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Dispersion of talc particles in a silica sol

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Abstract

The dispersion of talc particles in silica sol has been investigated by zeta potential, sedimentation, viscosity and rheological measurements. Talc suspensions dispersed in silica sol displays an absolute maximum in zeta potential value and a minimum in sedimentation volume and viscosity around pH 10.5. The viscosity of the suspensions depends strongly on the silica sol concentration and reaches a minimum in 5 wt.% silica sols. Effects of pH, solids content and silica sol concentration on the rheological behavior of sol-dispersed talc slurries are discussed in detail.

Keywords: Talc; Dispersion; Silica sol; Suspensions; Rheology

1. Introduction

Colloidal processing of advanced ceramics has received considerable interest in recent years. This interest is not only to obtain improved microstructure and homogeneity, but also to tailor the rheological properties of the suspension [1]. In colloidal processing, an appropriate choice of the dispersant type and concentration is essential to obtain adequate stability of the suspension and ensure acceptable quality of the products [2].

Organic dispersants exhibit several advantages over inorganic dispersants, including greater stability, greater control of thixotropy (or) flocculation state and higher consolidated green density, and reduction in sintering temperature [3]. Therefore, organic dispersants are almost the only choice in the earlier periods of colloidal processing. Recently, researchers show that zirconium hydrogel and alumina sol can be used as effective-processing aids for various ceramic powders [4–6]. Zhu et al [7] used silica sol as dispersion to successfully disperse alumina powders. These results show that inorganic sols can enhance the stability of alumina, silicon carbide, titania and zirconia suspensions and change the zeta potential of these ceramic particles. Now inorganic sol is considered as an efficient, clean dispersant for ceramic powders, because it cannot only provide high bond strength for ceramics bodies due to its conversion to a solid gel at relatively low temperature, but also improve sinterability of ceramic powders [8,9]. At the same time, unlike organic additives, the inorganic additive is compatible with the base ceramic, therefore, its removal by burning out or distillation before sintering is not required [10,11]. Hence, inorganic sol has been used as an effective-processing aid for various ceramic powders [4]. However, a few works [7] have been done to research rheological behavior of ceramic suspensions stabilized by inorganic sol, and no papers have been found to research dispersion properties of talc powders in silica sol.

Talc is an important raw material of fabricating cordierite based ceramics. In recent years, cordierite, with high elastics modulus and strength, as well as a low thermal expansion coefficient and excellent shock resistance, is broadly researched as insulator and refractory material [12–15], or using its low melt point as a sintering aid [16]. The research of dispersion of talc in silica sol is to prepared reticulated

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cordierite ceramics and reticulated cordierite combined silicon carbide as molten metal filters.

The objective of this work is to study the dispersion of talc particles in silica sol. Effects of pH, solids content and silica sol concentration on the rheological behavior of the slurry are investigated by employing zeta potential, sedimentation, viscosity and rheological measurements. The results showed that dispersion of talc particles was improved in silica sol.

2. Experimental procedure

2.1. Materials

A commercial talc particle ($Mg_3(Si_4O_{10})(OH)_2$, d_{50}=5.9 μm, D=2.70 g/cm^3, 99.99% purity, PR China). A commercial silica sol (26.2 wt.%, pH=9.5–10, Shanghai Second Reagent Plant, PR China) were used as raw materials in this study. The shape of talc was observed by using scanning electron microscopy (SEM) (model EPMA-8705Q, HII, Shimadzu, Japan), which is shown in Fig. 1. Talc particles represented the irregular and rectangle shapes. The colloidal particles size distribution in silica sol is measured by a laser scattering method (ZetaSizer Nano S, Malven Instruments, UK), which is shown in Fig. 2. Silica sol showed bi-modal distribution and the mean particle size of it is 82 nm.

2.2. Slurry preparation

Talc particles were dispersed by agitation in a plastic jar with zirconia's balls for 24 h. The pH value of the slurry was adjusted by 1 N NaOH or 1 N HCl. The solids loading of the slurry (which was the ratio of the weight of talc particles and the weight of the mixture of talc particles, silica sol and water) is different from 30 to 55 wt.%.

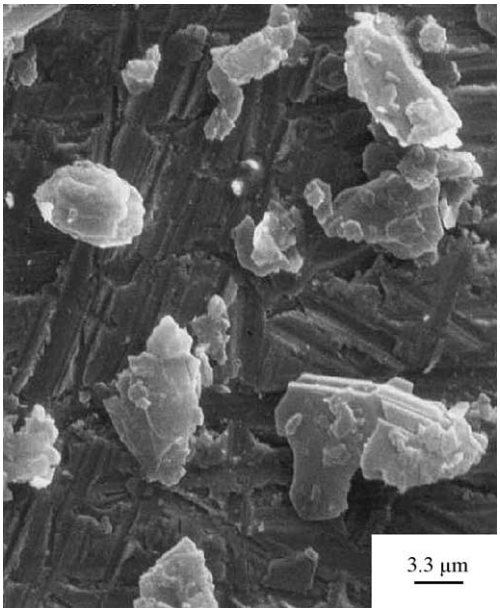

Fig. 1. SEM micrographs of talc particles.

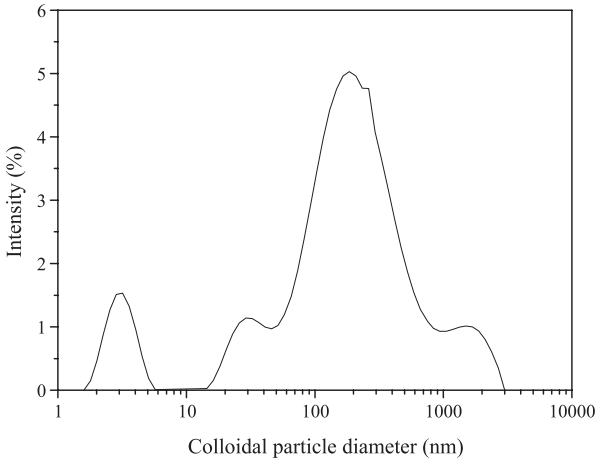

Fig. 2. Colloidal Particles size distribution in silica sol.

2.3. Zeta potential measurement

The zeta potential of talc particles dispersed in deionized water and silica sol solution, as a function of pH, has been determined by the microelectrophoretic light scattering and the Laser Dopper Velocimetry method with Zeta Potential Analyzer (Zeta Plus, Brookhaven, USA). When zeta potential of the particles dispersed in deionized water was measured, 1 mN KCl liquid was added.

The 12.5 wt.% talc suspensions using deionized water and silica sol as dispersing medium were prepared, respectively, by stirring 30 min. These suspensions were centrifuged and the supernatant was decanted into a beaker, subsequently, a very minute amount of the sediment was remixed with the supernatant. The samples were ultrosonicated 5–10 min prior to the measurement to ensure that only the mobility of the single particles was measured. The pH value of suspensions was adjusted with 1 N HCl and 1 N NaOH.

2.4. Sedimentation test

The 12.5 wt.% talc suspensions, with different pH values ranging from 2 to 13, were put in volumetric cylinders to measure the sedimentation volume as a function of time. Sediment volume percent is the volume of the sediment relative to the whole suspension volume in the cylinder.

2.5. Viscosity and rheological measurements

The rheological behavior was characterized using a stress controlled Rheometrics scientific SR5 (Rheological Scientific, USA) with a parallel plate geometry (25 mm