Summary

~~According to a first aspect, t~~There is provided a method for forming a titania-coated inorganic particle comprising the steps of (a) stirring a mixture of a titania precursor and an inorganic particle in an organic solvent for a time period of more than 1 hour to cause adsorption of the titania precursor on the surface of the inorganic particle; and (b) adding water to the mixture under stirring to convert the titania precursor to titania which then forms a coating on the inorganic particle.

According to ~~a second~~ one aspect, there is provided a method for forming a paint formulation, comprising the steps of (a) stirring a mixture of a titania precursor and an inorganic particle in an organic solvent for a time period of more than 1 hour to cause adsorption of said titania precursor on the surface of said inorganic particle; (b) adding water to the mixture under stirring to convert said titania precursor to titania which then forms a coating on said inorganic particle; (c) separating the titania-coating inorganic particle from the mixture; and (d) adding said titania-coating inorganic particle to a paint formulation.

The disclosed method of forming the titania-coated inorganic particle is distinguished from the physical method of the prior art in which discrete titania (or titanium dioxide) particles and inorganic particles (in the form of hollow glass beads) are mixed together and physically stirred. The disclosed method thus does not suffer from the disadvantages associated with the physical method such as the large density difference between hollow glass beads (which can be as low as 0.1g/mL) and titanium dioxide (which is 4.23g/mL); the agglomeration of titanium dioxide powder; and the low refractive index of hollow glass beads. The former two disadvantages will affect the paint formulation quality and additional technology will be needed to overcome the former two disadvantages during paint formulation. For the last disadvantage, the interface between hollow glass bead and binder is not utilized efficiently, which limits the solar light reflectance of paint.

Advantageously, the present method of forming the titania-coated inorganic particles may solve the above disadvantages. The titania-coating on the inorganic particle may be present on a large area of the surface of the inorganic particle, such as at least 90% (90%, 91%, 92%, 93%, 94%, 95%, 96%, 97%, 98%, 99% or 100%) of the surface of the inorganic particle is coated with the titania-coating. The titania-coating may completely cover the surface of the inorganic particle (that is, a 100% coating coverage). Having this high coverage of the coating on the surface of the inorganic particle may lead to an increase in the interfacial area with refractive index difference, which will increase solar light reflectance of the titania-coated inorganic particles. Depending on whether the inorganic particle is hydrophilic or hydrophobic, the type of bonding between the titania and the inorganic particle will be different. Where the inorganic particle is hydrophilic (or having a hydrophilic treated surface), the present method may be considered as a chemical method that results in the formation of covalent bonds between the titania and the surface of the inorganic particle. Where the inorganic particle is hydrophobic (or having a hydrophobic treated surface), the present method may be considered to be a physical method that results in physical bonding between the titania and the surface of the inorganic particle. The present method results in titania-coated inorganic particles with high solar light reflectance, without any agglomeration of the titania particles. When the titania-coated inorganic particle of the disclosure is used in a paint formulation, due to the increases in the refractive

index difference and effective interfacial surface area in the interface between the inorganic particle and the binder, this may lead to an increase in the solar light reflectance.

Advantageously, the density of the titania-coated inorganic particle of the present application may be tuned. Due to the shape of the inorganic particle, which is typically spherical or substantially spherical, the inorganic particle has good fluidity in paint. Thus, the titania-coated inorganic particle will also have good fluidity in paint since the titanit coating does not substantially change the shape of the inorganic particle.

Advantageously, the disclosed method may be undertaken at a neutral pH and ambient conditions. This is a departure from some of the prior art methods which rely heavily on pH control (either highly acidic or highly basic), on temperature control (heating or cooling), surfactant utilization, precipitator utilization, preheating or post annealing treatment of the materials to form the titania from a particular precursor. These controls and treatments usually result in more operation procedures and equipments. In addition, some of the prior art methods require the titania to be in a particular crystal phase to be of use. Hence, the disclosed method may optionally not include any pre-heating step. The disclosed method may optionally not require the use of surfactants in the method. The disclosed method may be widely applicable to titania of any crystal phase and is not limited to requiring the titania to be in a particular crystal phase to be of use.

Advantageously, the disclosed method is more economical than prior art methods while allowing the ability to finely tune the coating conditions to coat the titania coating onto the surface of the inorganic particles without any obvious freestanding titania agglomerates to increase the solar light reflectance property of the titania-coated inorganic particle pigment.

According to ~~a third~~ another aspect, there is provided a titania-coated inorganic particle, wherein the titania is amorphous titania.

An advantage of amorphous titania over anatase titania is that the amorphous titania does not have photocatalytic performance, which will not cause photodegradation of binder during application (such as in a paint formulation). Hence, when the amorphous titania-coated inorganic particle is used in a paint formulation, as compared to using anatase titania-hollow glass beads, the amorphous titania-coated inorganic particle may aid to increase the stability of the paint while having comparable solar light reflectance with that of anatase titania-hollow glass beads.

According to another ~~a fourth~~ aspect, there is provided a paint formulation comprising a titania-coated inorganic particle, wherein the titania is amorphous titania.

According to another ~~a fifth~~ aspect, there is provided use of a titania-coated inorganic particle in a paint formulation, wherein the titania is amorphous titania.

Definitions

The following words and terms used herein shall have the meaning indicated:

The term ‘titania’ is to be used interchangeably with titanium dioxide, or titanium (IV) oxide, and has the chemical formula TiO_2. Titania can exist in the amorphous form, or may be in a crystal form such as rutile, anatase, brookite, or mixtures thereof. Titania can exist

Claims

1. A method for forming a titania-coated inorganic particle comprising the steps of:

    a. stirring a mixture of a titania precursor and an inorganic particle in an organic solvent for a time period of more than 1 hour to cause adsorption of said titania precursor on the surface of said inorganic particle; and

    b. adding water to the mixture under stirring to convert said titania precursor to titania which then forms a coating on said inorganic particle.

2. The method according to claim 1, wherein in step (a), said titania precursor and said inorganic particle are present at a ratio of titania precursor (molar) to inorganic particle (g) in the range from 8:1 to 18:1 (mmol/g).

3. The method according to claim 1 or 2, wherein in step (b), said water and said titania precursor are present at a molar ratio of water to titania precursor in the range of 2:1 to 8:1.

4. The method according to any one of the preceding claims, wherein said titania precursor is a titanium alkoxide.

5. The method according to claim 4, wherein said titanium alkoxide is a titanium C_{1-10} alkoxide.

6. The method according to claim 5, wherein said titanium alkoxide is a C_{1-4} alkoxide selected from the group consisting of titanium methoxide, titanium ethoxide, titanium isopropoxide and titanium butoxide.

7. The method according to any one of the preceding claims, wherein said inorganic particle is a glass particle selected from the group consisting of a silica glass particle, a soda-lime glass particle, a borosilicate glass particle, an aluminosilicate glass particle and mixtures thereof.

8. The method according to claim 7, wherein said glass particle is a hollow glass particle comprising a glass shell encapsulating an inner void.

9. The method according to any one of the preceding claims, wherein said inorganic particle is a microsphere.

10. The method according to any one of the preceding claims, wherein said organic solvent is an alcohol.

11. The method according to any one of the preceding claims, wherein said water is added to said stirred mixture in the form of water droplets.

12. The method according to any one of the preceding claims, wherein in step (b), said stirring is undertaken for more than an hour.

13. The method according to any one of the preceding claims, wherein said method is undertaken at neutral pH.

~~14. The method according to any one of the preceding claims, further comprising the step of:~~

~~c. separating the titania-coated inorganic particle from the mixture.~~

~~15. The method according to claim 14, further comprising the step of:~~

~~d. drying the titania-coated inorganic particle at a temperature in the range of 25°C to 100°C.~~

~~16.~~1. A method for forming a paint formulation, comprising the steps of:

a. stirring a mixture of a titania precursor and an inorganic particle in an organic solvent for a time period of more than 1 hour to cause adsorption of said titania precursor on the surface of said inorganic particle;

b. adding water to the mixture under stirring to convert said titania precursor to titania which then forms a coating on said inorganic particle;

c. separating the titania-coating inorganic particle from the mixture; and

d. adding said titania-coating inorganic particle to a paint formulation.

~~17.~~2. A titania-coated inorganic particle, wherein said titania is amorphous titania.

~~18.~~3. The titania-coated inorganic particle of claim ~~17~~2, wherein said titania coating is of a thickness in the range of 50 nm to 300 nm.

~~19.~~4. The titania-coated inorganic particle of claim ~~17~~ 2 or ~~18~~3, wherein said titania-coated inorganic particle has a density in the range of 0.1 g/mL to 1 g/mL.

~~20.~~5. The titania-coating inorganic particle of any one of claims ~~17~~ 2 to ~~19~~4, wherein the titania coating is disposed on at least 90% of the surface of said inorganic particle.

~~21.~~6. A paint formulation comprising a titania-coated inorganic particle, wherein the titania is amorphous titania.

~~22.~~7. The paint formulation of claim ~~21~~6, wherein the titania-coated inorganic particle is present in said paint formulation at a weight % of 1 wt% to 20 wt%.

~~23.~~8. Use of a titania-coated inorganic particle in a paint formulation, wherein said titania is amorphous titania.