## Claims

What is claimed is:

1. A method for preparing a neutral, stable and transparent photocatalytic titanium dioxide sol, comprising the steps of:

(1) reacting a hydrous titanium dioxide gel with an alkaline peptizing agent to provide a peptized alkaline titanium dioxide sol; and

(2) neutralizing the peptized alkaline titanium dioxide sol with an acid comprising phosphoric acid to obtain a neutral, stable and transparent photocatalytic titanium dioxide sol.

2. The method of claim 1, wherein the alkaline peptizing agent is selected from the group consisting of an alkylamine, a quarternary ammonium hydroxide, and combinations thereof, for example:

i) the alkylamine is diethyl amine; or

ii) the quaternary ammonium hydroxide is tetramethyl ammonium hydroxide.

3. The method of claim 2, wherein the alkaline peptizing agent is present in the neutral, stable and transparent photocatalytic titanium dioxide sol in an amount of at least about 7 wt%, based on the combined weight of the alkaline peptizing agent and titanium dioxide.

4. The method of claim 2, wherein the alkaline peptizing agent is present in the neutral, stable and transparent photocatalytic titanium dioxide sol in an amount of at least about 18wt%, based on the combined weight of the alkaline peptizing agent and titanium dioxide.

5. The method of claim 2, wherein the peptized alkaline titanium dioxide sol is neutralized with a combination of phosphoric acid and acetic acid, optionally:

the weight ratio of the phosphoric acid to the acetic acid is in the range of from about 0.8:1 to about 1.2:1; and

the phosphoric acid and the acetic acid are substantially simultaneously added to the peptized alkaline titanium dioxide sol.

6. The method of any one of claims 2 to 5, wherein the neutral, stable and transparent photocatalytic titanium dioxide sol comprises in the range of from about 0.5 to about 20 wt% titanium dioxide, or the neutral, stable and transparent photocatalytic titanium dioxide sol comprises in the range of from about 30 to about 40 wt% titanium dioxide, and optionally:

the neutral, stable and transparent photocatalytic titanium dioxide sol comprises titanium dioxide crystallites having an average particle size of less than about 50 nm, at least 90% of which are in the anatase form.

7. The method of any one of claims 1 to 6, wherein the neutral, stable and transparent photocatalytic titanium dioxide sol is doped with a metal, wherein the metal is selected from the group consisting of Ag, Zn, Mg, Sn, Fe, Co, Ni, Se, Ce, Cu and combinations thereof.

8. The method of any one of claims 1 to 7, wherein the neutral, stable and transparent photocatalytic titanium dioxide sol is washed with demineralized water such that the concentration of calcium ions is less than about 71 ppm and the concentration of sodium ions is less than about 13 ppm in the resulting washed neutral, stable and transparent photocatalytic titanium dioxide sol, and wherein the filtrate conductivity is equal to or less than 500 μS, and wherein the viscosity of the washed neutral, stable and transparent photocatalytic titanium dioxide sol is less than about 100 centipoise after at least 4 weeks at room temperature.

9. A method for preparing a neutral, stable and transparent photocatalytic titanium dioxide sol, comprising:

(1) precipitating hydrous titanium dioxide from a solution having a titanium containing compound therein to form titanium dioxide particles;

(2) forming a dispersion of the titanium dioxide particles in a liquid medium;

(3) treating the dispersion with an alkaline peptizing agent to obtain a peptized alkaline titanium dioxide sol; and

(4) neutralizing the peptized alkaline titanium dioxide sol with an acid comprising phosphoric acid to obtain a neutral, stable and transparent photocatalytic titanium dioxide sol.

10. The method of claim 9, wherein:

the titanium containing compound is selected from the group consisting of titanium alkoxide, titanium oxychloride, titanium sulfate, titanium oxynitrate, titanyl acetylacetonate, and combinations thereof, or

the titanium containing compound comprises titanium sulfate, and the method further comprising the step of treating a solution of the titanium sulfate with an ion-exchange resin to de-ionize the solution prior to using the solution of the titanium sulfate in the step of precipitating the hydrous titanium dioxide.

11. The method of claim 9 or 10, wherein the titanium containing compound is treated with a basic chelating agent prior to precipitating the hydrous titanium dioxide, wherein the basic chelating agent is selected from the group consisting of dialkanolamine, trialkanolamine and combinations thereof.

12. The method of any one of claims to 11, wherein:

the alkaline peptizing agent is selected from the group consisting of a mono-, di-, and trialkylamine, or

the alkaline peptizing agent is selected from the group consisting of tert-butylamine, triethylamine, diethylamine, isopropylamine, diisopropyl-ethylamine, isobutylamine, isoamylamine and combinations thereof, or

the alkaline peptizing agent comprises a quaternary ammonium hydroxide.

13. The method of any one of claims 9 to 12, wherein the acid further comprises acetic acid, and wherein the neutral, stable and transparent photocatalytic titanium dioxide sol comprises titanium dioxide crystallites having an average particle size of less than about 10 nm, at least 90% of which are in the anatase form.

14. A method of improving deNOx properties of an item, the method comprising preparing a neutral, stable and transparent photocatalytic titanium dioxide sol by:

(1) reacting a hydrous titanium dioxide gel with an alkaline peptizing agent to provide a peptized alkaline titanium dioxide sol;

(2) neutralizing the peptized alkaline titanium dioxide sol with an acid comprising phosphoric acid to obtain the neutral, stable and transparent photocatalytic titanium dioxide sol; and

(3) at least partially coating the item with the neutral, stable and transparent photocatalytic titanium dioxide sol.

~~14. A neutral, stable and transparent photocatalytic titanium dioxide sol formed according to claim 2 and doped with a metal, wherein the metal is selected from the group consisting of Ag, Zn, Mg, Sn, Fe, Co, Ni, Se, Ce, Cu and combinations thereof.~~

~~15. A neutral, stable and transparent photocatalytic titanium dioxide sol formed according to claim 2, wherein the alkaline titanium dioxide sol is peptized with an alkaline peptizing agent selected from the group consisting of an alkylamine, a quaternary ammonium hydroxide and combinations thereof, thereby forming a peptized alkaline titanium dioxide sol which is neutralized by an acid comprising phosphoric acid, and optionally~~

- ~~the peptized alkaline titanium dioxide sol is neutralized by an acid comprising phosphoric acid and acetic acid, or~~
- ~~the neutral, stable and transparent photocatalytic titanium dioxide sol has in the range of from about 0.5 to about 20 wt% titanium dioxide, or~~
- ~~the neutral, stable and transparent photocatalytic titanium dioxide sol has in the range of from about 30 to about 40 wt% titanium dioxide, or~~
- ~~a washed neutral, stable and transparent photocatalytic titanium dioxide sol is formed by washing the neutral, stable and transparent photocatalytic titanium dioxide sol with demineralized water such that the concentration of calcium ions is less than about 71 ppm and the concentration of sodium ions is less than about 13 ppm in the washed neutral, stable and transparent photocatalytic titanium dioxide sol, wherein the washed neutral, stable and transparent photocatalytic titanium dioxide sole has a viscosity which is less than about 100 centipoise after at least 4 weeks at room temperature.~~

~~16. A structure with a titanium dioxide-containing layer, comprising: a substrate; and a substantially anatase titanium dioxide-containing layer on the surface of the substrate, wherein~~

the transparency of the titanium dioxide-containing layer at visible light wavelength of 400-700 nm is from about 65% to about 95% and the titanium dioxide-containing layer is formed from a neutral, stable and transparent photocatalytic titanium dioxide sol made according to any one of claims 1 to 13, wherein the thickness of the titanium dioxide-containing layer is about 0.1-1.5 μm, and optionally wherein an initial amount of NOx removal from air in proximity to the titanium dioxide-containing layer is at least about 80% .

17. A method of improving the deNOx properties of an item; wherein the item is at least partially coated with a neutral, stable and transparent photocatalytic titanium dioxide sol produced according to the method of any one of claims 1 to 13.

18. An anti-bacterial composition comprising: a neutral, stable and transparent photocatalytic titanium dioxide sol produced according to the method of any one of claims 1 to 13; wherein the anti-bacterial composition, when placed in contact with bacteria, kills at least 80% of the bacteria, or kills at least 90% of the bacteria.

19. The anti-bacterial composition of claim 18, wherein the photocatalytic antibacterial activity of the anti-bacterial composition, when placed in contact with the bacteria, is at least about 2; wherein the photocatalytic antibacterial activity is determined in accordance with the formula: $\log(B_L / C_L) - \log(B_D / C_D)$; and wherein $B_L$ = mean bacterial count on a control surface not coated with the anti-bacterial composition after X hours light exposure; $C_L$ = mean bacterial count on a test surface coated with the anti bacterial composition after X hours light exposure; Bd = mean bacterial count on a control surface not coated with the anti-bacterial composition after X hours darkness; $C_D$ = mean bacterial count on a test surface coated with the anti-bacterial composition after X hours darkness; and X ranges from about 14 to about 24 hours.

20. The antibacterial composition of claim 19, wherein the photocatalytic anti-bacterial activity of the anti-bacterial composition, when placed in contact with the bacteria, is at least about 3.

21. An item comprising: a device; and a coating on at least a portion of the surface of the device, wherein the coating comprises the anti-bacterial composition of any one of claims 18 to 20, for example, the device is a medical device.