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Controlling the Degree of Dispersion of Aluminum Hydroxide Suspensions by Steric Stabilization

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Abstract

Eighty-eight percent hydrolyzed polyvinyl alcohol was effective in dispersing an amorphous carbonate-containing aluminum hydroxide suspension. It is believed that the polyvinyl acetate units are adsorbed, providing an anchor for the highly hydrated polyvinyl

alcohol units. Hydroxypropyl cellulose did not exhibit steric stabilization, probably because it is too soluble to be significantly adsorbed.

Introduction

Several recent studies have demonstrated that the degree of dispersion of amorphous carbonate-containing aluminum hydroxide suspensions can be controlled by electrostatic stabilization.[1-10] Thus, the desired degree of dispersion is achieved by adjusting the pH in relation to the point of zero charge to produce the required surface potential[1-9] or the surface potential is altered by adsorption of either a polyelectrolyte or an ionic surface active agent.[10] Steric stabilization also influences the degree of dispersion but is characterized by the absence of an electrostatic component. Thus, steric stabilization operates in aqueous suspensions regardless of ionic strength as well as in nonaqueous suspensions. In addition, good freeze-thaw stability is attributed to sterically stabilized suspensions.[11-13]

Steric stabilization requires a nonionic polymer which is adsorbed to the particle surface and is also highly solvated by the dispersion medium.[14] Since steric stabilization offers advantages in controlling the degree of dispersion, studies were undertaken to apply this approach to aluminum hydroxide suspensions.

Two nonionic polymers were chosen for evaluation: hydroxypropyl cellulose, a water soluble polymer; and 88% hydrolyzed polyvinyl alcohol, a copolymer of polyvinyl alcohol and polyvinyl acetate. The polyvinyl acetate units are insoluble in water while the polyvinyl alcohol segments are water soluble.[15]

Materials and Methods

Amorphous carbonate-containing aluminum hydroxide suspension (Chattem), 88% hydrolyzed polyvinyl alcohol (Aldrich) and hydroxypropyl cellulose (Hercules) were obtained commercially. The equivalent aluminum oxide content was determined by chelatometric titration.[16] The point of zero charge was found to be 6.8 by potentiometric titration.[1] A gasometric displacement technique was used to determine the carbonate content.[17] The use of the fiber optic Doppler anemometer (SIRA) to monitor particle interactions has been previously described.[4]

The empirical formula, $AL(OH)_{3-R}(HCO_3)_R$, was used to calculate the volume fraction, where R is the carbonate to aluminum ratio. All suspensions were prepared by adding a solution containing the appropriate quantity of polymer to the amorphous carbonate-containing aluminum hydroxide suspension. The suspension was diluted to a volume fraction of 0.035 with doubly distilled water. The pH of each suspension

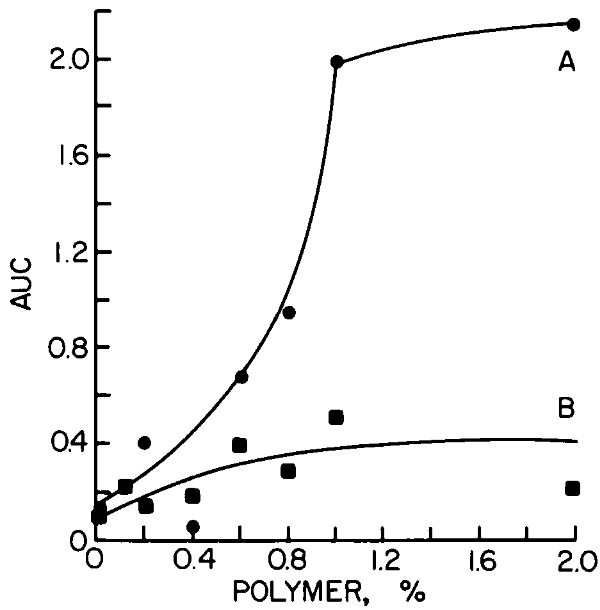

Figure 1

Effect of 88% hydrolyzed polyvinyl alcohol (line A) and hydroxypropyl cellulose (line B) on the degree of dispersion of an amorphous carbonate-containing aluminum hydroxide suspension at a volume fraction of 0.03 and pH 6.8. The point of zero charge is 6.8. The degree of dispersion is characterized by the area under the curve (AUC) of the modified Lorentzian power spectrum as determined by fiber optic Doppler anemometry.

was adjusted to pH 6.8 with 1 N NaOH and a final dilution with doubly distilled water brought the volume fraction to 0.030.

Results and Discussion

The degree of dispersion was monitored by fiber optic Doppler anemometry[4,5]. FODA measures the shift in frequency of back scattered light caused by randomly moving particles[18]. The area under the curve (AUC) of the modified Lorentzian power spectrum is an indication of the relative number of freely diffusing particles[4]. Thus, the AUC is greatest when the suspension is dispersed and approaches zero when the suspension is flocculated or coagulated. The pH of the suspension was adjusted to be equal to the point of zero charge. As expected, attractive interparticle forces predominated under these conditions and the AUC of the control approached zero (Fig. 1). Addition of 88% hydrolyzed polyvinyl alcohol caused the AUC to increase, indicating increased dispersion (Fig. 1, line A). Maximum dispersion occurred with 1% polymer. In contrast, virtually no dispersion was observed when up to 2% hydroxypropyl cellulose was added (Fig. 1, line B).

The results emphasize the importance of adsorption and solvation in steric stabilization. It is believed that the 88% hydrolyzed polyvinyl alcohol had the proper balance of these properties to effect dispersion. The polyvinyl acetate units were adsorbed by the carbonate-containing aluminum hydroxide surface, providing an anchor for the highly hydrated polyvinyl alcohol units. In contrast, hydroxypropyl cellulose was probably too water soluble to be significantly adsorbed. Thus, it did not sterically stabilize the carbonate-containing aluminum hydroxide suspensions.

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