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19 July 1990

Dear David,

European Patent Application No. 87 303 681.8
Your reference : CH-1371

I am pleased to report that the response filed in April 1990 has been successful. I have now received the Rule 51(4) communication with a copy of the final text, on which it is proposed to grant the patent. A copy of the final text is enclosed.

We are required to state our approval of the final text by 11 November 1990, and I propose to do this about one month prior to the due date unless I hear from you to the contrary.

We will then have to instruct the nominated agents in the designated states - Germany, France, Holland, Belgium and Spain to proceed with the national phase requirements to validate the patent in those countries. Again, unless we hear from you to the contrary, we shall proceed on the assumption that it is still desired to proceed in all the countries and we will instruct the agents in due course.

Yours sincerely,

pp David Woodcraft

DAVID C. WOODCRAFT

FILE CHECKED
AUG 09 1990

Encl:

N 30956

CH-1371

TITLE

Titanium Dioxide Pigment Coated with Cerium Cations, Selected Acid Anions, and Alumina

BACKGROUND OF THE INVENTION

The present invention relates generally to pigments composed of coated TiO_2 particles, and particularly to TiO_2 pigments having coatings comprising cerium cations, selected acid anions, and an outer coating of alumina.

TiO_2 has a high refractive index for its density, which renders it a superior pigment for use in coatings, e.g., paints. However, TiO_2 is photoactive; exposure to ultraviolet radiation results in generation of free radicals on the surface of TiO_2 particles. Thus, where a TiO_2 pigment is employed in a paint exposed to sunlight, free radicals are generated which can migrate to the film-forming component of the paint, resulting in coating degradation or failure.

Therefore, minimizing free radical migration is desirable in order to provide lightfast and stable pigments for coating use. Heretofore, the majority of commercial TiO_2 pigments have been coated with dense silica or densified alumina to provide lightfastness. However, some patent references have disclosed use of cerium in association with TiO_2 pigments to promote lightfastness.

Lederer, U. S. Patent 3,513,007, discloses TiO_2 particles having coatings formed from dispersions containing water-soluble hydrolyzable compounds of silicon, titanium, zirconium, or phosphorus, to which water-soluble hydrolyzable compounds of aluminum, cerium, and or calcium and alkali are added.

Barnard, U.S. Patent 4,239,548, discloses pigments having inner coatings comprising cerium and phosphate radicals and outer coatings comprising aluminum and phosphate radicals and optionally hydrous alumina.

Jacobson, U.S. Patent 4,460,655, describes pigments of TiO_2 particles associated with compounds selected from the group consisting of $Na_7Ce_6F_{31}$, $K_7Ce_6F_{31}$, $Li_7Ce_6F_{31}$, and$(NH_4)_7Ce_6F_{31}$.

Jacobson, U.S. Patent 4,461,810, discloses pigments of TiO_2 particles, the surfaces of which are associated with cerium cations and sulfate, phosphate, or silicate anions. The particles are also provided with an outer coating of alumina.

Newland et al., U.S. Patent 4,022,632, describes TiO_2 pigments treated with carboxylate salts of cobalt, cerium or manganese.

Bramekamp, U.S. Patent 3,506,466, discloses TiO_2 pigment particles coated with inorganic oxides, where the inorganic oxide bears on its surface an amine salt of an oxycarboxylic acid selected from the group consisting of lactic, citric, malic, tartaric and glycolic acids.

GB-A-1580882 describes a method of making a coated inorganic pigment which performs adequately in terms of gloss and dispersibility both organic and aqueous-based paint media. The inorganic pigment particles, which are preferably TiO_2 are coated with alumina and then contacted with one or more organic hydroxy acids or salts or with a water-soluble reaction product of one or more di- or polyhydric alcohols and one or more di- or poly-basic organic hydroxy acids.

It has now been found that pigments of TiO_2 particles treated with cerium cations in association with certain polyfunctional water-soluble acid anions or borate ions, and then topcoated with alumina, exhibit excellent lightfastness, gloss and dispersion characteristics.

→ 2a

SUMMARY OF THE INVENTION

The present invention provides a pigment consisting essentially of rutile TiO_2 particles bearing coatings of alumina or alumina-silica, the particle surfaces having associated therewith 0.05-2%, by weight of the TiO_2, of cerium cations and an associated

quantity of borate anions or polyfunctional organic acid anions having a solubility in water of at least 10 grams per liter at 25°C.

DETAILED DESCRIPTION OF THE INVENTION

The pigments of the present invention are composed of rutile TiO_2 particles treated with cerium cations in association with selected polyfunctional organic acid anions such as citrate anions, and then topcoated with alumina or alumina-silica. Optionally, the acid anions can be borate. In extreme lightfastness exposures, the pigments of this invention provide performance equivalent to TiO_2 coated with 6% by weight silica and 2% by weight alumina. It is believed that cerium citrate in association with the TiO_2 particle surfaces provides recombination centers for electron/hole pairs produced when pigments containing such particles are exposed to actinic radiation. Quenching of electron/hole pairs eliminates free radical production which might otherwise degrade a paint film or other organic materials in proximity to pigment particles.

The TiO_2 used to prepare the pigment of the invention can be of the conventional rutile variety, prepared by either the chloride or sulfate process.

Associated with the particle surfaces of the TiO_2 are cerium cations and selected acid anions. "Associated with the particle surfaces" means that the ions are bound to the TiO_2 particles by a chemical or physical attraction.

The acid anions associated with the cerium cations are borate anions or polyfunctional organic acid anions having water solubilities greater than 10 grams per liter at 25°C. Exemplary of such organic acid anions are citrate, succinate, fumarate, adipate, tartrate, and maleate ions. Of the foregoing, citrate ions are preferred.

The cerium cations can be supplied by any water-soluble cerium salt, e.g., ceric sulfate or ceric nitrate, which are added to rutile slurries at pH 2-7. Polyfunctional organic acid anions are supplied by addition of the appropriate acid. Borate anions are supplied by addition of $Na_2B_2O_4$. The cerium ion content of the pigment can be determined by ion plasma chromatography. The polyfunctional organic acid anion content can be determined using a Leco or other total carbon analyzer.

The amount of alumina or alumina-silica which the particles bear as coatings can be varied depending primarily upon the pigment's intended use. Ordinarily, the alumina coating will constitute 0.5-10% of the total weight of the particles. Preferably, the alumina coating constitutes 1-6%, and most preferably, 2-4%, of the total weight of the pigment particles. The amount of alumina the particles bear as coatings, expressed as percent by weight, is calculated by first determining, by ion plasma spectroscopy, the alumina content of the coated pigment. The alumina content of the uncoated rutile TiO_2 is similarly determined, and the alumina content attributable to the coating is determined by computing the difference between coated and uncoated alumina contents.

The pigment of the present invention can be prepared from an aqueous slurry containing 200-450 grams per liter TiO_2. This slurry is brought to 45°-70°C and is held at that temperature throughout the preparation procedure. The slurry is adjusted to a pH at which added cerium ions will remain in solution by addition of mineral acid, e.g., HCl, and then sufficient cerium salt is added to provide a cerium ion concentration in the slurry of 0.05-2%, by weight of the TiO_2. For example, if cerium ions are supplied by addition of ceric nitrate, pH should be adjusted to 2-4; if cerium ions

are added in the form of ceric sulfate, pH should be adjusted to the range 2-7.

At this point, a sufficient quantity of a selected anion species (i.e, organic acid or borate) is added to the slurry to provide a concentration of added anion ranging from 100% to 300% of the cerium ion concentration. As a result, cerium will precipitate upon the surfaces of the TiO_2 particles in association with the added anion.

Alumina is then precipitated on the TiO_2 particles by slowly adding enough sodium aluminate to the slurry to provide a concentration of about 2-8% by weight of the TiO_2. Acid, normally sulfuric or hydrochloric, is added at the same time to maintain the pH of the slurry within the range 6-9 during the precipitation step. After addition of aluminate is complete, the slurry is allowed to cure, with continuous stirring, for 15-30 minutes.

The resulting pigment is then separated from the liquid by filtration or centrifugation, washed with water, and dried.

Coating compositions can be prepared with the pigments of the invention in conventional ways, e.g., by blending the pigment with a film-forming component and a liquid carrier.

The following examples illustrate particular aspects of the present invention. In the examples, all parts and percentages are by weight and all degrees are Celsius unless otherwise indicated.

Example 1

In a large plastic vessel equipped with stirring apparatus and a pH probe, 11,000 parts water are mixed with 5000 parts rutile TiO_2.

The resulting slurry is heated to 60°, and the pH is adjusted to about 3.0 by addition of HCl. 42 parts of a 1.5 M $Ce(NO_3)_4$ solution are then added,

followed by 40 parts citric acid. The resulting mixture is then stirred for a period of about 5 minutes, and then the pH is increased to about 7.5 by addition of NaOH.

A coating of 2% hydrous alumina is then deposited on the pigment by simultaneously adding 250 mL $NaAlO_2$ solution (containing the equivalent of 400 g Al_2O_3 per liter solution) and HCl, such that the pH of the slurry is continuously maintained from about 7.0 to about 7.5.

The resulting coated pigment is cured by holding for about 30 minutes at 60° and pH 7.5. The pigment is then filtered from the slurry, washed free of salts with deionized water, and air-dried. The pigment is then micronized, using 3 lbs. superheated steam per lb. pigment. The resulting pigment, containing about 0.2% CeO_2 as $Ce_3(C_6H_5O_7)_4$, and a 2.0% alumina coating, is suitable for use in paint systems.

Example 2

A mill base is made by mixing

Pigment of Example 1	387 parts
alkyd resin (Syntex ®3145; Celanese Coatings Co.)	149.6 parts
n-butanol	9.4 parts
xylol	79 parts.

This mixture is sand ground, and then the sand is filtered from the mill base. A paint is made by mixing 100 parts of the mill base with the following:

xylol	1.4 parts
alkyd resin (Syntex® 3145; Celanese Coatings Co.)	71.8 parts
melamine resin solution (Cymel® 248-8, 55% solids, American Cyanamid Co.)	38.5 parts.

CLAIMS

1. A pigment consisting essentially of rutle TiO_2 particles bearing coatings of alumina or alumina-silica, the particle surfaces having associated therewith 0.05-2%, by weight of the TiO_2, of cerium cations and an associated quantity of borate anions or polyfunctional organic acid anions having a solubility in water of at least 10 grams per liter at 25°C.

2. A pigment according to claim 1, wherein the alumina or alumina-silica coating constitutes 0.5-10% of the total weight of the TiO_2 particles.

3. A pigment according to claim 2, wherein the alumina or alumina-silica coating constitutes 1-6% of the total weight of the TiO_2 particles.

4. A pigment according to claim 3, wherein the alumina or alumina-silica coating constitutes 2-4% of the total weight of the TiO_2 particles.

5. A pigment according to any one of the preceding claims wherein the associated anions are borate ions.

6. A pigment according to claim 1, wherein the associated anions are polyfunctional organic acid anions having a solubility in water of at least 10 grams per liter at 25°C.

7. A pigment according to any one of claims 1 to 4, wherein the associated anions are citrate, succinate, fumarate, adipate, tartrate or maleate ions.

8. A coating composition comprising a pigment according to any one of claims 1 to 7, a film-forming material, and a liquid carrier.

CLAIMS

1. A pigment consisting essentially of rutile TiO_2 particles bearing a coating of alumina or alumina-silica, the TiO_2 particle surfaces having bound therewith 0.05-2%, by weight of the TiO_2, of cerium cations and an associated quantity of borate anions or polyfunctional organic acid anions having a solubility in water of at least 10 grams per liter at 25°C, said coating of alumina or alumina-silica forming a top coat on the TiO_2 particles.

2. A pigment according to claim 1, wherein the alumina or alumina-silica coating constitutes 0.5-10% of the total weight of the TiO_2 particles.

3. A pigment according to claim 2, wherein the alumina or alumina-silica coating constitutes 1-6% of the total weight of the TiO_2 particles.

4. A pigment according to claim 3, wherein the alumina or alumina-silica coating constitutes 2-4% of the total weight of the TiO_2 particles.

5. A pigment according to any one of the preceding claims wherein the associated anions are borate ions.

6. A pigment according to claim 1, wherein the associated anions are polyfunctional organic acid anions having a solubility in water of at least 10 grams per liter at 25°C.

7. A pigment according to any one of claims 1 to 4, wherein the associated anions are citrate, succinate, fumarate, adipate, tartrate or maleate ions.

8. A coating composition comprising a pigment according to any one of claims 1 to 7, a film-forming material, and a liquid carrier.

9. A method of producing coated TiO_2 pigment particles which comprises (a) forming an aqueous slurry containing 200 to 450 grams per litre of TiO_2 and having a pH at which cerium ions will remain in solution, (b) adding sufficient cerium salt to provide a cerium ion concentration in the slurry of 0.05 to 2% by weight of TiO_2, (c) adding a sufficient quantity of a source of borate or polyfunctional organic acid anions to provide a concentration of said anions of from 100 to 300% of the cerium ion concentration thereby causing the cerium ions to precipitate onto the surfaces of the TiO_2 particles in association with the said borate or polyfunctional organic acid anions and (d) depositing an alumina or silica-alumina coating on the treated TiO_2 particles.

10. A method according to claim 9 wherein in step (d) alumina is precipitated onto the treated TiO_2 particles by adding enough sodium aluminate to the slurry to provide a concentration of abut 2 to 8% by weight of the TiO_2 and adjusting the pH to within the range of 6 to 9 during the precipitation step.