Claims

1. A nanoparticle complex comprising:

a) a nanoparticle core having a diameter from 1 nm to 50 nm and a biodegradable coating on the outer surface of the nanoparticle core;

b) costimulatory complexes operatively coupled to the nanoparticle core, wherein the co-stimulatory complexes comprise a co-stimulatory molecule that targets a receptor selected from one or more of IL-15/IL-15Ra, or CD28, or is a costimulatory molecule selected from B7.1, 4-IBBL, CD40, CD80, CD86, or ICOS; and

c) 10 to 500 antigen/MHC complexes operatively coupled to the nanoparticle core or the biodegradable coating, wherein the antigen is a cancer or tumor-relevant specific antigen,

wherein the ratio of co-stimulatory complexes to the antigen/MHC complexes on the nanoparticle core is from about 0.1:1 to about 50:1 and wherein the biodegradable coating optionally comprises one or more of dextran, mannitol, or poly(ethylene glycol).

2. The nanoparticle complex of claim 1, wherein the co-stimulatory complexes operatively coupled to the nanoparticle core are identical or different.

3. The nanoparticle complex of claims 1 or 2, wherein the MHC molecule of the antigen/MHC complex is MHC class I or class. II.

4. The nanoparticle complex of any of claims 1-3, wherein the MHC class I comprises all or part of a HLA-A, HLA-B, HLA-C, HLA-E, HLA-F, HLA-G, or CD1 protein.

5. The nanoparticle complex of any of claims 1-3, wherein the MHC class I comprises all or part of a HLA-A*0201 protein.

6. The nanoparticle complex of any of claims 1-3, wherein the MHC class II component comprises all or part of a HLA-DR, HLA-DQ, or HLA-DP protein.

7. The nanoparticle complex of any of claims 1-6, wherein a plurality of identical or non-identical antigen epitopes are contained in the antigen/MHC complexes.

8. The nanoparticle complex of claim 7, wherein the plurality of identical or nonidentical antigen epitopes are derived from a single antigen or a plurality of antigens.

9. The nanoparticle complex of any of claims 1-8, wherein the nanoparticle core comprises one or more of a metal, a metal oxide, a metal sulfide, a metal selenide, a magnetic material, a polymer, gold, iron, or iron oxide.

10. The nanoparticle complex of claim 9, wherein the nanoparticle core comprises one or more of gold, iron, or iron oxide.

11. The nanoparticle complex of any of claims 1-10, wherein the nanoparticle core is biocompatible and/or bioabsorbable.

12. The nanoparticle complex of any of claims 1-11, wherein the co-stimulatory complexes and/or the MHC molecule of the antigen/MHC complexes are covalently coupled to the nanoparticle core or the biodegradable coating.

13. The nanoparticle complex of claim 12, wherein the co-stimulatory complexes and/or the MHC of the antigen/MHC complexes are covalently coupled to the nanoparticle core or the biodegradable coating via a linker.

14. The nanoparticle complex of claim 13, wherein the linker comprises ethylene glycol.

15. The nanoparticle complex of any of claims 1-12, wherein the co-stimulatory molecule complexes and/or the MHC of the antigen/MHC complexes are operatively coupled to the nanoparticle core or the biodegradable coating via one or more of a dimer, trimer, and/or a dimer of a dimer.

16. Use of the nanoparticle complex of any of claims 1-15, in the preparation of a medicament for treating a tumor or cancer in a subject, expanding and/or developing populations of antigen-specific anti-tumorigenic T cells in a subject, for inhibiting a growth of a tumor in a patient, or for inhibiting a metastasis of a cancer in a patient.

17. The nanoparticle complex of any of claims 1-15, for use in treating a tumor or cancer in a subject, expanding and/or developing populations of antigen-specific anti-tumorigenic T cells in a subject, inhibiting a growth of a tumor in a patient, or inhibiting a metastasis of a cancer in a patient.

18. The use of claim 16 or the nanoparticle complex for the use of claim 17, wherein the expanded population of anti-tumorigenic T cells are antigen-specific anti-tumorigenic memory T cells, circulating antigen-specific CD8+ T cells and/or CD4+ T cells.

19. The use or the nanoparticle complex for the use of any of claims 16-18, wherein the antigen-specific anti-tumorigenic T cells are CD8+ T cells.

20. The use or the nanoparticle complex for the use of any of claims 16-18, wherein the antigen-specific anti-tumorigenic T cells are CD4+ T cells.

21. The use or the nanoparticle complex for the use of any of claims 16-20, wherein the tumor is a cancerous tumor.

22. A pharmaceutical composition comprising the nanoparticle complex of any of claims 1-15.

23. An in vitro method to monitor the expansion of a population of antigen-specific anti-tumorigenic T cells, the method comprising:

- providing a sample from a subject administered with an effective amount of the high density nanoparticle complex of any of claims 1-15, wherein the subject is suspected of containing the population of anti-tumorigenic T cells;

–contacting the sample with an effective amount of a tetramer complex comprising the antigen-MHC complexes; and

–detecting and quantifying the number of anti-tumorigenic inflammatory cells bound to the tetramer complex.