Claims:

1. A composition, comprising a first population of mesoporous silica particles and a viral vector.

2. The composition of claim 1, wherein the viral vector is conjugated to the first population of mesoporous silica particles.

3. The composition of claim 2, wherein the viral vector is electrostatically or covalently conjugated to the first population of mesoporous silica particles.

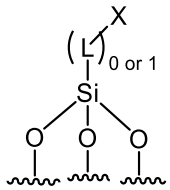
4. The composition of claim 2, wherein the first population of mesoporous silica particles are surface modified.

5. The composition of claim 4, wherein the surface modification on the first population of mesoporous silica particles comprises a primary, secondary, tertiary, or quaternary amine.

6. The composition of claim 4 or 5, wherein the the surface modification on the first population of mesoporous silica particles comprises a polyethyleneimine.

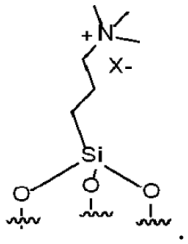
7. The composition of claim 5 or 6, wherein the polyethyleneimine or primary, secondary, tertiary, or quaternary amine is separated from the silica surface by a linker.

8. The composition of any one of claims 4-6, wherein the general structure of the surface modifications is as follows:



wherein L is a linker, and X is the primary, secondary, tertiary, or quaternary amine or polyethyleneimine.

9. The composition of any one of claims 4-8, wherein the surface modification on the first population of mesoporous silica particles comprises the following structure:



10. The composition of any one of claims 4-9, wherein the surface modification on the first population of mesoporous silica particles comprises:

(i) trimethylammonium;

(ii) N,N,N-trimethylpropan-1-ammonium; or

(iii) –OH (hydroxyl), amine, carboxylic acid, phosphonate, halide, azide, alkyne, epoxide, sulfhydryl, polyethyleneimine, a hydrophobic moiety, or salts thereof, optionally using a C_1 to C_{20} alkyl or $(-O(CH2-CH_2-)_{1-25}$ linker.

11. The composition of any one of claims 1-10, wherein the first population of mesoporous silica particles is covalently modified on their surface with a trialkoxysilyl compound or a trihydroxysilyl compound.

12. The composition of any one of claims 4-11, wherein the surface modification on the first population of mesoporous silica particles comprises a polyethyleneimine having an average molecular weight of about 1000 to 20,000 Da, about 1,200 to 15,000 Da, about 1,500 to 12,000 Da, about 2,000 Da, about 3,000 Da, about 4,000 Da, about 5,000 Da, about 6,000 Da, about 7,000 Da, about 8,000 Da, about 9,000 Da, or about 10,000 Da, as measured by gel permeation chromatography (GPC).

13. The composition of any one of the preceding claims, wherein:

(a) the mesoporous silica particles comprise pores of between 2-50 nm in diameter;

(b) the mesoporous silica particles have a surface area of at least about 100 m^2/g;

(c) the composition is suitable for injectable use.

14. The composition of any one of the preceding claims, wherein the viral vector is a retrovirus, adenovirus, adeno-associated virus, herpes virus, or lentivirus.

15. The composition of any one of the preceding claims, wherein the viral vector comprises an expression control sequence operatively linked to a nucleotide sequence.

16. The composition of claim 15, wherein the nucleotide sequence encodes:

(i) a chimeric antigen receptor (CAR), an engineered TCR, one or more cytokines, one or more chemokines a polypeptide which targets a tumor antigen; or

(ii) an shRNA to block an inhibitory molecule or an mRNA to induce expression of a protein.

17. The composition of claim 16, wherein the CAR comprises an antigen binding domain, a transmembrane domain, a costimulatory signaling region, and a signaling domain.

18. The composition of claim 17, wherein:

(i) the antigen binding domain binds a tumor antigen; and/or

(ii) the signaling domain is a CD3 zeta signaling domain.

19. The composition of any one of claims 16-18, wherein the tumor antigen is selected from TSHR, CD19, CD123, CD22, CD30, CD171, CS-1, CLL-1, CD33, EGFRvIII , GD2, GD3, BCMA, Tn Ag, PSMA, ROR1, FLT3, FAP, TAG72, CD38, CD44v6, CEA, EPCAM, B7H3, KIT, IL-13Ra2, Mesothelin, IL-11Ra, PSCA, PRSS21, VEGFR2, LewisY, CD24, PDGFR-beta, SSEA-4, CD20, Folate receptor alpha, ERBB2 (Her2/neu), MUC1, EGFR, NCAM, Prostase, PAP, ELF2M, Ephrin B2, IGF-I receptor, CAIX, LMP2, gp100, bcr-abl, tyrosinase, EphA2, Fucosyl GM1, sLe, GM3, TGS5, HMWMAA, o-acetyl-GD2, Folate receptor beta, TEM1/CD248, TEM7R, CLDN6, GPRC5D, CXORF61, CD97, CD179a, ALK, Polysialic acid, PLAC1, GloboH, NY-BR-1, UPK2, HAVCR1, ADRB3, PANX3, GPR20, LY6K, OR51E2, TARP, WT1, NY-ESO-1, LAGE-1a, MAGE-A1, legumain, HPV E6,E7, MAGE A1, ETV6-AML, sperm protein 17, XAGE1, Tie 2, MAD-CT-1, MAD-CT-2, Fos-related antigen 1, p53,

p53 mutant, prostein, survivin and telomerase, PCTA-1/Galectin 8, MelanA/MART1, Ras mutant, hTERT, sarcoma translocation breakpoints, ML-IAP, ERG (TMPRSS2 ETS fusion gene), NA17, PAX3, Androgen receptor, Cyclin B1, MYCN, RhoC, TRP-2, CYP1B1, BORIS, SART3, PAX5, OY-TES1, LCK, AKAP-4, SSX2, RAGE-1, human telomerase reverse transcriptase, RU1, RU2, intestinal carboxyl esterase, mut hsp70-2, CD79a, CD79b, CD72, LAIR1, FCAR, LILRA2, CD300LF, CLEC12A, BST2, EMR2, LY75, GPC3, FCRL5, IGLL1, or a combination thereof.

20. The composition of any one of the preceding claims, further comprising:

(i) a T cell stimulating compound or tumor antigen; and/or

(ii) a cytokine.

21. The composition of claim 20, wherein the T cell stimulating compound or the tumor antigen is IL-2, IL-15, anti-CD2 mAb, anti-CD3 mAb, anti-CD28 mAb, neo-antigen peptides peptides from shared antigens such as TRP2, gp100, tumor cell lysate, CD19, CD20, CD22, ROR1, mesothelin, CD33/IL3Ra, c-Met, PSMA, Glycolipid F77, EGFRvIII, GD-2, NY-ESO-1 TCR, MAGE A3 TCR, or combinations thereof.

22. The composition of any one of claims 1-21, which further comprises a second population of mesoporous silica particles.

23. The composition of claim 22, wherein the T cell stimulating compound or tumor antigen is conjugated to or adsorbed:

(i) on the first population of mesoporous silica particles or the second population of mesoporous silica particles; or

(ii) to a lipid envelope on the surface of the second population of mesoporous silica particles.

24. The composition of any one of claims 20-23, wherein the cytokine:

(i) is conjugated to or adsorbed on the first or second population of mesoporous silica particles; and/or

(ii) is IL-1, IL-2, IL-4, IL-5, IL-7, IL-10, IL-12, IL-15, IL-17, IL-21, or transforming growth factor beta (TGF-β), or an agonist thereof, a mimetic thereof, a variant thereof, a functional fragment thereof, or a combination thereof.

25. A method comprising contacting T lymphocytes with the composition of any one of claims 1-24.

26. The method of claim 25, wherein the method further comprises contacting the T lymphocytes with a T cell stimulating compound or tumor antigen.

27. The method of claim 25 or 26, wherein the contacting occurs *in vitro* or *in vivo.*

28. The method of any one of claims 25-27, wherein the method further comprises activating the T lymphocytes by contacting the T lymphocytes with a T cell stimulating compound or tumor antigen.

29. A method of expanding a T lymphocyte population, comprising

(a) contacting the T lymphocyte population with the composition of any one of claims 1-24; and

(b) contacting the T lymphocyte population with a T cell stimulating compound or tumor antigen.

30. The method of claim 28 or 29, wherein the T cell stimulating compound or tumor antigen is IL-2, IL-15, anti-CD2 mAb, anti-CD3 mAb, anti-CD28 mAb, neo-antigen peptides, CD19, CD20, CD22, ROR1, mesothelin, CD33/IL3Ra, c-Met, PSMA, Glycolipid F77, EGFRvIII, GD-2, NY-ESO-1 TCR, MAGE A3 TCR, or combinations thereof.

31. The method of any one of claims 28-30, wherein the T cell stimulating compound or tumor antigen is conjugated to or adsorbed:

(i) on the first population of mesoporous silica particles or a second population of mesoporous silica particles; and/or

(ii) to a lipid envelope on the surface of a second population of mesoporous silica particles.

32. The method of any one of claims 25-31, further comprising contacting the T lymphocytes with a cytokine; optionally, wherein the cytokine is IL-1, IL-2, IL-4, IL-5, IL-7, IL-10, IL-12, IL-15, IL-17, IL-21, or transforming growth factor beta (TGF-β), or an agonist thereof, a mimetic thereof, a variant thereof, a functional fragment thereof, or a combination thereof.

33. A pharmaceutical composition comprising the composition of any one of claims 1-24, and a pharmaceutically acceptable excipient.

34. Use of the composition of any one of claims 1-24 or the pharmaceutical composition of claim 33, in the manufacture of a medicament for treating a subject having a disease, disorder, or condition associated with a tumor antigen.

35. The use of claim 34, wherein the disease, disorder, or condition associated with a tumor antigen is a cancer.