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Study on new alcohol based nano transparent infrared thermal insulation method for preventing sedimentation

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Abstract. By adding additives such as eliminating agent and stabilizer, it can effectively reduce the sedimentation rate of ATO nano-heat insulation slurry in alcohols solvent. It provides a new preparation method of alcohol nanometer transparent infrared thermal insulation and anti-sedimentation. In addition, it also provides a safe, reliable, efficient and new energy-saving glass material for construction projects.

1. Preface

This research provides a new preparation method of alcohol nanometer transparent infrared thermal insulation and anti-sedimentation. By adding additives such as eliminating agent and stabilizer, it can effectively reduce the sedimentation rate of ATO nano-heat insulation slurry in alcohols solvent. Furthermore, the dispersion effect and stability of the slurry are further improved and the preservation time is prolonged. In addition, it also provides a safe, reliable, efficient and new energy-saving glass material for construction projects [1-3].

2. Experimental preparation and related processes

ATO powder is mainly composed of tin oxide and antimony oxide, which is a kind of particle with a certain porosity structure. In the process of dispersion, the volume of ATO particles becomes smaller due to the existence of small size effect [4-6].

The particle size will continuously decrease. When the particle size is similar to or smaller than the wavelength of the solar wavelength, a series of optical, electrical, thermal, and magnetic properties will change in the ATO material. Its concrete manifestation is as follows: it has good visible light transmittance in the 380-780nm band of solar radiation. Under the action of quantum force, particles absorb the blue band and shift to the shortwave direction, which results in the ATO particles having a better barrier to the solar long-wave radiation above 780nm in solar radiation. In this way, it has a better absorption effect on the infrared band of the sun [7-9].

However, in the process of dispersion which also is the process of ATO particles becoming smaller, the number of atoms on the particle surface increases with decreasing particle size, and the surface activity of particles increases because of the existence of free energy on the surface of particles [10-12]. With the increasing of surface energy of particles, these particles are in unstable state because of the existence of surface energy and suspended bond, and the pore network of particle surface is connected with each other. In this case, it is easy for ATO particles to attract the surrounding particles



because of the interaction of the surface solid bridge bonds and then to become larger particles. When the number and type of particles are adsorbed to a certain extent, the ATO particles will produce a relative aggregation phenomenon and stable state. However, due to the existence of surface effect, it is easy to agglomerate and precipitate in the dispersion of ATO slurry or in the later storage, which is also the difficult and key part for dispersion and preservation of ATO[13-16].

In order to obtain stable ATO slurry in the process of dispersion and preservation, it is generally necessary to reduce the agglomeration between ATO particles by good dispersion method or by adding modified reagent.

3. Experimental equipment

In the experiment, the ATO dispersion instrument was mainly a powder disperser and a high-speed ball mill disperser. These devices mainly performed physical dispersion of ATO materials.

In the experiment, the visible light and infrared spectrum of the coated glass were detected mainly by a spectrophotometer, and the light transmission and absorption of the 380 nm-780 nm band and the 780 nm band were detected.

In the experiment, a mixture of the slurry and the coating was used. The magnetic stirrer was used to drive the material by changing the magnetic poles at the bottom end of the instrument. The mixture was blended evenly in the stirring process.

4. The experimental materials

The main materials used in this experiment were thermal insulation materials and alcohol based resins, with dispersants, infrared removers and UV removers.

The experimental materials: ATO powder for 500 grams per bag; GTO powder for 500 grams per bag; The solid component is more than 35%, and the PH value is 8; Analysis of pure (AR, second grade) alcohol solvent ; Analyze the dispersants of pure (AR, grade two); Analysis of pure (AR, second grade) infrared removal agent; Analysis of pure (AR, second grade) uv remover; Analyze the leveling agent of pure (AR, second grade); Analysis of pure (AR, second grade) potassium hydroxide.

ATO Chinese name is tin oxide, commonly used materials in thermal insulation coatings. GTO is a new type of nanometer material that has appeared in recent years. It is similar to ATO in terms of appearance, morphology, characteristics, and functions, but in the near-infrared region, especially in the wavelength region of 800nm-1600nm, the heat insulation of GTO powder in the near infrared region is higher than 20% of the ATO powder, showing a better insulation performance. However, its price is high, which is not conducive to mass use and promotion.

5. Technical route of experiment

The technical route of this experiment is as follows: it mainly focuses on improving the performance of existing building glass insulation coatings and quantifying the thermal performance of the coating thermal insulation glass.

Alcohol solvent is added into additives such as ATO and GTO powders , decision powder and away from the water, dispersing agent, and it can be finely separated by stages. It can be get a preparation of coating glass which is made of thermal insulation coating materials, such as alcohol slurry and auxiliary and alcohol resin .Based on the analysis of the optical, physical, environmental and aging properties of the coated glass, the corresponding thermal parameters are obtained.

Finally, two comparative methods are used to simulate and measure the building energy saving rate. One is to simulate the building energy consumption by DEST software and the other is to analyze the energy saving effect by measuring the indoor and outdoor temperature[17-19].

6. Experimental scheme and dispersion method

6.1. Composition

The alcoholic nano transparent infrared thermal insulation anti-settling slurry includes the following quality components:

8-12 pieces of ATO nanometer doped with antimony oxide, 4-6 pieces of GTO nano powder, 3-6 pieces of Alcohol solvent, the D-type dispersant is 5-10 parts of alkyl ammonium salt, the p-type dispersant is 6-12 parts of polyethylene amines, and one each of pH adjuster, infrared eliminator, ultraviolet eliminator and leveling agent; The amount of pH adjuster used is based on the pH of the alcoholic nano transparent infrared heat insulation and anti-settling slurry adjusted to 8-10.

The pH adjusters include potassium hydroxide, sodium hydroxide and hydrogen chloride. It includes the following components in parts by mass, 1 to 3 parts of potassium hydroxide, 1 to 3 parts of sodium hydroxide, and 1 to 3 parts of hydrogen chloride.

Alcohols are one or more of anhydrous ethanol, isopropyl alcohol, isobutanol and allyl alcohol, and all alcohol solvent specifications are pure (AR, second grade).

6.2. Experimental Procedure

The preparation method of the alcohol nanometer transparent infrared thermal insulation and anti-settling slurry comprises the following steps:

6.2.1. Step one. Take 8-12 pieces of ATO nanometer doped antimony dioxide and 3-6 parts of alcohol solvent into the container, and mix uniformly with magnetic stirring rod.

6.2.2. Step two. A mixture of ATO nano-doped tin oxide (GTO powder) and alcohol solvent is put into powder dispersing instrument, and 5-10 parts of D-type dispersants are also put into the powder dispersing instrument. They are dispersed for 80 to 160 minutes and obtained the pulp A component.

6.2.3. Step three. By putting A and 6-12 parts of P-type dispersant and moderate pH regulator scattered into the high-speed ball mill instrument. After dispersing them for 60-120 mins, the slurry of the alcohol nano-transparent infrared insulation and deposition can be obtained.

6.3. Factors Affecting Slurry Stability

The pH of the slurry is mainly determined by the components of H and OH. According to the theory of colloidal dispersion system, the stability of particles mainly depends on the gravity and repulsive force between particles. When the repulsion and gravity between ATO particles change, the colloidal state changes. When the gravity between ATO particles is larger than the repulsive force, the particle colloid will reunite; otherwise, it will be in a stable state.

There is a certain correlation between the potential and PH value. When the potential is from ± 30 MV to ± 40 MV, the stability of ATO colloid is normal, and this value is the critical value of colloid stability. The stability of ATO colloid will be further stable as the relative value of electric potential value continues to expand. The stability of ATO colloid tends to condense when the relative value of potential becomes smaller.

For ATO slurry, acid solvent and alkaline solvent were used to adjust the pH of ATO slurry under the same conditions of solid content, solvent type and dispersion condition. After a period of dispersed precipitation, it is found that when the PH value is 3-7, the slurry will have a certain degree of settlement. When the PH value of the slurry is 9-10, the stability of the slurry is better.

6.4. Data analysis

With the increase of the pH value of the slurry, the Zeta potential of ATO slurry decreases continuously. In other words, the absolute value of the Zeta potential of the ATO slurry continuously increases, and the electrostatic repulsion of the slurry particles can overcome the van Edward force

between the slurry particles, so that the ATO slurry particles remain in a stable state. With the continuous increase of PH, ATO pulp dispersion stability decline trend. This is because the repulsion force between ATO particles increases, which results in the secondary agglomeration between particles, and the optimum PH value of ATO slurry is 9-10.

The ethanol molecule is composed of three kinds of atoms of C,H,O, which are divided into ethyl and hydroxyl groups. Using the properties of carbonyl bond (carbon oxygen bond) and hydroxyl bond (hydrogen oxygen bond) in ethanol molecule are easily broken. We dissolve the ethanol and ATO powder, and make the ratio and dispersion according to a certain dose of dispersant, and obtain a more stable ATO slurry.

The stability of slurry obtained from the proportioning of ethanol, ATO slurry and different dispersants. The first bottled slurry from left to right appeared obvious solidification at the first hour after dispersion and completely solidified within 5 hours. The second bottled slurry appeared obvious solidification in 10 hours, and completely solidified into solid within 20 hours. The third bottled slurry showed obvious solidification on tenth days, and completely solidified into solid within 16 days. The fourth bottle slurry appeared solidification within a period of one month, but in the later observation, there was no solidification bottom again, which kept a certain stable state. The fifth and sixth bottles of slurry were observed for 2 months without solidification, keeping good stability, no obvious settlement and delamination.

The length of static time is of great significance for the analysis of dispersing stability of slurry. Generally speaking, the longer the static time, the lower the settling rate, which indicates the better stability of the slurry. It can be seen from the experimental results that the stability of slurry gradually increases with the increase of dispersant /ATO ratio. In the proportion of less than 0.18, the stability of ATO slurry is poor, and in the proportion of more than 0.18, the stability of the slurry is better. It shows that the specific gravity of dispersant and ATO 0.18 is a turning point for ethanol as solvent.

In ATO nano-material and alcohol solvent, adding dispersant, in which the solid content of ATO is 20%, the dispersant is 5% of the solid content. They were grinded and dispersed on high speed dispersing machines and ball mills for a long time, and then placed in 120ml's reagent bottles for stability study.

Three dispersants are selected in the experiment: small molecular dispersant A system, polymer anionic dispersant system B and cationic dispersant C system.

The dispersants of the three systems are investigated according to the settlement of ATO slurry and the stratification of solvent and slurry. Using the dispersant of the small molecule A system, the ATO slurry appears the transparent solvent in the upper layer and the ATO powder in the lower layer. The stability of slurry under the dispersing agent of small molecule A is the worst, and the layering phenomenon of solvent and ATO powder is serious.

Polymer type anionic dispersant B system: solvent and ATO slurry appear stratification, the upper layer is turbid solution, and the lower layer is ATO slurry. The stability of the slurry in this system is bad, and the layering phenomenon occurs in the upper and lower layers. The polymer type Anionic Dispersant B is not suitable for dispersion of ATO slurry.

Cationic dispersant C system: solvent and slurry are dispersed together into a turbid solution without obvious delamination. The stability of the slurry in this system is good, but Whether it is suitable for the preparation of glass thermal insulation coating requires further experimental verification. The C system dispersants can be divided into C1 and C2 systems.

6.5. Experimental analysis

Through experiments on small-molecular dispersants, polymeric anionic dispersants and polymeric cationic dispersants, it can be found that the dispersion effects of different dispersant systems have obvious differences in the stability of ATO slurry.

The dispersion mechanism of Nonionic small molecular dispersant is to disperse the slurry by changing the electrostatic repulsion force on the surface of ATO slurry. However, These electrostatic repulsion generated by ATO is insufficient to make the particles of ATO slurry arrive even and

balanced, resulting in the phenomenon of ATO slurry settling and delamination. While the polymer dispersant increases the electrostatic repulsion, it increases the steric resistance of the space by increasing the thickness of the molecular adsorption layer. The thermodynamics state formed by the position resistance is a relatively stable state, which is less affected by the external conditions, and can make the slurry reach a relatively stable state. In alkaline environment, the positive particles are more active, which is easier to adsorb on the surface of the alkaline substance and produce the reaction. ATO slurry is a kind of alkalescent material, so ATO slurry is easier to adsorb the dispersant of positive particles. The dispersion effect is achieved by using the potential resistance of the dispersant adsorbing film on the surface of the particle. At the same time, When the dispersant adsorbs and enters the inner particle of ATO slurry, it has the function of grinding. All of these have played a good role in dispersing ATO slurry evenly.

7. Conclusions

By adding additives such as eliminating agent, stabilizer and so on, it can effectively reduce the sedimentation rate of ATO nano-heat insulation slurry in alcohols solvent. It provides a new preparation method of alcohol nanometer transparent infrared thermal insulation and anti-sedimentation.

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