-Gly-Gln-Met-Val-His-Gln-Ala-Ile-Ser-Pro-Arg-Thr-Leu-Asn-Ala-Trp-Val-Lys-Val-Val-Glu-Glu-Lys

SEQ ID N°25

EAELELAENREILKEPVHGVYYDPSKDLIAEIQKQ

Glu-Ala-Glu-Leu-Glu-Leu-Ala-Glu-Asn-Arg-Glu-Ile-Leu-Lys-Glu-Pro-Val-His-Gly-Val-Tyr-Tyr-Asp-Pro-Ser-Lys-Asp-Leu-Ile-Ala-Glu-Ile-Gln-Lys-Gln

SEQ ID N°26

TPDKKHQKEPPFLWMGYELHPDKWTVQPIVLPEKD

Thr-Pro-Asp-Lys-Lys-His-Gln-Lys-Glu-Pro-Pro-Phe-Leu-Trp-Met-Gly-Tyr-Glu-Leu-His-Pro-Asp-Lys-Trp-Thr-Val-Gln-Pro-Ile-Val-Leu-Pro-Glu-Lys-Asp

SEQ ID N°27

EPFRDYVDRFYKTLRAEQASQEVKNWMTETLLVQN

Glu-Pro-Phe-Arg-Asp-Tyr-Val-Asp-Arg-Phe-Tyr-Lys-Thr-Leu-Arg-

Ala-Glu-Gln-Ala-Ser-Gln-Glu-Val-Lys-Asn-Trp-Met-Thr-Glu-Thr-Leu-Leu-Val-Gln-Asn

SEQ ID N°28

NEWTLELLEELKSEAVRHFPRIWLHGLGQHIYETY

Asn-Glu-Trp-Thr-Leu-Glu-Leu-Leu-Glu-Glu-Leu-Lys-Ser-Glu-Ala-Val-Arg-His-Phe-Pro-Arg-Ile-Trp-Leu-His-Gly-Leu-Gly-Gln-His-Ile-Tyr-Glu-Thr-Tyr

SEQ ID N°29

EGLIYSQKRQDILDLWVYHTQGYFPDWQNYTPGPG

Glu-Gly-Leu-Ile-Tyr-Ser-Gln-Lys-Arg-Gln-Asp-Ile-Leu-Asp-Leu-Trp-Val-Tyr-His-Thr-Gln-Gly-Tyr-Phe-Pro-Asp-Trp-Gln-Asn-Tyr-Thr-Pro-Gly-Pro-Gly

SEQ ID N°30

HFLKEKGGLEGLIYSQKRQDILDLWVYHTQGYFPD

His-Phe-Leu-Lys-Glu-Lys-Gly-Gly-Leu-Glu-Gly-Leu-Ile-Tyr-Ser-Gln-Lys-Arg-Gln-Asp-Ile-Leu-Asp-Leu-Trp-Val-Tyr-His-Thr-Gln-Gly-Tyr-Phe-Pro-Asp

SEQ ID N°31

FPVRPQVPLRPMTYKAAVDLSHFLKEKGGLEGLIY

Phe-Pro-Val-Arg-Pro-Gln-Val-Pro-Leu-Arg-Pro-Met-Thr-Tyr-Lys-Ala-Ala-Val-Asp-Leu-Ser-His-Phe-Leu-Lys-Glu-Lys-Gly-Gly-Leu-Glu-Gly-Leu-Ile-Tyr

SEQ ID N°32

FPQITLWQRPLVTIKIGGQLKEALLDTGADDTVLE

Phe-Pro-Gln-Ile-Thr-Leu-Trp-Gln-Arg-Pro-Leu-Val-Thr-Ile-Lys-Ile-Gly-Gly-Gln-Leu-Lys-Glu-Ala-Leu-Leu-Asp-Thr-Gly-Ala-Asp-Asp-Thr-Val-Leu-Glu

SEQ ID N°33

LVITTYWGLHTGERDWHLGQGVSIEWRKKRYSTQV

Leu-Val-Ile-Thr-Thr-Tyr-Trp-Gly-Leu-His-Thr-Gly-Glu-Arg-Asp-Trp-His-Leu-Gly-Gln-Gly-Val-Ser-Ile-Glu-Trp-Arg-Lys-Lys-Arg-Tyr-Ser-Thr-Gln-Val

SEQ ID N°34

APPEESFRFGEETTTPSQKQEPIDKELYPLASLRS

Ala-Pro-Pro-Glu-Glu-Ser-Phe-Arg-Phe-Gly-Glu-Glu-Thr-Thr-Thr-Pro-Ser-Gln-Lys-Gln-Glu-Pro-Ile-Asp-Lys-Glu-Leu-Tyr-Pro-Leu-Ala-Ser-Leu-Arg-Ser

SEQ ID N°35

KRRVVQREKRAVGIGAMFLGFLGAAGSTMGAASMT

Lys-Arg-Arg-Val-Val-Gln-Arg-Glu-Lys-Arg-Ala-Val-Gly-Ile-Gly-Ala-Met-Phe-Leu-Gly-Phe-Leu-Gly-Ala-Ala-Gly-Ser-Thr-Met-Gly-Ala-Ala-Ser-Met-Thr

SEQ ID N°36

GLGQHIYETYGDTWAGVEAIIRILQQLLFIHFRIG

Gly-Leu-Gly-Gln-His-Ile-Tyr-Glu-Thr-Tyr-Gly-Asp-Thr-Trp-Ala-Gly-Val-Glu-Ala-Ile-Ile-Arg-Ile-Leu-Gln-Gln-Leu-Leu-Phe-Ile-His-Phe-Arg-Ile-Gly

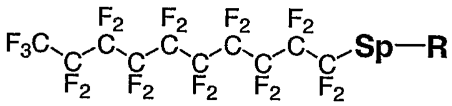
Candidate peptides for inclusion into a prophylactic or therapeutic vaccine for HIV may be peptides from any of the structural or functional domains Gag, Pol, Nef, Env, Vif, Vpr, Vpu, Tat or Rev in any such combination.

CLAIMS

1. A fluorocarbon vector of structure C_mF_n-C_yH_x-L, or derivatives thereof, where m = 3 to 30, n <= 2m +1, y = 0 to 15, x <= 2y, (m + y) = 3 - 30 and L is a ligand to facilitate covalent attachment to an antigen.

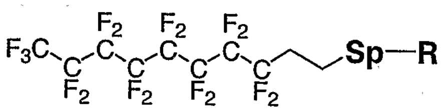
2. A fluorocarbon vector-antigen construct of structure C_mF_n-C_yH_x-(Sp)-R or derivatives thereof, where m = 3 to 30, n <= 2m +1, y = 0 to 15, x <= 2y, (m + y) = 3 - 30 and Sp is an optional chemical spacer moiety and R is an antigen.

3. A fluorocarbon vector-antigen construct as claimed in claim 2 of structure



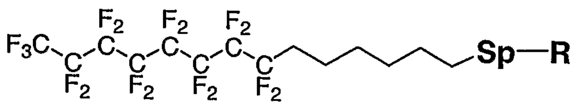
where **Sp** is an optional chemical spacer moiety and **R** is an antigen.

4. A fluorocarbon vector-antigen construct as claimed in claim 2 of structure



where **Sp** is an optional chemical spacer moiety and **R** is an antigen.

5. A fluorocarbon vector-antigen construct as claimed in claim 2 of structure



where **Sp** is an optional chemical spacer moiety and **R** is an antigen.

6. The fluorocarbon vector-antigen construct of any one of claims 2 to 5 wherein **R** is an antigen from a virus, bacteria, parasite, an autologous protein or cancer antigen.

7. The fluorocarbon vector-antigen construct of any one of claims 2 to 6 wherein **R** is protein, protein subunit, peptide, carbohydrate or lipid or combinations thereof.

8. The fluorocarbon vector-antigen construct of any one of claims 2 to 5wherein **R** comprises one or more epitopes from a viral protein.

9. The fluorocarbon vector-antigen construct of any one of claims 2 to 5 wherein **R** comprises one or more epitopes from a human immunodeficiency virus protein.

10. The construct of any one of claims 2 to 5 wherein R is a peptide consisting of between 7 to 70 amino acids.

11. The construct of any one of claims 2 to 5 wherein R comprises at least one MHC class I or II, or B cell epitope.

12. The construct of any one of cliams 2 to 5 wherein R comprises more than two or more overlapping epitopes.

13. The fluorocarbon vector-antigen construct of any one of claims 2 to 5 where **R** is an HIV epitope.

14. The fluorocarbon vector-antigen construct of any one of claims 2 to 5 wherein R is a peptide selected from the 2004 Los Alamos National Laboratory database or fragments, derivatives, homologues or combinations thereof.

15. The fluorocarbon vector-antigen construct of any one of claims 2 to 5 wherein R is a peptide selected from SEQ ID Nos 1, 2, 3, 4, 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 or 36 or fragments, derivatives, homologues or combinations thereof.

16. The fluorocarbon vector-antigen construct of any one of claims 2 to 5 wherein **R** is one or more HIV *env* epitopes.

17. The fluorocarbon vector-antigen construct of Claim 13 where **R** is the HIV *env*

epitope peptide with the amino acid sequence **NNTRKRIRIQRGPGRAFVTIGK-NH$_2$**

18. The fluorocarbon vector of Claim 1 non-covalently associated with an antigen.

19. The fluorocarbon vector-antigen construct of any one of claims 2 to 5 wherein **R** comprises multiple epitopes and/or fusion peptides.

20. A preventative or therapeutic formulation comprising one or more fluorocarbon vector-antigen constructs of Claims 2-19, optionally in combination with one or more pharmaceutically acceptable carriers, excipient, diluents or adjuvants.

21. A preventative or therapeutic formulation as claimed in claim 20 formulated for parenteral, oral, ocular, rectal, nasal, transdermal, topical, or vaginal administration.

22. A preventative or therapeutic formulation as claimed in claim 20which is a liquid, solid, aerosol or gas.

23. A preventative or therapeutic formulation as claimed in any one of claims 20 to 22which includes an adjuvant selected from the group consisting of muramyldipeptide (MDP) derivatives, CpG, monophosphoryl lipid A, oil in water adjuvants, water-in-oil adjuvants, aluminium salts, immunostimulating complex (ISCOMs), liposomes, microparticules, saponins, cytokines, or bacterial toxins and toxoids.

24. The use of the fluorocarbon vector-antigen construct as claimed in any one of claims 2-19 or a formulation as claimed in any one of claims 20 to 23 in the preparation of a prophylactic vaccine or immunotherapeutic pharmaceutical product.

25. The use of a flurocarbon vector as claimed in claim 1 in the preparation of a flurocarbon vector-antigen construct as claimed in any one of claims 2 to 19.

26. The use as claimed in claim 24wherein the vaccine or product is for parenteral, mucosal, oral, nasal, topical, ocular, rectal, transdermal, or vaginal administration.

27. A method of treatment or immunisation of a subject in need therof comprising the step of administering an effective amount of a construct as claimed in any one of claims 2 to 19 or a formulation as claimed in any one of claims 20 to 23.

28. A method of stimulating an immune response in a subject in need thereof comprising the step of administering an effective amount of a construct as claimed in any one of claims 2 to 19 or a formulation as claimed in any one of claims 20 to 23..

29. A method as claimed in claim 28, wherein the subject is a mammal, preferably a human.

30. The method as claimed in any one of claims 27-29 wherein the construct or formulation is combined with antiviral therapy.

31. The method as claimed in any one of claims 27-29 wherein the construct or formulation is administered with Highly Active Anti-Retroviral Therapy (HAART).

32. The use of a fluorocarbon vector as claimed in claim 1 or a fluorocarbon vector-antigen construct as claimed in any one of claims 2 to 19 in medicine.

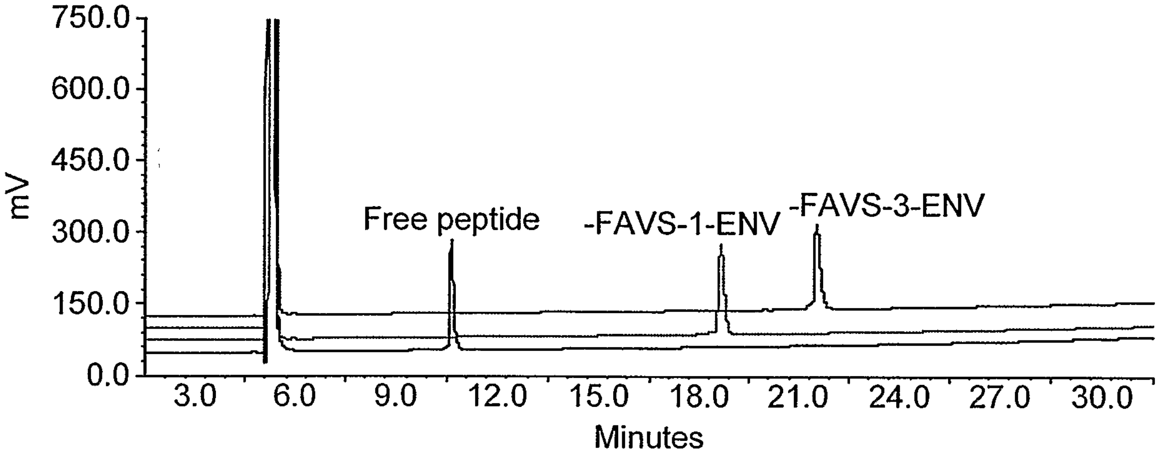

750.0
600.0
450.0
300.0
150.0
0.0
mV
Free peptide
-FAVS-1-ENV
-FAVS-3-ENV
3.0
6.0
9.0
12.0
15.0
18.0
21.0
24.0
27.0
30.0
Minutes

FIG. 1

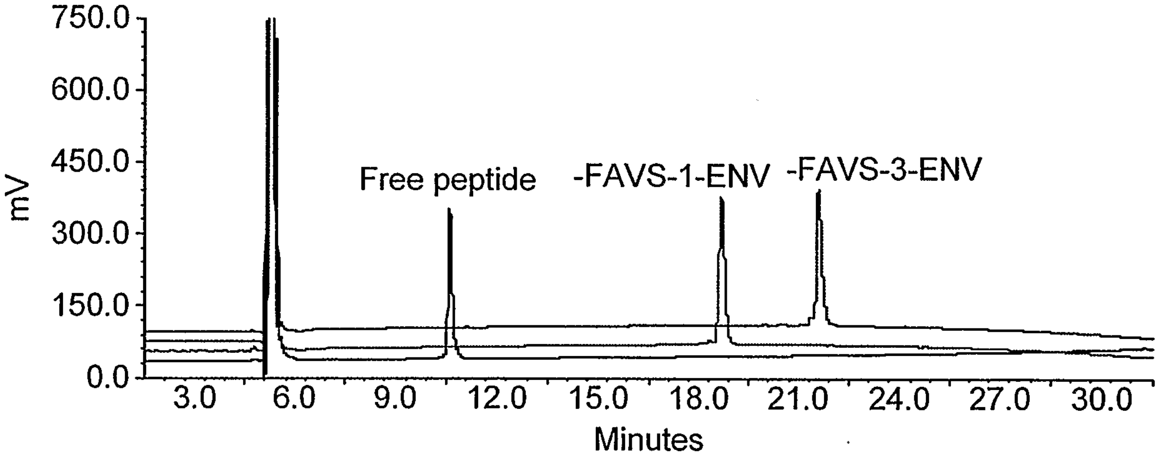
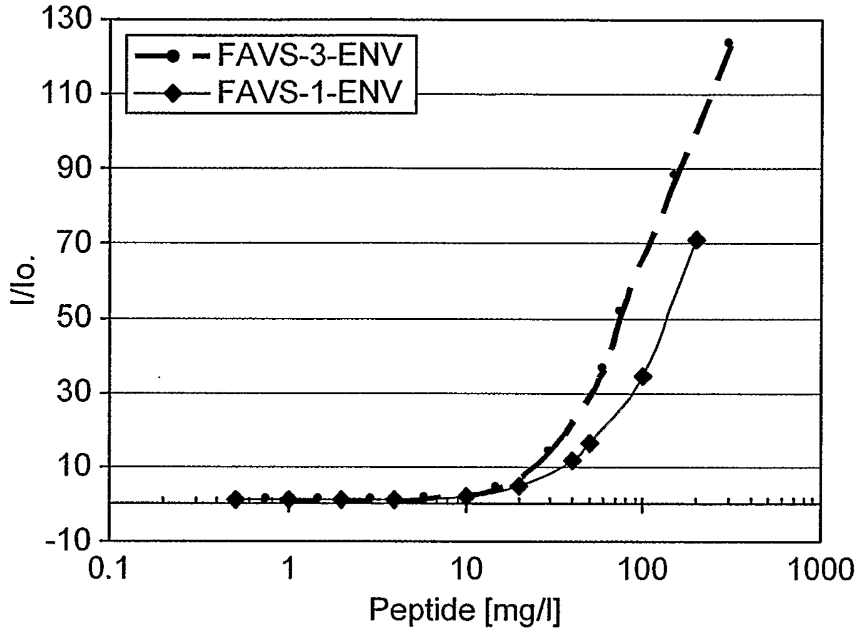

750.0
600.0
450.0
300.0
150.0
0.0
mV
Free peptide
-FAVS-1-ENV
-FAVS-3-ENV
3.0
6.0
9.0
12.0
15.0
18.0
21.0
24.0
27.0
30.0
Minutes

FIG. 2



Peptide	CMC (mg/l)	CMC (nmol/ml)
ENV	None	None
FAVS-1-ENV	15	1.6
FAVS-3-ENV	15	1.7

FIG. 3

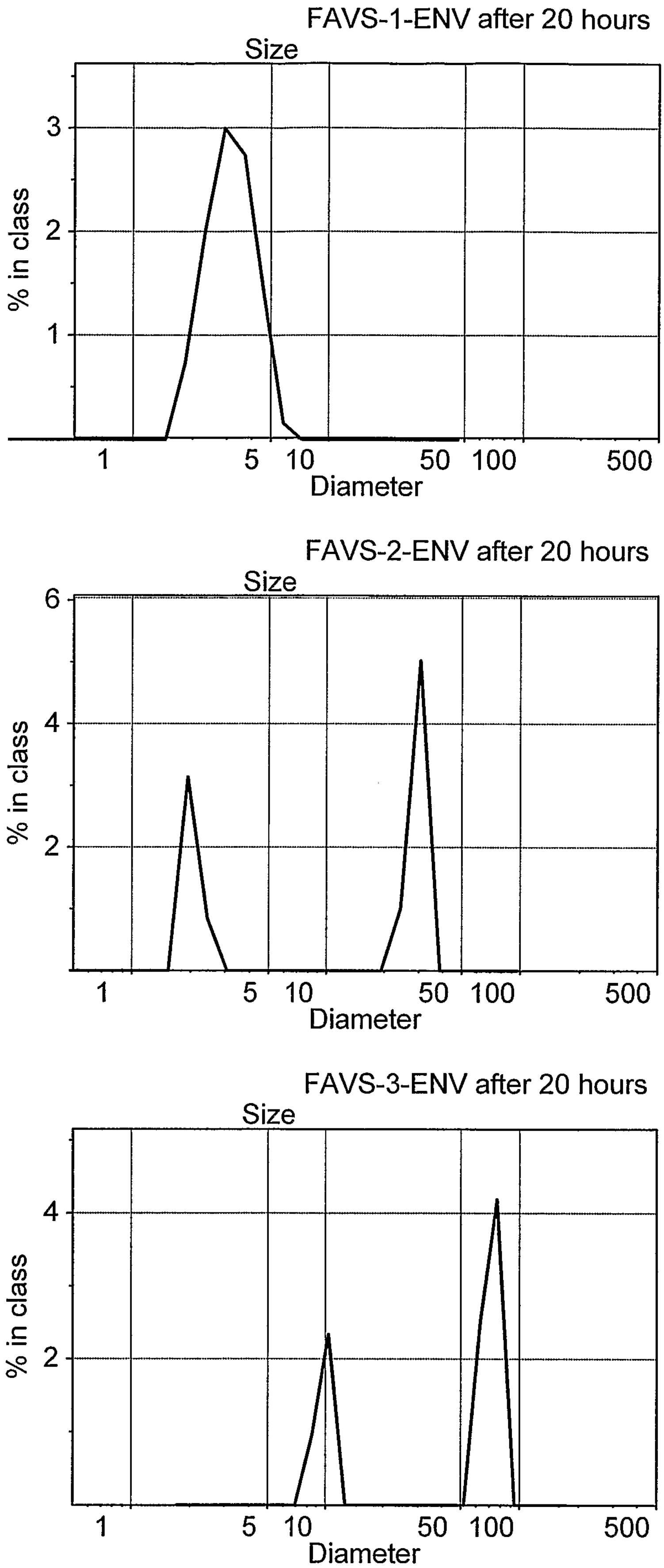

FAVS-1-ENV after 20 hours
Size
% in class
Diameter
FAVS-2-ENV after 20 hours
Size
% in class
Diameter
FAVS-3-ENV after 20 hours
Size
% in class
Diameter

FIG. 4

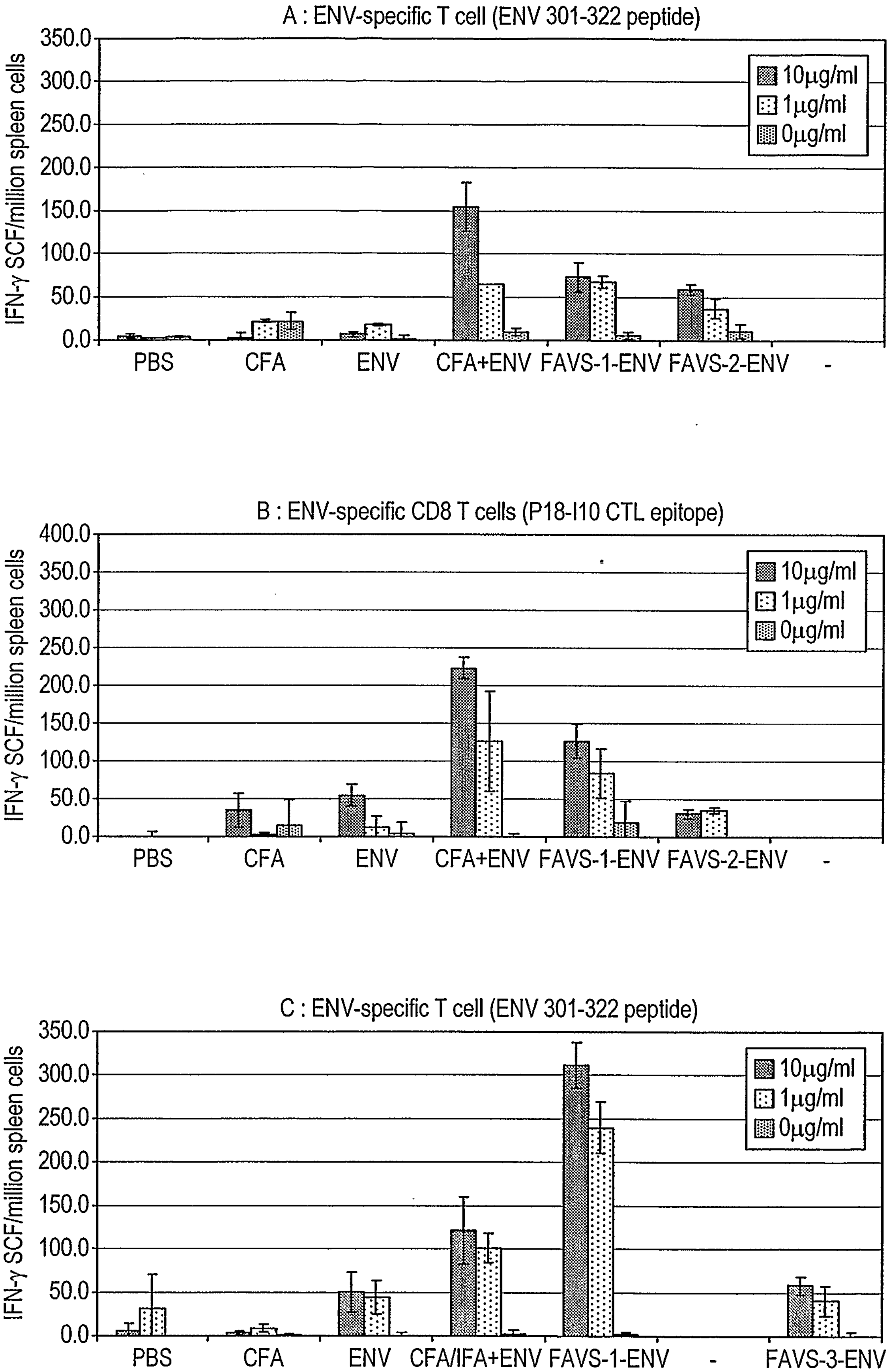
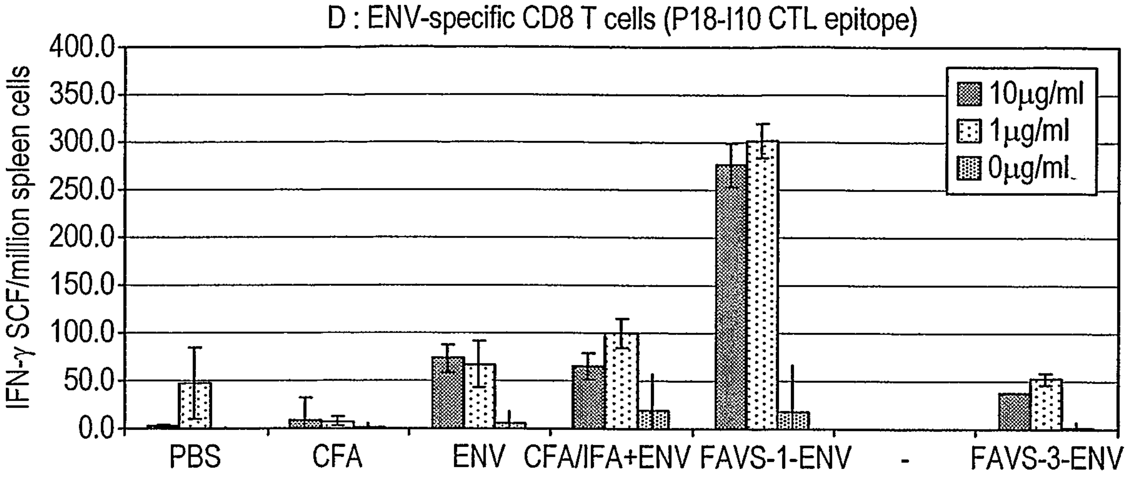
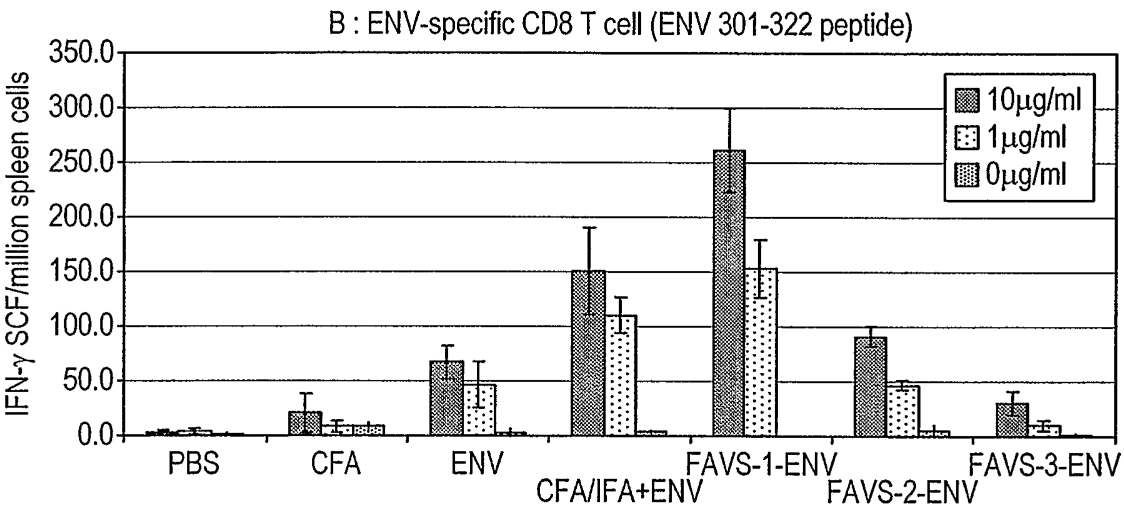

A : ENV-specific T cell (ENV 301-322 peptide)
IFN-γ SCF/million spleen cells
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
10μg/ml
1μg/ml
0μg/ml
PBS
CFA
ENV
CFA+ENV
FAVS-1-ENV
FAVS-2-ENV
-
B : ENV-specific CD8 T cells (P18-I10 CTL epitope)
IFN-γ SCF/million spleen cells
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
10μg/ml
1μg/ml
0μg/ml
PBS
CFA
ENV
CFA+ENV
FAVS-1-ENV
FAVS-2-ENV
-
C : ENV-specific T cell (ENV 301-322 peptide)
IFN-γ SCF/million spleen cells
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
10μg/ml
1μg/ml
0μg/ml
PBS
CFA
ENV
CFA/IFA+ENV
FAVS-1-ENV
-
FAVS-3-ENV

FIG. 5


D : ENV-specific CD8 T cells (P18-I10 CTL epitope)
IFN-γ SCF/million spleen cells
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
10μg/ml
1μg/ml
0μg/ml
PBS
CFA
ENV
CFA/IFA+ENV
FAVS-1-ENV
-
FAVS-3-ENV


B : ENV-specific CD8 T cell (ENV 301-322 peptide)
IFN-γ SCF/million spleen cells
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
10μg/ml
1μg/ml
0μg/ml
PBS
CFA
ENV
CFA/IFA+ENV
FAVS-1-ENV
FAVS-2-ENV
FAVS-3-ENV

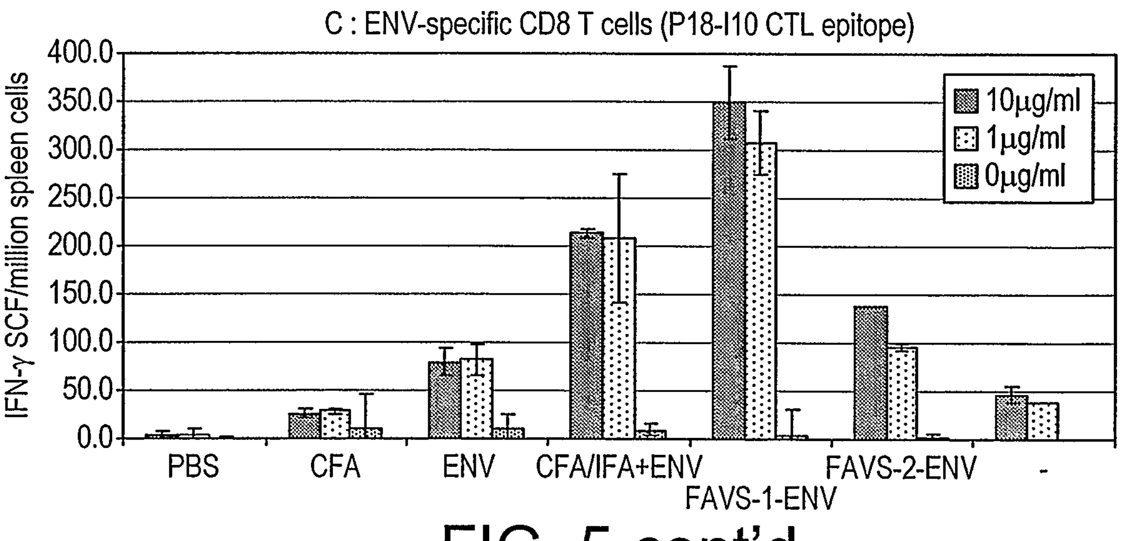

C : ENV-specific CD8 T cells (P18-I10 CTL epitope)
IFN-γ SCF/million spleen cells
400.0
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
10μg/ml
1μg/ml
0μg/ml
PBS
CFA
ENV
CFA/IFA+ENV
FAVS-1-ENV
FAVS-2-ENV
-

FIG. 5 cont'd

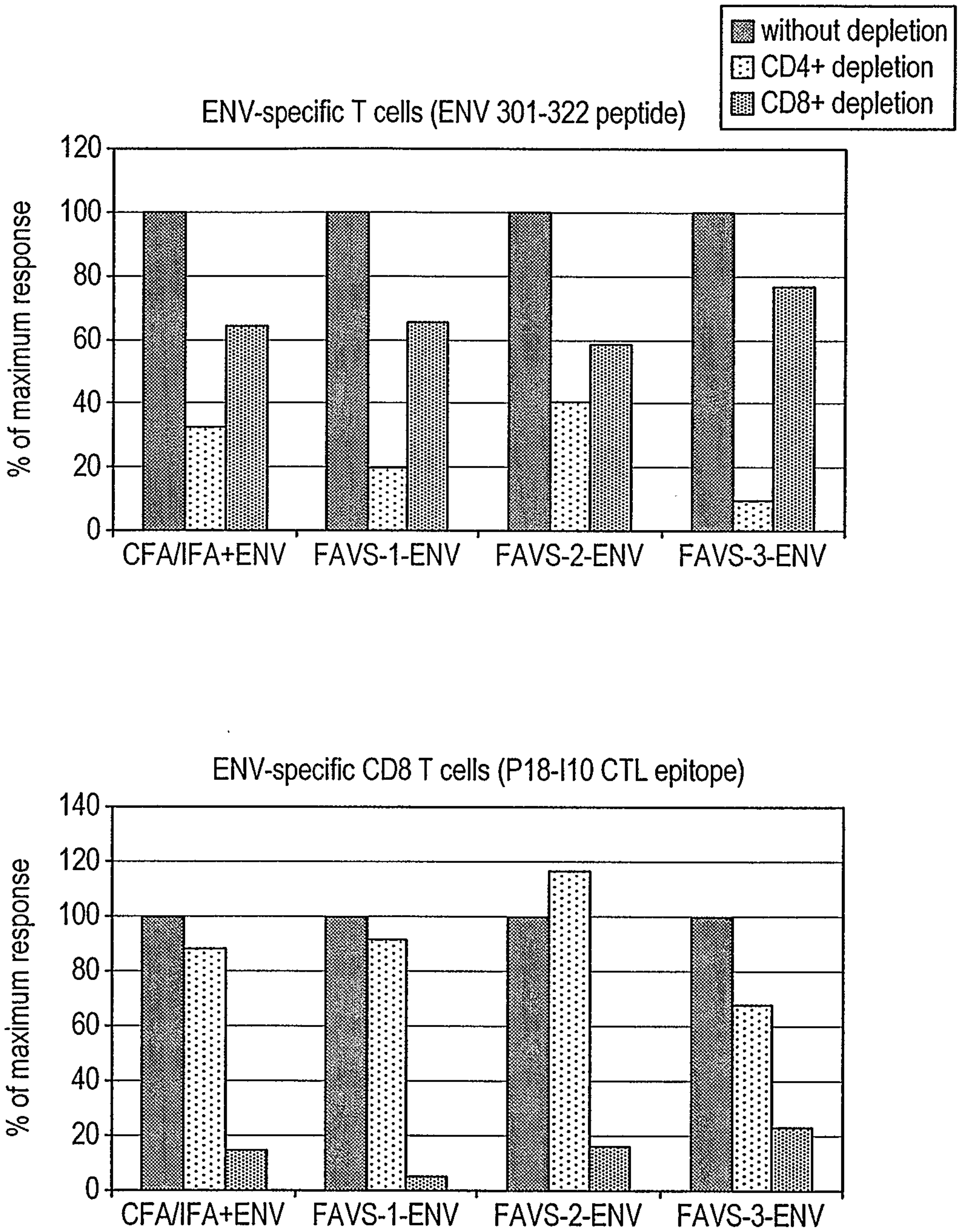
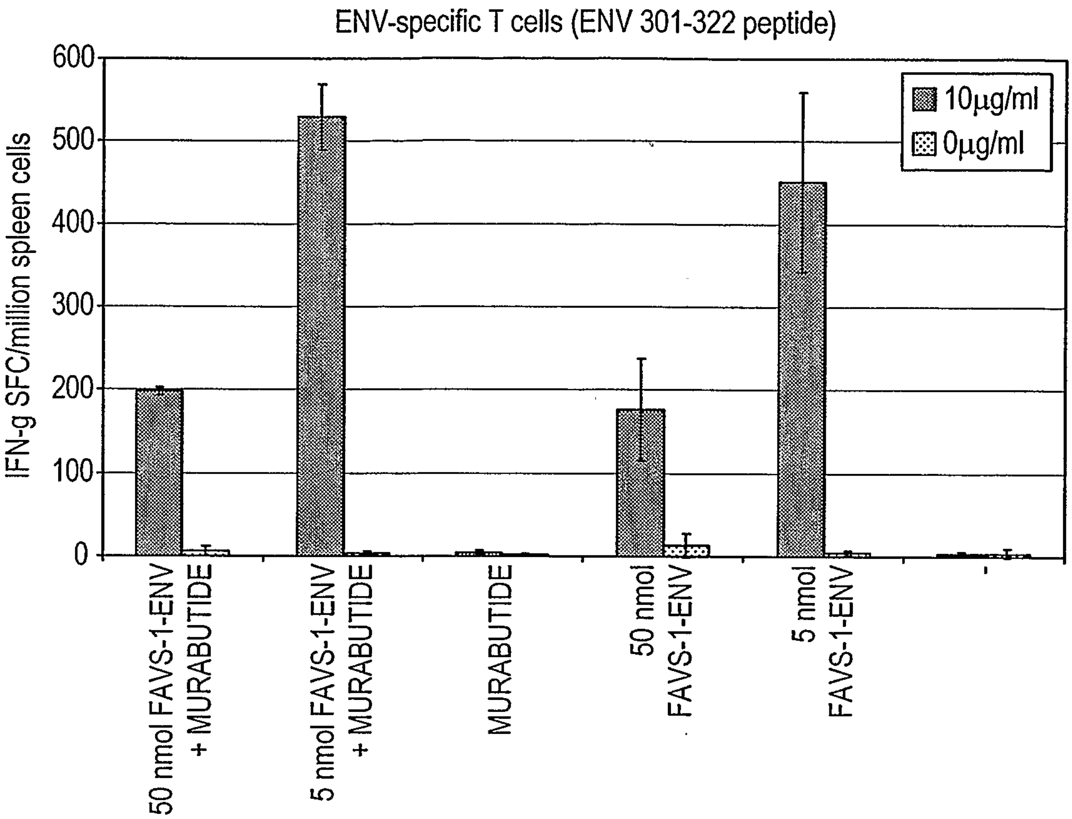

without depletion
CD4+ depletion
CD8+ depletion
ENV-specific T cells (ENV 301-322 peptide)
% of maximum response
0
20
40
60
80
100
120
CFA/IFA+ENV
FAVS-1-ENV
FAVS-2-ENV
FAVS-3-ENV
ENV-specific CD8 T cells (P18-I10 CTL epitope)
% of maximum response
0
20
40
60
80
100
120
140
CFA/IFA+ENV
FAVS-1-ENV
FAVS-2-ENV
FAVS-3-ENV

FIG. 6


ENV-specific T cells (ENV 301-322 peptide)
IFN-g SFC/million spleen cells
600
500
400
300
200
100
0
10µg/ml
0µg/ml
50 nmol FAVS-1-ENV + MURABUTIDE
5 nmol FAVS-1-ENV + MURABUTIDE
MURABUTIDE
50 nmol FAVS-1-ENV
5 nmol FAVS-1-ENV
-

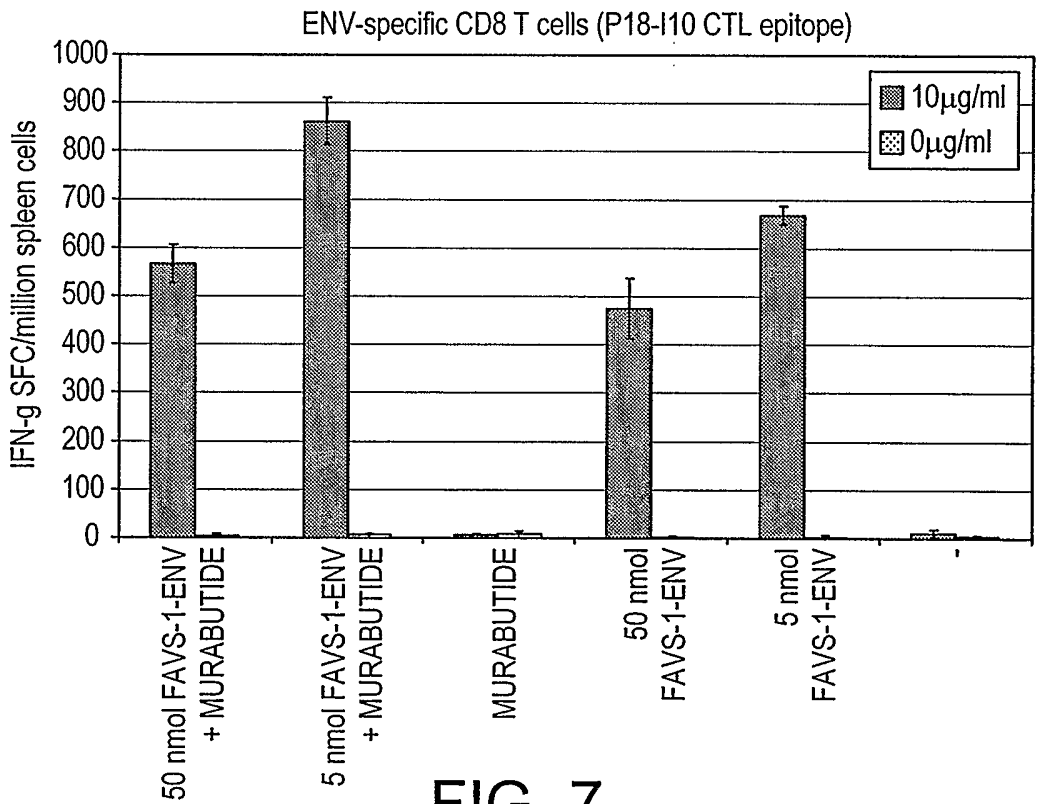

ENV-specific CD8 T cells (P18-I10 CTL epitope)
IFN-g SFC/million spleen cells
1000
900
800
700
600
500
400
300
200
100
0
10µg/ml
0µg/ml
50 nmol FAVS-1-ENV + MURABUTIDE
5 nmol FAVS-1-ENV + MURABUTIDE
MURABUTIDE
50 nmol FAVS-1-ENV
5 nmol FAVS-1-ENV
-

FIG. 7

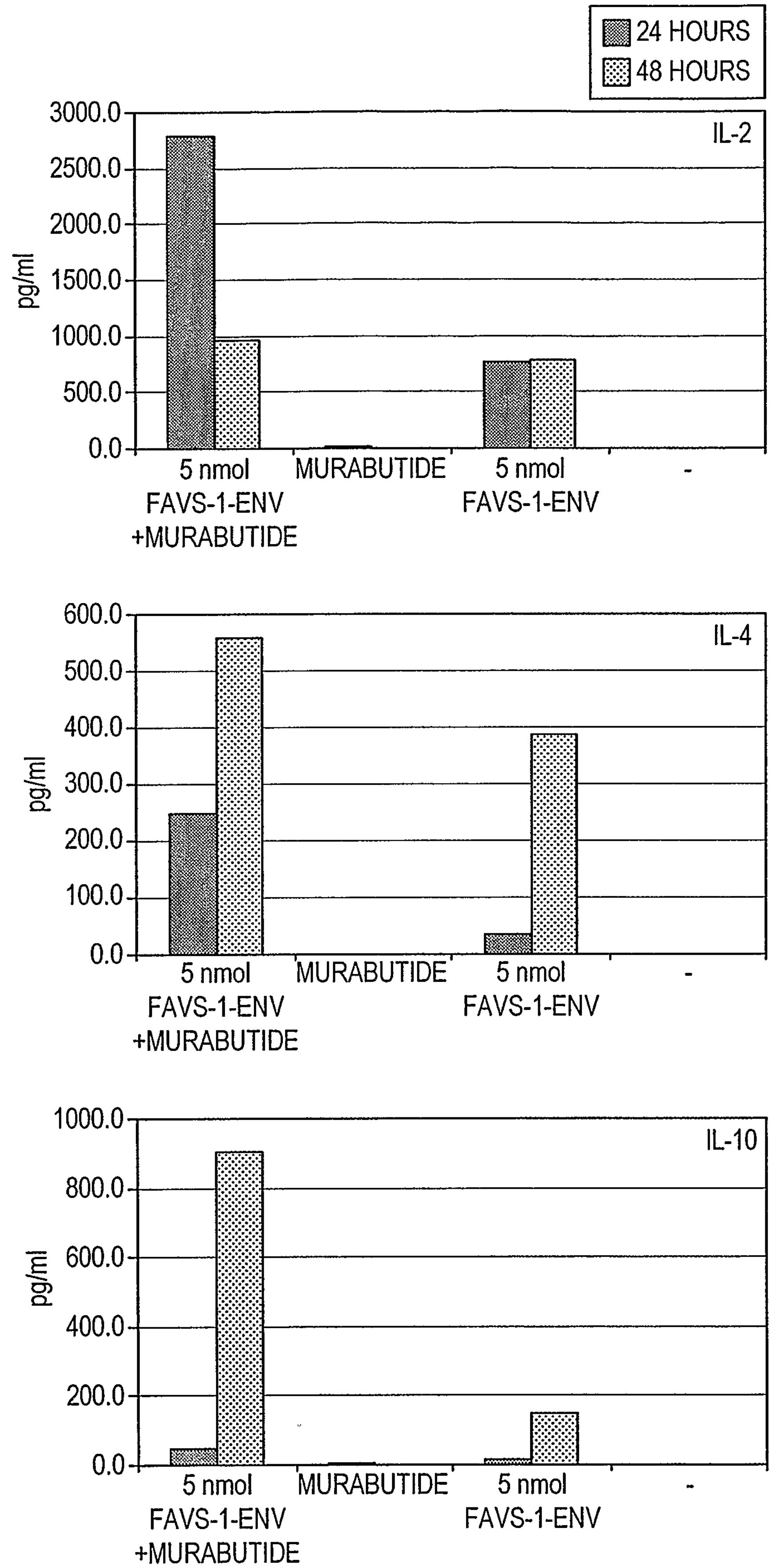

24 HOURS
48 HOURS
3000.0
2500.0
2000.0
1500.0
1000.0
500.0
0.0
pg/ml
IL-2
5 nmol FAVS-1-ENV +MURABUTIDE
MURABUTIDE
5 nmol FAVS-1-ENV
-
600.0
500.0
400.0
300.0
200.0
100.0
0.0
pg/ml
IL-4
5 nmol FAVS-1-ENV +MURABUTIDE
MURABUTIDE
5 nmol FAVS-1-ENV
-
1000.0
800.0
600.0
400.0
200.0
0.0
pg/ml
IL-10
5 nmol FAVS-1-ENV +MURABUTIDE
MURABUTIDE
5 nmol FAVS-1-ENV
-

FIG. 8

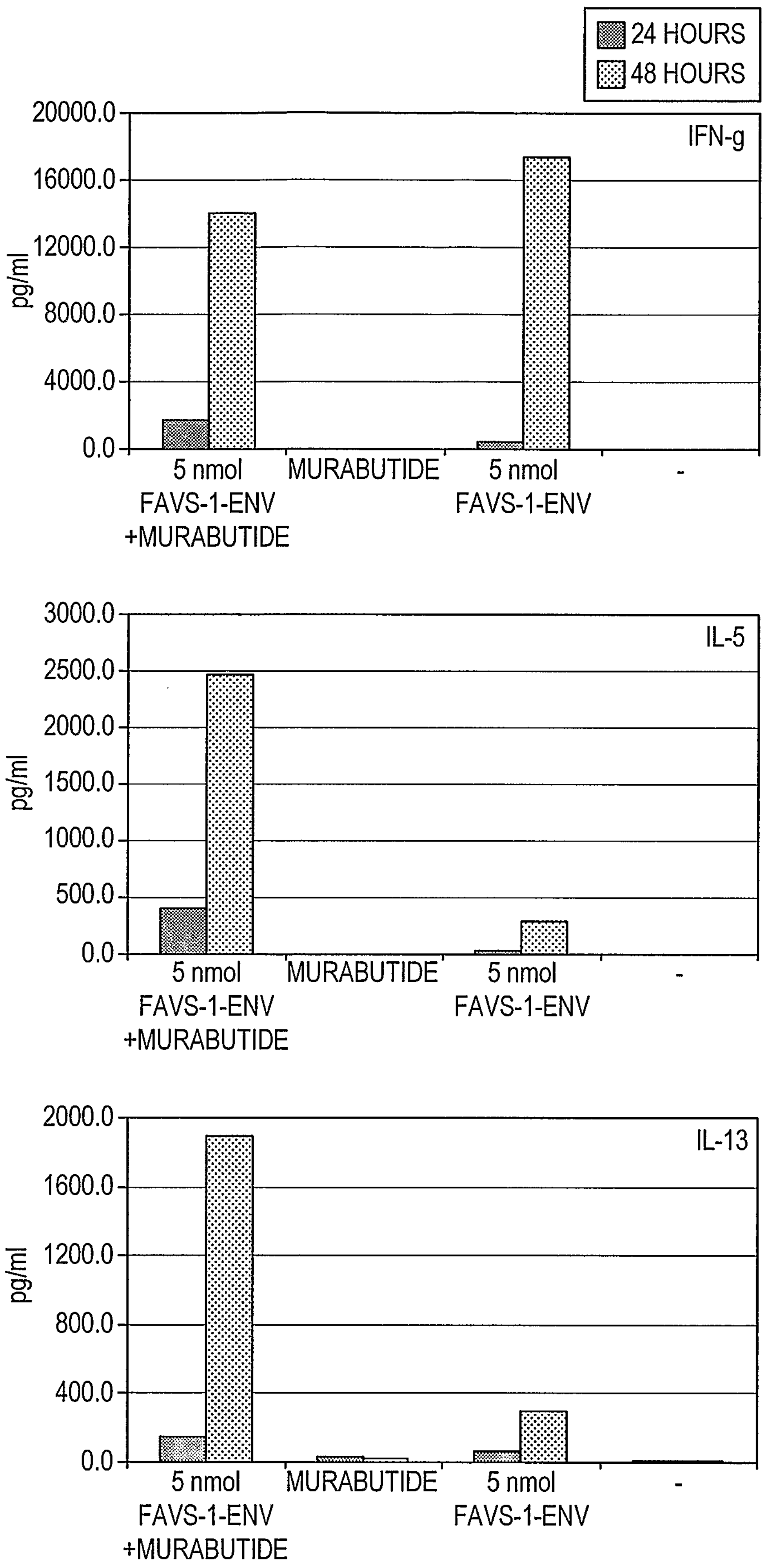

24 HOURS
48 HOURS
IFN-g
pg/ml
20000.0
16000.0
12000.0
8000.0
4000.0
0.0
5 nmol FAVS-1-ENV +MURABUTIDE
MURABUTIDE
5 nmol FAVS-1-ENV
-
IL-5
pg/ml
3000.0
2500.0
2000.0
1500.0
1000.0
500.0
0.0
5 nmol FAVS-1-ENV +MURABUTIDE
MURABUTIDE
5 nmol FAVS-1-ENV
-
IL-13
pg/ml
2000.0
1600.0
1200.0
800.0
400.0
0.0
5 nmol FAVS-1-ENV +MURABUTIDE
MURABUTIDE
5 nmol FAVS-1-ENV
-

FIG. 8 cont'd

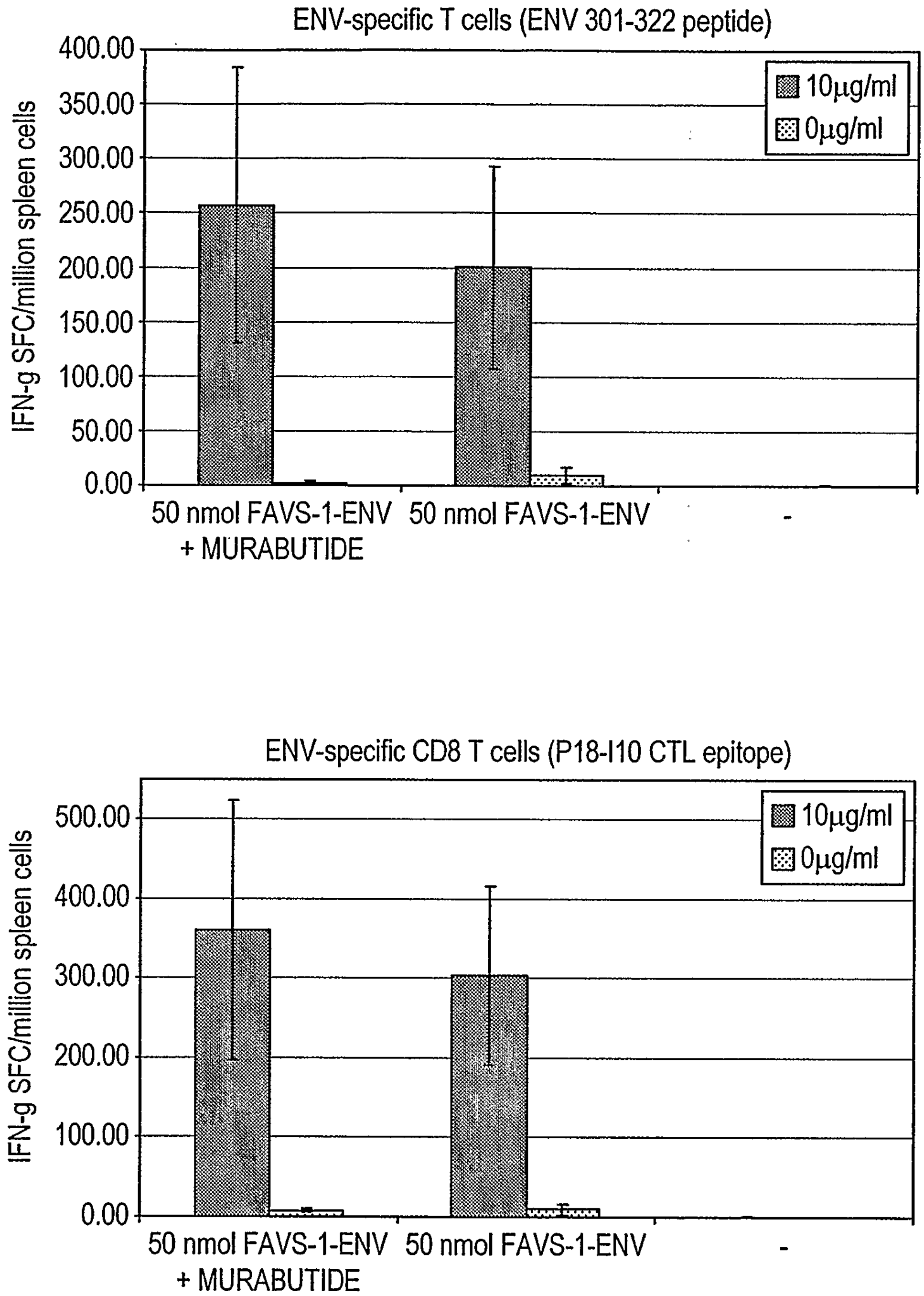

ENV-specific T cells (ENV 301-322 peptide)
IFN-g SFC/million spleen cells
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
10μg/ml
0μg/ml
50 nmol FAVS-1-ENV + MURABUTIDE
50 nmol FAVS-1-ENV
-
ENV-specific CD8 T cells (P18-I10 CTL epitope)
IFN-g SFC/million spleen cells
500.00
400.00
300.00
200.00
100.00
0.00
10μg/ml
0μg/ml
50 nmol FAVS-1-ENV + MURABUTIDE
50 nmol FAVS-1-ENV
-

FIG. 9