



(12) **DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION**

(13) **A1**

(86) Date de dépôt PCT/PCT Filing Date: 2018/02/22
(87) Date publication PCT/PCT Publication Date: 2018/08/30
(85) Entrée phase nationale/National Entry: 2019/08/20
(86) N° demande PCT/PCT Application No.: EP 2018/054427
(87) N° publication PCT/PCT Publication No.: 2018/154010
(30) Priorité/Priority: 2017/02/23 (EP17157687.9)

(51) Cl.Int./Int.Cl. *A61K 39/385* (2006.01),
A61P 37/04 (2006.01)
(71) Demandeur/Applicant:
ALPHA-O PEPTIDES AG, CH
(72) Inventeurs/Inventors:
KULANGARA, CAROLINE, CH;
PAULILLO, SARA MARIA, CH;
PIAZZA, MATTEO, GB;
RAMAN, SENTHIL KUMAR, CH;
BURKHARD, PETER, DE
(74) Agent: LAVERY, DE BILLY, LLP

(54) Titre : NANOPARTICULES DE PROTEINE A AUTO-ASSEMBLAGE ENCAPSULANT DES ACIDES NUCLEIQUES
IMMUNOSTIMULATEURS
(54) Title: SELF-ASSEMBLING PROTEIN NANOPARTICLES ENCAPSULATING IMMUNOSTIMULATORY NUCLEID
ACIDS

(57) **Abrégé/Abstract:**

The present invention relates to self-assembling protein nanoparticles encapsulating immunostimulatory nucleid acids. Furthermore, the invention relates to the use of such nanoparticles for vaccination.

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

(19) World Intellectual Property
Organization
International Bureau(10) International Publication Number
WO 2018/154010 A1(43) International Publication Date
30 August 2018 (30.08.2018)

(51) International Patent Classification:

A61K 39/385 (2006.01) A61P 37/04 (2006.01)

Published:

- with international search report (Art. 21(3))
- with sequence listing part of description (Rule 5.2(a))

(21) International Application Number:

PCT/EP2018/054427

(22) International Filing Date:

22 February 2018 (22.02.2018)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

17157687.9 23 February 2017 (23.02.2017) EP

(71) Applicant: ALPHA-O PEPTIDES AG [CH/CH]; Lör-racherstrasse 50, 4125 Riehen (CH).

(72) Inventors: KULANGARA, Caroline; Schwarzwaldallee 171, 4058 Basel (CH). PAULILLO, Sara Maria; Oltinger-strasse 53, 4055 Basel (CH). PIAZZA, Matteo; 106 Faulkner Street, Chester CH2 3BQ (GB). RAMAN, Senthil Kumar; Saint-Louis-Strasse 14, 4056 Basel (CH). BURKHARD, Peter; An der Halden 18, 79650 Schopfheim (DE).

(74) Agent: LATSCHA SCHÖLLHORN PARTNER AG; Austrasse 24, 4051 Basel (CH).

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

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

Declarations under Rule 4.17:

- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))

(54) Title: SELF-ASSEMBLING PROTEIN NANOPARTICLES ENCAPSULATING IMMUNOSTIMULATORY NUCLEIC ACIDS

(57) Abstract: The present invention relates to self-assembling protein nanoparticles encapsulating immunostimulatory nucleic acids. Furthermore, the invention relates to the use of such nanoparticles for vaccination.



WO 2018/154010 A1

Claims

1. A composition for inducing an immune response in a subject comprising:

(a) A self-assembling protein nanoparticle (SAPN) consisting of a multitude of building blocks of formula (I)

5 X1 – ND1 – L1 – ND2 – Y1 (I),

consisting of a continuous chain comprising a coiled-coil oligomerization domain ND1, a linker L1, a coiled-coil oligomerization domain ND2 and further substituents X1 and Y1, wherein

10 ND1 is a coiled-coil oligomerization domain that comprises oligomers (ND1)_m of m subunits ND1,

ND2 is a coiled-coil oligomerization domain that comprises oligomers (ND2)_n of n subunits ND2,

m and n each is a figure between 2 and 10, with the proviso that m is not equal n and not a multiple of n, and n is not a multiple of m,

15 L1 is a peptide linker with an overall positive charge of at least +2 at physiological conditions,

X1 is absent or a peptide or protein sequence comprising 1 to 1000 amino acids that may be further substituted.

20 Y1 is absent or a peptide or protein sequence comprising 1 to 1000 amino acids that may be further substituted,

wherein the multitude of building blocks of formula (I) is optionally co-assembled with a multitude of building blocks of formula (II)

X2 – ND3 – L2 – ND4 – Y2 (II),

25 consisting of a continuous chain comprising a coiled-coil oligomerization domain ND3, a linker L2, a coiled-coil oligomerization domain ND4, and further substituents X2 and Y2, wherein

ND3 is a coiled-coil oligomerization domain that comprises oligomers $(ND3)_y$ of y subunits ND3,

ND4 is a coiled-coil oligomerization domain that comprises oligomers $(ND4)_z$ of z subunits ND4,

5 y and z each is a figure between 2 and 10, with the proviso that y is not equal z and not a multiple of z , and z is not a multiple of y , and wherein

either ND3 is identical to ND1, or ND4 is identical to ND2 or both ND3 and ND4 are identical to ND1 and ND2, respectively,

10 L2 is a peptide linker with an overall positive charge of at least +2 at physiological conditions, X2 is absent or a peptide or protein sequence comprising 1 to 1000 amino acids that may be further substituted

Y2 is absent or a peptide or protein sequence comprising 1 to 1000 amino acids that may be further substituted,

15 (b) an immunostimulatory substance, wherein said immunostimulatory substance is a nucleic acid derivative wherein said nucleic acid derivative is encapsulated into said SAPN.

2. The composition according to claim 1 wherein the peptide linker L1 and/or the peptide linker L2 independently from each other consists of at least four amino acids and has an overall positive charge of at least +3 at physiological conditions.

20 3. The composition according to claim 1 wherein the peptide linker L1 and/or the peptide linker L2 independently from each other comprises an amino acid sequence selected from the group consisting of the amino acid sequence as shown in SEQ ID NO:4, the amino acid sequence as shown in SEQ ID NO:12, the amino acid sequence as shown in SEQ ID NO: 14 and the amino acid sequence as shown in SEQ ID NO: 15.

25 4. The composition according to any one of claims 1 to 3 wherein the nucleic acid derivative is selected from the group consisting of single-stranded DNA that contain a

cytosine followed by a guanine wherein the cytosine nucleotide is unmethylated, single-stranded RNA from RNA viruses, double-stranded RNA from RNA viruses and polymeric complexes mimicking double-stranded RNA from RNA viruses.

- 5 5. The composition according to any one of claims 1 to 3 wherein the nucleic acid derivative is a CpG oligodeoxynucleotide (CpG ODN) selected from the group consisting of Class A CpG ODN, Class B CpG ODN and Class C ODN.
- 10 6. The composition according to any one of claims 1 to 3 wherein the nucleic acid derivative is a CpG oligodeoxynucleotide (CpG ODN) selected from the group consisting of the nucleotide acid sequence as shown in SEQ ID NO:13, SEQ ID NO:39, SEQ ID NO:42, SEQ ID NO:43, SEQ ID NO:44, SEQ ID NO:45, SEQ ID NO:46, SEQ ID NO:47, SEQ ID NO:48 and SEQ ID NO:49.
7. The composition according to any one of claims 1 to 6 wherein the nucleic acid derivative is bound to the SAPN by ionic interactions.
- 15 8. The composition according to any one of claims 1 to 7 wherein the molar ratio of the protein chain of the SAPN consisting of a multitude of building blocks of formula (I) and the nucleic acid derivative is about 1 to about 0.6.
9. The composition according to any one of claims 1 to 8 wherein either ND1 and/or ND3 or ND2 and/or ND4 is a coiled coil selected from the group consisting of pentameric coiled coils, tetrameric coiled coils, trimeric coiled coils, and dimeric coiled coils.
- 20 10. The composition according to any one of claims 1 to 9 wherein either ND1 and/or ND3 or ND2 and/or ND4 is a pentameric coiled coil selected from the group consisting of 4PN8, 4PND, 4WBA, 3V2N, 3V2P, 3V2Q, 3V2R, 4EEB, 4EED, 3MIW, 1MZ9, 1FBM, 1VDF,

2GUV, 2HYN, 1ZLL, and 1T8Z, or wherein either ND1 and/or ND3 or ND2 and/or ND4 is a pentameric coiled coil selected from the group consisting of 4PN8, 4PND, 4WBA, 3V2N, 3V2P, 3V2Q, 3V2R, 4EEB, 4EED, 3MIW, 1MZ9, 1FBM, 1VDF, 2GUV, 2HYN, 1ZLL, and 1T8Z which contains an amino acid modification and/or is shortened at either
5 or both ends, wherein each coiled coil is indicated according to the pdb entry numbering of the RCSB Protein Data Bank (RCSB PDB).

11. The composition according to any one of claims 1 to 9 wherein either ND1 and/or ND3 or ND2 and/or ND4 is a tetrameric coiled coil selected from the group consisting of 5D60, 5D5Y, 5AL6, 4WB4, 4BHV, 4C5Q, 4GJW, 4H7R, 4H8F, 4BXT, 4LTO, 4LTP, 4LTQ, 4LTR, 3ZDO, 3RQA, 3R4A, 3R4H, 3TSI, 3K4T, 3F6N, 2O6N, 2OVC, 2O1J, 2O1K, 2AG3, 2CCE, 1YBK, 1U9F, 1U9G, 1U9H, 1USD, 1USE, 1UNT, 1UNU, 1UNV, 1UNW, 1UNX, 1UNY, 1UNZ, 1UO0, 1UO1, 1UO2, 1UO3, 1UO4, 1UO5, 1W5I, 1W5L, 1FE6, 1G1I, 1G1J, 1EZJ, 1RH4, and 1GCL, or wherein either ND1 and/or ND3 or ND2 and/or ND4 is a tetrameric coiled coil selected from the group consisting of 5D60, 5D5Y, 5AL6, 4WB4, 4BHV, 4C5Q, 4GJW, 4H7R, 4H8F, 4BXT, 4LTO, 4LTP, 4LTQ, 4LTR, 3ZDO, 3RQA, 3R4A, 3R4H, 3TSI, 3K4T, 3F6N, 2O6N, 2OVC, 2O1J, 2O1K, 2AG3, 2CCE, 1YBK, 1U9F, 1U9G, 1U9H, 1USD, 1USE, 1UNT, 1UNU, 1UNV, 1UNW, 1UNX, 1UNY, 1UNZ, 1UO0, 1UO1, 1UO2, 1UO3, 1UO4, 1UO5, 1W5I, 1W5L, 1FE6, 1G1I, 1G1J, 1EZJ, 1RH4, and 1GCL which contains an amino acid modification and/or is shortened
15 at either or both ends, wherein each coiled coil is indicated according to the pdb entry numbering of the RCSB Protein Data Bank (RCSB PDB).
20

12. The composition according to any one of claims 1 to 9 wherein either ND1 and/or ND3 or ND2 and/or ND4 is a trimeric coiled coil selected from the group consisting of 5TOH, 5TOI, 5K92, 5KB0, 5KB1, 5KB2, 5KKV, 5EFM, 2N64, 5ABS, 5IEA, 5APP, 5APQ, 5APS, 5APY, 5APZ, 5D5Z, 4YPC, 4YV3, 4CGB, 4CGC, 4CJD, 4R0R, 4UW0, 4P67, 4OXM, 3W8V, 3W92, 3W93, 4I2L, 4K8U, 4JBZ, 3VTQ, 4L1R, 4JDO, 4J4A, 4E52, 3VYI, 3ZMF, 3VU5, 3VU6, 2YNY, 2YNZ, 2YO0, 2YO1, 2YO2, 4G1A, 4GIF, 3TQ2, 4DZK, 4DZL, 4DZN, 3TE3, 3R48, 3SWF, 3SWY, 3PR7, 2YKO, 2YKP, 2YKQ, 3NTN, 3PP5, 3MKO, 3MGN, 3NWA, 3NWD, 3NWF, 3L35, 3L36, 3L37, 3M9B, 3M9D, 2X6P, 3LJM, 3AHA, 3H7X, 3H7Z, 3LT6, 3LT7, 3GJP, 2KP8, 3KPE, 2WPR, 2WPS, 2WPY, 2WPZ, 2WQ0,
25
30

2WQ1, 2WQ2, 2WQ3, 3HFC, 3HFE, 3HRN, 3HRO, 3H5F, 3H5G, 2WG5, 2WG6, 2W6B, 2JJL, 2VRS, 3EFG, 3DUZ, 2OT5, 2Z2T, 2QIH, 3BK6, 2O7H, 2R32, 2JGO, 2Q7C, 2Q3I, 2Q5U, 2IBL, 1ZV8, 1ZVB, 2FXP, 1WT6, 2AKF, 1TGG, 1SLQ, 1S9Z, 1PW9, 1PWB, 1M7L, 1GZL, 1KYC, 1KFM, 1KFN, 1IJ0, 1IJ1, 1IJ2, 1IJ3, 1HQJ, 1QU1, 1B08, 1CZQ, 1CUN, 1SVF, 1CE0, 1PIQ, 1AQ5, 1AVY, 1HTN, 1AA0, 1ZIJ, 1ZIM, 1COI, 1SWI, 1GCM, and 1HUP, or wherein either ND1 and/or ND3 or ND2 and/or ND4 is a trimeric coiled coil selected from the group consisting of 5TOH, 5TOI, 5K92, 5KB0, 5KB1, 5KB2, 5KKV, 5EFM, 2N64, 5ABS, 5IEA, 5APP, 5APQ, 5APS, 5APY, 5APZ, 5D5Z, 4YPC, 4YV3, 4CGB, 4CGC, 4CJD, 4R0R, 4UW0, 4P67, 4OXM, 3W8V, 3W92, 3W93, 4I2L, 4K8U, 4JBZ, 3VTQ, 4L1R, 4JDO, 4J4A, 4E52, 3VYI, 3ZMF, 3VU5, 3VU6, 2YNY, 2YNZ, 2YO0, 2YO1, 2YO2, 4G1A, 4GIF, 3TQ2, 4DZK, 4DZL, 4DZN, 3TE3, 3R48, 3SWF, 3SWY, 3PR7, 2YKO, 2YKP, 2YKQ, 3NTN, 3PP5, 3MKO, 3MGN, 3NWA, 3NWD, 3NWF, 3L35, 3L36, 3L37, 3M9B, 3M9D, 2X6P, 3LJM, 3AHA, 3H7X, 3H7Z, 3LT6, 3LT7, 3GJP, 2KP8, 3KPE, 2WPR, 2WPS, 2WPY, 2WPZ, 2WQ0, 2WQ1, 2WQ2, 2WQ3, 3HFC, 3HFE, 3HRN, 3HRO, 3H5F, 3H5G, 2WG5, 2WG6, 2W6B, 2JJL, 2VRS, 3EFG, 3DUZ, 2OT5, 2Z2T, 2QIH, 3BK6, 2O7H, 2R32, 2JGO, 2Q7C, 2Q3I, 2Q5U, 2IBL, 1ZV8, 1ZVB, 2FXP, 1WT6, 2AKF, 1TGG, 1SLQ, 1S9Z, 1PW9, 1PWB, 1M7L, 1GZL, 1KYC, 1KFM, 1KFN, 1IJ0, 1IJ1, 1IJ2, 1IJ3, 1HQJ, 1QU1, 1B08, 1CZQ, 1CUN, 1SVF, 1CE0, 1PIQ, 1AQ5, 1AVY, 1HTN, 1AA0, 1ZIJ, 1ZIM, 1COI, 1SWI, 1GCM, and 1HUP which contains an amino acid modification and/or is shortened at either or both ends, wherein each coiled coil is indicated according to the pdb entry numbering of the RCSB Protein Data Bank (RCSB PDB).

13. The composition according to any one of claims 1 to 9 wherein either ND1 and/or ND3 or ND2 and/or ND4 is a dimeric coiled coil selected from the group consisting of 5M97, 5M9E, 5FIY, 5F4Y, 5D3A, 5HMO, 5EYA, 5IX1, 5IX2, 5JHF, 5JVM, 5JVP, 5JVR, 5JVS, 5JVU, 5JX1, 5FCN, 5HHE, 2N9B, 4ZRY, 4Z6Y, 4YTO, 4ZI3, 5AJS, 5F3K, 5F5R, 5HUZ, 5DJN, 5DJO, 5CHX, 5CJ0, 5CJ1, 5CJ4, 5C9N, 5CFF, 4WHV, 3WUT, 3WUU, 3WUV, 4ZQA, 4XA3, 4XA4, 4PXJ, 4YVC, 4YVE, 5BML, 5AL7, 4WOT, 4CG4, 5AMO, 4WII, 4WIK, 4RSJ, 4CFG, 4R3Q, 4WID, 4CKG, 4CKH, 4NSW, 4W7P, 4QQ4, 4OJK, 4TL1, 4OH9, 4LPZ, 4Q62, 4L2W, 4M3L, 4CKM, 4CKN, 4N6J, 4LTB, 4LRZ, 2MAJ, 2MAK, 4NAD, 4HW0, 4BT8, 4BT9, 4BTA, 4HHD, 4M8M, 4J3N, 4L6Q, 4C1A, 4C1B, 4GDO,

4BWK, 4BWP, 4BWX, 4HU5, 4HU6, 4L9U, 4G0U, 4G0V, 4G0W, 4L3I, 4G79, 4GEU,
4GEX, 4GFA, 4GFC, 4BL6, 4JMR, 4JNH, 2YMY, 4HAN, 3VMY, 3VMZ, 3VN0, 4ABX,
3W03, 2LW9, 4DZM, 4ETO, 3TNU, 3THF, 4E8U, 3VMX, 4E61, 3VEM, 3VBB, 4DJG,
3TV7, 3STQ, 3V8S, 3Q8T, 3U1C, 3QH9, 3AZD, 3ONX, 3OKQ, 3QX3, 3SJA, 3SJB,
5 3SJC, 2L2L, 3QFL, 3QKT, 2XV5, 2Y3W, 3Q0X, 3AJW, 3NCZ, 3NI0, 2XU6, 3M91,
3NMD, 3LLL, 3LX7, 3ME9, 3MEU, 3MEV, 3ABH, 3ACO, 3IAO, 3HLS, 2WMM, 3A6M,
3A7O, 2WVR, 3ICX, 3ID5, 3ID6, 3HNW, 3I1G, 2K6S, 3GHG, 3G1E, 2W6A, 2V51,
3ERR, 3E1R, 2VY2, 2ZR2, 2ZR3, 3CL3, 3D9V, 2Z17, 2JEE, 3BBP, 3BAS, 3BAT,
2QM4, 2V71, 2NO2, 2PON, 2V0O, 2DQ0, 2DQ3, 2Q2F, 2NRN, 2E7S, 2H9V, 2FXM,
10 2HJD, 2GZD, 2GZH, 2FV4, 2F2U, 2EUL, 2ESM, 2ETK, 2ETR, 1ZXA, 1YIB, 1YIG,
1XSX, 1RFY, 1U0I, 1XJA, 1T3J, 1T6F, 1R7J, 1UII, 1PL5, 1S1C, 1P9I, 1R48, 1URU,
1OV9, 1UIX, 1NO4, 1NYH, 1MV4, 1LR1, 1L8D, 1LJ2, 1KQL, 1G XK, 1GXL, 1GK6, 1JR5,
1GMJ, 1JAD, 1JCH, 1JBG, 1JTH, 1JY2, 1JY3, 1IC2, 1HCI, 1HF9, 1HBW, 1FXK, 1D7M,
1QUU, 1CE9, 2A93, 1BM9, 1A93, 1TMZ, 2AAC, 1ZII, 1ZIK, 1ZIL, 2ARA, 2ARC, 1JUN,
15 1YSA, and 2ZTA, or wherein either ND1 and/or ND3 or ND2 and/or ND4 is a dimeric
coiled coil selected from the group consisting of 5M97, 5M9E, 5FIY, 5F4Y, 5D3A,
5HMO, 5EYA, 5IX1, 5IX2, 5JHF, 5JVM, 5JVP, 5JVR, 5JVS, 5JVU, 5JX1, 5FCN, 5HHE,
2N9B, 4ZRY, 4Z6Y, 4YTO, 4ZI3, 5AJS, 5F3K, 5F5R, 5HUZ, 5DJN, 5DJO, 5CHX, 5CJ0,
5CJ1, 5CJ4, 5C9N, 5CFF, 4WHV, 3WUT, 3WUU, 3WUV, 4ZQA, 4XA3, 4XA4, 4PXJ,
20 4YVC, 4YVE, 5BML, 5AL7, 4WOT, 4CG4, 5AMO, 4WII, 4WIK, 4RSJ, 4CFG, 4R3Q,
4WID, 4CKG, 4CKH, 4NSW, 4W7P, 4QQ4, 4OJK, 4TL1, 4OH9, 4LPZ, 4Q62, 4L2W,
4M3L, 4CKM, 4CKN, 4N6J, 4LTB, 4LRZ, 2MAJ, 2MAK, 4NAD, 4HW0, 4BT8, 4BT9,
4BTA, 4HHD, 4M8M, 4J3N, 4L6Q, 4C1A, 4C1B, 4GDO, 4BWK, 4BWP, 4BWX, 4HU5,
4HU6, 4L9U, 4G0U, 4G0V, 4G0W, 4L3I, 4G79, 4GEU, 4GEX, 4GFA, 4GFC, 4BL6,
25 4JMR, 4JNH, 2YMY, 4HAN, 3VMY, 3VMZ, 3VN0, 4ABX, 3W03, 2LW9, 4DZM, 4ETO,
3TNU, 3THF, 4E8U, 3VMX, 4E61, 3VEM, 3VBB, 4DJG, 3TV7, 3STQ, 3V8S, 3Q8T,
3U1C, 3QH9, 3AZD, 3ONX, 3OKQ, 3QX3, 3SJA, 3SJB, 3SJC, 2L2L, 3QFL, 3QKT,
2XV5, 2Y3W, 3Q0X, 3AJW, 3NCZ, 3NI0, 2XU6, 3M91, 3NMD, 3LLL, 3LX7, 3ME9,
3MEU, 3MEV, 3ABH, 3ACO, 3IAO, 3HLS, 2WMM, 3A6M, 3A7O, 2WVR, 3ICX, 3ID5,
30 3ID6, 3HNW, 3I1G, 2K6S, 3GHG, 3G1E, 2W6A, 2V51, 3ERR, 3E1R, 2VY2, 2ZR2,
2ZR3, 3CL3, 3D9V, 2Z17, 2JEE, 3BBP, 3BAS, 3BAT, 2QM4, 2V71, 2NO2, 2PON,
2V0O, 2DQ0, 2DQ3, 2Q2F, 2NRN, 2E7S, 2H9V, 2FXM, 2HJD, 2GZD, 2GZH, 2FV4,
2F2U, 2EUL, 2ESM, 2ETK, 2ETR, 1ZXA, 1YIB, 1YIG, 1XSX, 1RFY, 1U0I, 1XJA, 1T3J,

- 1T6F, 1R7J, 1UII, 1PL5, 1S1C, 1P9I, 1R48, 1URU, 1OV9, 1UIX, 1NO4, 1NYH, 1MV4, 1LR1, 1L8D, 1LJ2, 1KQL, 1GXK, 1GXL, 1GK6, 1JR5, 1GMJ, 1JAD, 1JCH, 1JBG, 1JTH, 1JY2, 1JY3, 1IC2, 1HCI, 1HF9, 1HBW, 1FXK, 1D7M, 1QUU, 1CE9, 2A93, 1BM9, 1A93, 1TMZ, 2AAC, 1ZII, 1ZIK, 1ZIL, 2ARA, 2ARC, 1JUN, 1YSA, and 2ZTA, which contains an amino acid modification and/or is shortened at either or both ends, wherein each coiled coil is indicated according to the pdb entry numbering of the RCSB Protein Data Bank (RCSB PDB).
- 5
14. The composition according to any one of claims 1 to 13 wherein the multitude of building blocks of formula (I) is co-assembled with a multitude of building blocks of formula (II) and the co-assembled SAPN comprising a multitude of building blocks of formula (I) and a multitude of building blocks of formula (II) has a co-assembly ratio of about 48 to about 59 of the continuous chain comprising a building block of formula (I) to about 1 to about 12 of the continuous chain comprising a building block of formula (II).
- 10
15. The composition according to any one of claims 1 to 14 for use in a method of vaccinating a human or non-human animal, the method comprising administering an effective amount of said composition to a human or non-human animal in need of such vaccination.
- 15