[0005] The carbohydrate-modified particles disclosed herein are relatively small and have an effective average diameter within a microscale or a nanoscale. Specifically, the carbohydrate-modified particles may be referred to as "carbohydrate-enhanced nanoparticles" or "CENPs." The particles are modified via attachment of one or more carbohydrate moieties at the surface of the particles. Preferably, the particles are modified via covalent attachment of one or more carbohydrate moieties at the surface of the particles. The carbohydrate moieties may be attached directly to the surface of the particles or via one or more linker molecules. The carbohydrate moieties preferably function as immune modulators, for example, modulators that induce immune tolerance.

[0005a] In one aspect, there is provided carbohydrate-modified particles, the particles comprising a biodegradable polymeric base material having an effective average diameter of 0.01-500 μm and a carbohydrate moiety that is an immune modulator covalently attached at the surface of the particles.

[0006] The disclosed particles of the compositions and formulations preferably are biodegradable and are formed from a polymeric base material. In some embodiments, the particles comprise polymeric base material formed from carbohydrate monomers or pre-polymers.

[0007] In addition to the carbohydrate moiety, the disclosed carbohydrate-modified particles may include additional components for modulating an immune response. In particular, the disclosed carbohydrate-modified particles may include an antigen, for example, a peptide, polypeptide, or protein that is utilized as an antigen and administered to a subject in order to desensitize the subject to the antigen and or to induce tolerance in the subject. Suitable antigens for inclusion in the disclosed carbohydrate-modified particle may include autoantigens associated with autoimmune disease (*e.g.*, peptides, polypeptides, or proteins that are associated with autoimmune disease). Suitable antigens may include autoantigens associated with type 1 diabetes (T1D). Suitable antigens also may include antigens associated with allergic reactions (*i.e.*, allergens).

[0008] The disclosed particles may be prepared by methods that include one or more of the following steps: (a) screening a library of carbohydrate moieties for immune-modulator activity by contacting the library with an immune cell and measuring the effect of the library on stimulating the immune cell (*e.g.*, by measuring cytokine production over baseline and in particular IL-10, TGFβ, and/or CCL4 production versus IL-6 production); (b) selecting a

carbohydrate moiety based on its effect on stimulating the immune cell; and (c) attaching the carbohydrate moiety thus selected to particles formed from a polymeric base material, preferably by covalently attaching the carbohydrate moiety to the surface of particles formed from a biodegradable polymeric base material.

[0008a] In another aspect, there is provided a method for preparing the particles disclosed herein, the method comprising one or more of the following steps:

(a) screening a library of carbohydrate moieties for immune modulator activity by contacting the library with an immune cell and measuring the effect of the library on stimulating the immune cell;

(b) selecting a carbohydrate moiety based on its effect on stimulating the immune cell; and

(c) attaching the carbohydrate moiety to particles formed from a polymeric base material.

[0009] The disclosed particles may be formulated as a composition for modulating an immune response. In another aspect, there is provided a pharmaceutical composition comprising the particles disclosed herein together with a suitable carrier, excipient, or diluent. As such, the compositions may be administered to a subject in need thereof in order to induce an immune response, which may include but is not limited to desensitizing the subject and/or inducing tolerance in the subject. The compositions may be administered to treat and/or prevent diseases and disorders associated with autoimmune responses or to treat and/or prevent allergic reactions. The composition may be administered to treat and/or prevent transplant rejection.

[0009a] In another aspect, there is provided use of the composition disclosed herein in the manufacture of a medicament for treating a disease or disorder in a subject in need thereof.

BRIEF DESCRIPTION OF THE DRAWING

[0010] Figure 1 illustrates that in vitro stimulation (LPS) of macrophage by PLGA particles (PP) does not enhance IL-10 while EDC-cells (EDC SP) does enhance IL-10.

[0011] Figure 2 illustrates a strategy for high throughput screening of carbohydrate compounds for induction of cytokine production by macrophage.

[0012] Figure 3A and 3B illustrate induction heat-maps for up-regulation or down-regulation of IL-10 response as determined using a high throughput screen as illustrated in Figure 2.

[0013] Figure 4 illustrates chemical coupling reactions for adding L-fucose to PLGA nanoparticles.

[0014] Figure 5 illustrates that fucosylated PLGA (F-CENP) promote a stronger IL-10 induction than PLGA alone, EDC-cells, or free L-fucose.

[0015] Figure 6 illustrates immunological mechanisms of sensitization and tolerance.

12. Use of the composition of claim 11 in the manufacture of a medicament for treating a disease or disorder in a subject in need thereof.

13. The use of claim 12, wherein the subject has or is at risk for developing an immune disease or disorder.

14. The use of claim 13, wherein the immune disease or disorder is an allergic reaction and the method induces tolerance in the subject.

15. The use of claim 13, wherein the immune disease or disorder is an autoimmune disease or disorder.

16. The use of claim 15, wherein the immune disease or disorder is diabetes mellitus type 1.

17. A method for preparing the particles of claim 1, the method comprising one or more of the following steps:

(a) screening a library of carbohydrate moieties for immune modulator activity by contacting the library with an immune cell and measuring the effect of the library on stimulating the immune cell;
(b) selecting a carbohydrate moiety based on its effect on stimulating the immune cell; and
(c) attaching the carbohydrate moiety to particles formed from a polymeric base material.

18. The method of claim 17, wherein measuring the effect of the library on stimulating the immune cell comprising measuring cytokine production.

19. The method of claim 18, wherein measuring cytokine production comprises measuring IL-10 production over baseline and measuring IL-6 production over baseline, and selecting a carbohydrate moiety based on its effect on stimulating the immune cell comprises selected a carbohydrate moiety that increases IL-10 secretion over baseline while not changing IL-6 secretion or while decreasing IL-6 secretion.