Rheology of Titania Pigment Slurry

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Abstract:
The influence of polymeric dispersants containing different functional groups on the suspension behaviour of titania pigment slurry was investigated. The dispersants chosen were polyacrylic acid and modified polyacrylamides including homo and copolymers modified with carboxylate and/or hydroxyl groups. The pigment slurry rheology was strongly affected by both pH and dispersant chemical groups. The inorganic coating layer on the titania surface is not smooth, but rough or porous. The surface roughness of the pigment can generate additional contribution to the affinity of the dispersants for adsorption.

Zusammenfassung:
Der Einfluss von polymeren Dispergiermitteln mit unterschiedlichen funktionellen Gruppen auf das Verhalten von Suspensionen von Titandioxidpigment-Gemischen wurde untersucht. Die ausgewählten Dispergiermittel waren Polyacrylsäure und modifizierte Polyacrylamide mit Homo- und Copolymeren, die mit Carboxyl- und/oder Hydroxylgruppen modifiziert wurden. Die rheologischen Eigenschaften der Pigmentmischungen wurden beeinflusst vom pH-Wert und den chemischen Gruppen des Dispergiermittels. Die anorganische Schicht auf der Titandioxidoberfläche ist nicht glatt, sondern rauh oder porös. Die Oberflächenrauhigkeit der Pigmente besitzt einen zusätzlichen Beitrag zu der Affinität der Dispergiermittel hinsichtlich des Adsorptionsverhaltens.

Résumé:
Nous étudions l'influence de dispersant de type polymère contenant différents groupes fonctionnels, sur le comportement de suspension d'une boue de pigment de titania. Les dispersants choisis sont l'acide polyacrylique et des polyacrylamides modifiées incluant des homo et copolymères modifiés avec des groupes carboxylates et/ou hydroxyles. La rhéologie de la boue de pigment est fortement affectée par le pH et les groupes chimiques du dispersant. La couche inorganique qui recouvre la surface du titania n'est pas lisse, mais rugueuse et poreuse. La rugosité de la surface du pigment peut générer une contribution additionnelle à l'affinité des dispersants pour l'adsorption.

Key words: titania pigment, polyacrylic acid, polyacrylamide, polymeric dispersant, titanium dioxide

1 INTRODUCTION

Titania is one of the most important white pigments currently used in the world with a total annual production of about 6 million [1]. Titania pigment slurry properties are very important for consumer industries such as paints, papermaking and plastics; if aggregates are present, the end-use properties including gloss, brightness, colour hue, opacity and storage stability will be highly affected [2]. Dispersion properties can be greatly improved by addition of a polymeric dispersant [3]. It is therefore very important to understand the interaction between the pigment particles and polymeric dispersants of varying functionality [4]. Pigment dispersion stabilisation is generally provided by two major mechanisms of electrostatic and steric stabilisation repulsion [5, 6]. It is also possible to combine chemical functional groups within the same dispersant molecule to provide both steric and electrostatic stabilization [3].

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ing the effect of these two polymers on the rheology and flow behaviour of the titania suspension. As discussed, the floc size may be determined using shear rate data (Equation 3). The attempt to use Equation 3 to estimate the pigment floc size was not successful in the current study (using n = 0.2 [19]). More detailed work is needed to relate 'shear rate' and 'particle aggregate size' to solve this problem.

3.2 PIGMENT PARTICLE SIZE

Figure 4 shows the 50 % values of the cumulative pigment particle size distribution D_{50} in the absence and presence of polymeric dispersant, as a function of pH. The average pigment particle size at neutral pH in the concentrated suspensions, obtained using ultrasonic attenuation AcoustoSizer II is 0.7 micrometer (Figure 5) which is larger than 0.3 micrometer obtained for very dilute pigment slurry using laser diffractometry. Therefore, the pigment particles in the concentrated suspension show some level of aggregation. Figure 4 shows that the suspension pH has a significant effect on the titania pigment particle size. The particle size increasing with pH until a maximum (at approximately the pigment *iep*), after which it decreases. At the *iep*, the pigment zeta potential is zero, which results in minimal electrostatic repulsion between the particles, and therefore aggregation occurs.

In general, the change in particle size upon adsorption of different dispersants as a function of pH coincidences with the changes observed in the suspension yield stress (Figure 4). In the presence of Polymer-A and Polymer-C, the pigment particle size decreases at neutral and alkaline pH values. However, at low pH values the particle size increases due to the presence of carboxylate groups in agreement with the pigment zeta potential values [8]. In the presence of Polymer-H, the pigment particle size decreases probably due to steric stabilization. Evidentially, Polymer-N has a minimal effect at pH values above the pigment iep (pH > 7.8), but at pH values below the *iep* it even causes the pigment particle to aggregate, which is similar to the behaviour observed in the rheological studies (Figure 3).

4 CONCLUSIONS

The pH and the dispersant functional groups have a significant effect on the rheology of the titania pigment slurry and the pigment particle size. The pigment slurry exhibited maximum yield stress and pigment particle size at the pigment *iep*. The negatively charged carboxylate functional groups present in Polymer-A and Polymer-C considerably decreased both the yield stress of the pigment slurry and the mean pigment particle size by electrostatic and steric stabilization. The presence of hydroxyl functional groups, attached to the polyacrylamide backbone in Polymer-H, caused a reduction in the suspension yield stress and the mean pigment particle size by steric stabilization. The inorganic coating layer on the titania surface is not smooth, but rough or porous. The surface roughness of the pigment can generate additional contribution to the affinity of the dispersants for adsorption.

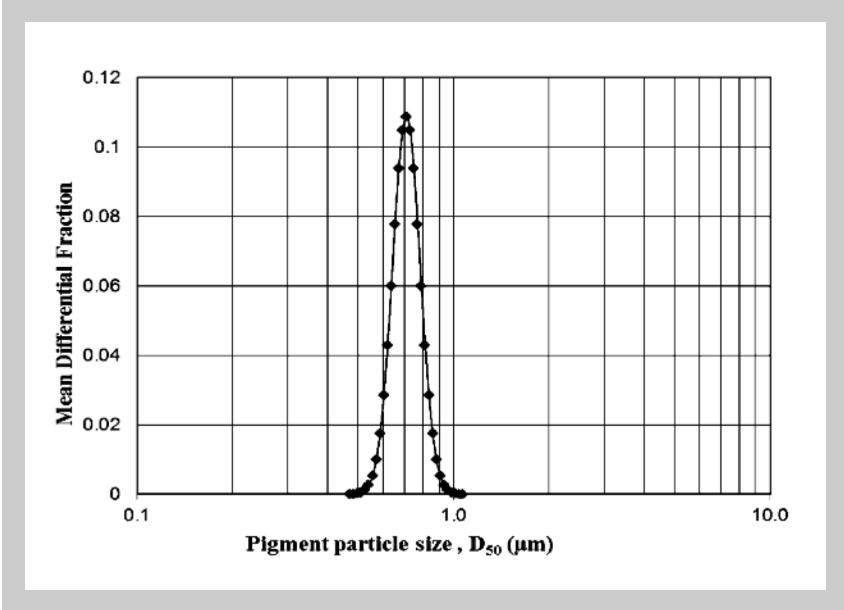

Figure 5: Titania pigment particle size D_{50} at neutral pH in the concentrated suspensions obtained using ultrasonic attenuation AcoustoSizer II.

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