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FLUIDIZATION OF ALUMINUM HYDROXIDE GELS CONTAINING XANTHAN GUM

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ABSTRACT

Suspensions of aluminum hydroxide dried gel interacted with xanthan gum to form a thick coagulum. Addition of low concentrations of deflocculants (sodium tripolyphosphate, sodium citrate, potassium phosphate dibasic) prevented coagulum formation. Sorbitol, 5%, was also effective. Suspensions made from a fluid aluminum hydroxide concentration did not become coagulated in the presence of xanthan gum.

INTRODUCTION

The extent of flocculation of several substances was increased in the presence of xanthan gum[1]. Evidence obtained from sedi-

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mentation, adsorption and zeta potential measurements suggested that flocculation involved bridging of the positively charged particles by gum molecules, which are anionic[2]. Further evidence for an adsorption based mechanism was obtained from studies with magnesium carbonate suspensions containing various concentrations of docusate sodium, which acted as a deflocculant[3]. Because of competition for surface sites on the particles, the flocculating tendency of xanthan gum was reduced as the docusate sodium concentration was increased.

Flocculated suspensions are generally preferred because they can usually be redispersed by shaking after sedimentation while deflocculated suspensions tend to settle into a non-redispersible cake. However, excessive flocculation is also undesirable because pourability and appearance are adversely affected.

In experiments performed in our laboratory, it was found that a thick coagulum sometimes resulted when xanthan gum was added to suspensions containing aluminum hydroxide. The viscosity of highly concentrated antacid suspensions was reduced by carrageenan, which acted by reducing the zeta potential of the particles so that deflocculation occurred[4]. Experiments were conducted to determine whether the addition of deflocculants to aluminum hydroxide suspensions containing xanthan gum might modify or prevent coagulum formation. Included were sodium tripolyphosphate, potassium phosphate dibasic, and sodium citrate. Sorbitol was also used in some of the suspensions.

EXPERIMENTAL

Materials used included aluminum hydroxide dried gel (F-1000, Reheis Chemical), fluid aluminum hydroxide concentrate (liquigel, Reheis Chemical), xanthan gum (Keltrol, Kelco Div. Merck and Co.), sodium tripolyphosphate, purified (Fisher Scientific), potassium phosphate dibasic (Fisher Scientific), sodium citrate, hydrous (Merck and Co.) Polyvinylpyrrolidone (Fisher Scientific) and sorbitol (ICI Americas). Water used to prepare stock solutions and make the suspensions contained 0.1% methylparaben (Eastman) and 0.2% propylparaben (Eastman).

All suspensions contained an amount of aluminum hydroxide equivalent to 4 g aluminum oxide/100 mL. For suspensions made with the dried gel, 100 mL of water were placed in a beaker. The dried gel was added and dispersed with a Brookfield Counter-Rotating Mixer. After 15 minutes of mixing, ingredients other than xanthan gum were added in the form of a liquid concentrate. (Except for sorbitol, 10% stock solutions were generally employed.) The dispersion was then mixed for 5 minutes. The xanthan gum was next added as a 1% solution in water and mixing was continued for an additional 5 minutes. The suspension was then made up to volume (200 mL) and the finished suspension made with fluid aluminum hydroxide concentrate was the same except that 50 mL of water was used in the initial dispersion step.

Suspensions were evaluated after 6 weeks of storage at room temperature. Sedimentation volume (height of the sediment divided by the height of the suspension) was measured on samples stored in cylindrical bottles. Viscosity was measured using a Brookfield LVT instrument with a No. 2 spindle at 30 RMP. Such measurements were made directly in the jars in which the suspensions were kept. Suspensions were shaken thoroughly prior to determination of viscosity. Redispersibility was judged qualitatively using the samples that had been permitted to sediment for a six week period in cylindrical bottles.

RESULTS AND DISCUSSION

Suspensions which contained only aluminum hydroxide dried gel settled to a sedimentation volume of 0.50. Although flocculated[1], these suspensions were not resuspendible. The addition of sodium tripolyphosphate (with no xanthan gum present) caused a considerable reduction in sedimentation volume that depended on tripolyphosphate concentration (Fig.1). When these suspensions settled the sediments could not be redispersed. The reduction in sedimentation volume, which is symptomatic of deflocculation, was probably due to adsorption of tripolyphosphate ions, carrying negative charges onto the surface of aluminum hydroxide particles. The negatively charged particles which repel one another settle individually to form a compact cake not easily disrupted by shear.

If 0.2% xanthan gum was included in a suspension of dried gel, a curdled mass formed. The resultant product was not pourable. The inclusion of small concentrations of deflocculants changed suspension characteristics to that of a fluid system

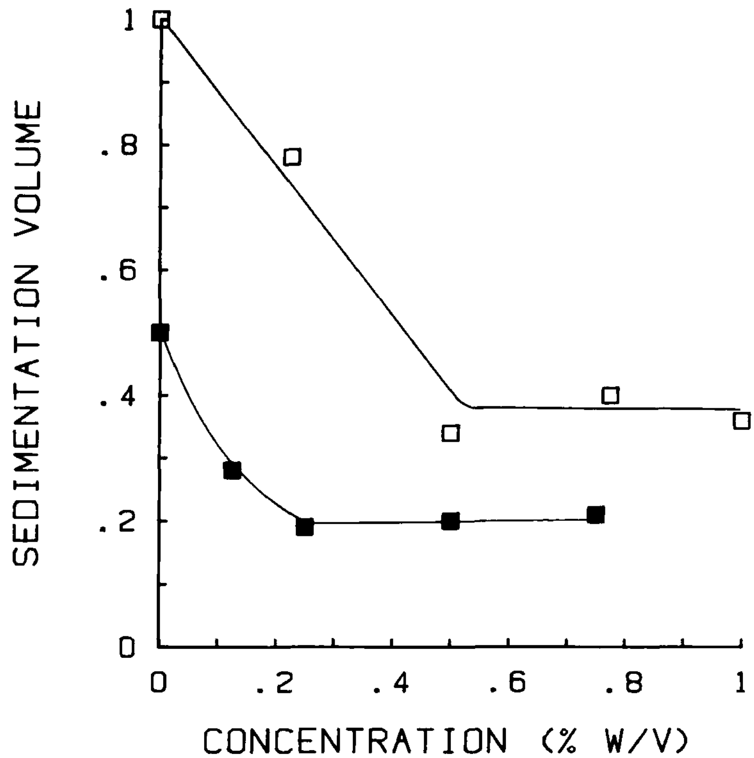

Fig. 1. - Sedimentation volume of suspensions of aluminum hydroxide dried gel containing various concentrations of sodium tripolyphosphate. Filled squares: no xanthan gum. Open squares: 0.2% xanthan gum.

which could easily be redispersed after settling. The effect of sodium tripolyphosphate on sedimentation volume of suspensions of aluminum hydroxide dried gel containing xanthan gum is shown in Fig. 1. All of these suspensions were resuspendible. Table I contains results for other additives. In general, the deflocculants (sodium tripolyphosphate, sodium citrate, potassium phosphate dibasic) reduced values of sedimentation volume and viscosity.

TABLE I

CHARACTERISTICS OF ALUMINUM HYDROXIDE DRIED GEL SUSPENSIONS CONTAINING 0.2% XANTHAN GUM

Additive, Concentration (% w/v)	Sedimentation Volume	Viscosity (cp)	Redispersibility
none	1.0	>1000	not redispersible
sodium citrate, 0.2	0.37	220	redispersible
sodium citrate, 1.0	0.19	190	redispersible
potassium phosphate dibasic, 0.2	0.99	310	redispensible
potassium phosphate dibasic, 1.0	0.75	180	redispersible
polyvinylpyrrolidone, 1.0	1.0	>1000	not redispersible

Polyvinylpyrrolidone, which is not charged, had no discernable effect on suspension properties.

Results for a series of suspensions containing 5% sorbitol are collected in Table II. Suspensions of aluminum hydroxide dried gel containing 0.2% xanthan gum and 5% sorbitol had the consistency of a soft gel and were resuspendable. The addition of deflocculants to these suspensions reduced viscosity and lowered sedimentation volume.

These results suggest that interaction of the aluminum hydroxide suspensions with xanthan gum may be due to extensive

TABLE II

CHARACTERISTICS OF ALUMINUM HYDROXIDE DRIED GEL SUSPENSIONS CONTAINING 0.2% XANTHAN GUM AND 5% SORBITOL

Additive, Concentration (% w/v)	Sedimentation Volume	Viscosity (cp)	Redispersibility
none	1.0	390	redispersible
sodium tripolyphosphate, 0.2	0.50	260	redispersible
sodium citrate, 0.2	0.75	230	redispersible
potassium phosphate dibasic, 0.2	0.97	240	redispersible

flocculation, which binds the particles together into a coherent three dimensional network. The mechanism of flocculation involves bridging and simultaneous adsorption of the negatively charged gum molecules to two or more of the positively charged particles of dried aluminum hydroxide gel[2]. The ability of sodium tripolyphosphate, sodium citrate and potassium phosphate dibasic to prevent coagulum formation appears to be tied to their surface activity. Adsorption of negative ions would make the surface potential more negative, thus reducing the attraction of particle surfaces for adsorption of xanthan gum and consequently reducing the degree of flocculation.

Too high a concentration of deflocculant is undesirable because the particles would acquire a substantial negative potential which might prevent flocculation altogether. This can lead to caking. The lowest concentration effective in preventing coagulum formation should be used.

Suspensions made from a fluid aluminum hydroxide concentration were easy to redisperse after six weeks of storage. The sedimentation volume was 0.64. Addition of 0.2% xanthan gum raised the sedimentation volume to a value of 1.0. There was no evidence of coagulum formation in this system.

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