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Guar gum and guar gum-oligomeric poly(vinyl alcohol) blends as novel flocculants for kaolinated waste water

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ABSTRACT

This is probably the first report on kaolin flocculation done with aqueous guar gum (GG) at various pH. Dynamic light scattering and reduced viscosity proved the polyelectrolytic feature (zeta potential) of aqueous GG which changed on changing pH. Interestingly, the molecular size of GG did not always increased with rising zeta potential due to strong intermolecular repulsion leading to macromolecular recoiling. Best pH range for settling was 4.0–5.0 which included isoelectric point (IEP) of kaolin. Post-settling turbidity was also acceptable at that range. Optimized GG was further blended with oligomeric poly (vinyl alcohol) (PVA) (Mn 14,000) to prepare a new set of flocculant. Oligomeric PVA was previously optimized at similar pH as excellent kaolin flocculant in our earlier investigation. All GG–PVA blends including neat GG exhibited faster settling than neat PVA. However, settling times of all blend compositions were slightly greater than that of neat GG except for few cases where the post settling turbidity was found significantly lower than all our previous investigations.

1. Introduction

Removal of kaolin from various industry effluents is an important issue since it is highly difficult to settle due to strong repulsion between its negatively charged silicate layers [1–6]. Inorganic salts like alum, carrying strong positive ions, were used earlier to flocculate kaolin via charge neutralization [7] but the practice was abandoned of late mainly due to (i) huge sludge formation and (ii) high physico-toxicity of the remnant metal ions [8]. Recent trend is to explore polymeric flocculants whose sludge content is far too less. But toxic intermediates produced by some synthetic polymers, such as poly (acrylamide) [6], are still a great concern [9]. Inclination is more toward biopolymers or polymers of synthetic origin having complete biodegradability. Various polysaccharides and carbohydrates e.g. guar gum [10,11], xanthan gum [12], agar [13], tamarind kernel [14], starch [15], cellulose [16], chitosan [17], preferably as grafted derivatives, have been explored as kaolin flocculants at times since grafting imparts strong polyionic character. But high synthetic content due to grafting often reduce biodegradability [18]. Example of biodegradable synthetic polymers such as kaolin flocculant is truly less barring our previous investigation using various PVA [2]. PVA of widely different molecular weight was explored as kaolin flocculant by changing the pH of the medium. Oligomeric PVA (Mn 14,000) at pH 4.0 was finally optimized as the best flocculant pertinent to settling time, residual turbidity and the amount of fresh water lost during settling. Balance between these issues is the key to commercial success of any flocculant but most of the literatures published so far have hardly addressed them with proper clarity. In the present article we have principally explored neat GG as the kaolin flocculant by changing its pH within the acidic range. It was needless to move toward basic range since isoelectric point (IEP) of kaolin lies within pH 4.0–5.0 [2,19]. After optimization, the best GG sol was further blended with oligomeric PVA in various weight proportions and similar investigations were repeated for further optimization.

2. Experiment

2.1. Materials

GG was gifted by Hindustan Gum, Bhiwani, Haryana, India. PVA of number average molecular weight 14,000 (PDI 1.42) was purchased from E. Merck, Germany. Kaolin (suspension zeta potential −4.9 mV at pH 7) was supplied by B.D. Pharmaceuticals Works Pvt. Ltd., Howrah, West Bengal, India. All materials were used as received without further purification. Tap water, used for flocculation study, had the following specifications: pH 7.0–7.3, turbidity ≈ 0.1 NTU, total hardness equal to 12 mg $CaCO_3$/L.

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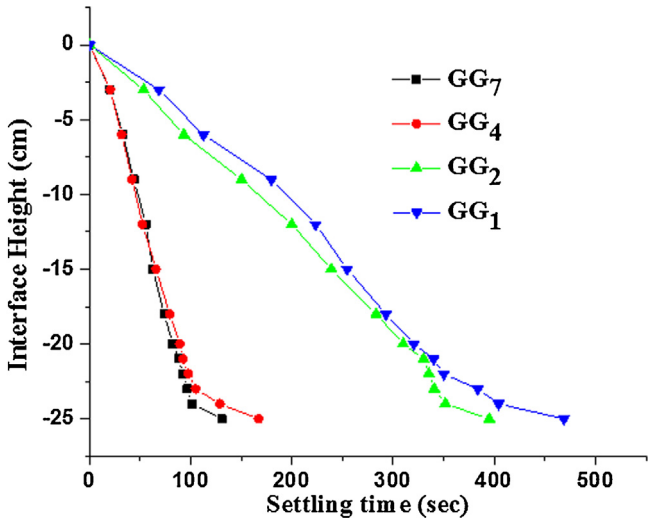

Fig. 1. Kaolin settling profiles using aqueous GG taken at various pH.

2.2. Flocculant preparation

1% aqueous GG was prepared by dissolving 1 g GG into 100 ml distilled water. Different acidic pH was adjusted by putting calculated amount of (N/10) hydrochloric acid in the sol. GG–PVA blends were prepared by mixing 1% GG with 5% aqueous PVA. Aqueous PVA was prepared by dissolving 5 g PVA into 100 ml distilled water under boiling condition. The sols were mixed together and sonicated for 30 min as per the intended GG:PVA mass proportions, stated in Table 1.

2.3. Flocculation study

Flocculation was studied via classical jar test at room temperature using aqueous GG and GG–PVA blends with model waste water made by dispersing 3 wt% kaolin. The kaolin suspension was shaken ten times for homogenization. 9 ml 0.01% aqueous flocculant was added to the suspension and the volume was made up to 100 ml in the graduated settling cylinder which was further inverted 10 times for homogeneous mixing. Final flocculant concentration in the cylinder was 9 ppm. It was universally maintained for each measurement since it was previously determined as the best flocculant dose. After 1 min equilibration, the change of interfacial height versus time data was recorded until 25 cm from the initial height was diminished.

2.4. Zeta potential measurement

Zeta potentials of different flocculants and kaolin suspension were measured in a Dynamic Light Scattering Spectrophotometer, DLS-7000.

2.5. Reduced viscosity measurement

Reduced viscosity of the flocculants was determined to understand their hydrodynamic volume. Falling time (t) of each aqueous flocculant was first measured at seven different concentrations in an Ubbelohde Viscometer as per ASTM-D-445 (capillary no: II, ID:

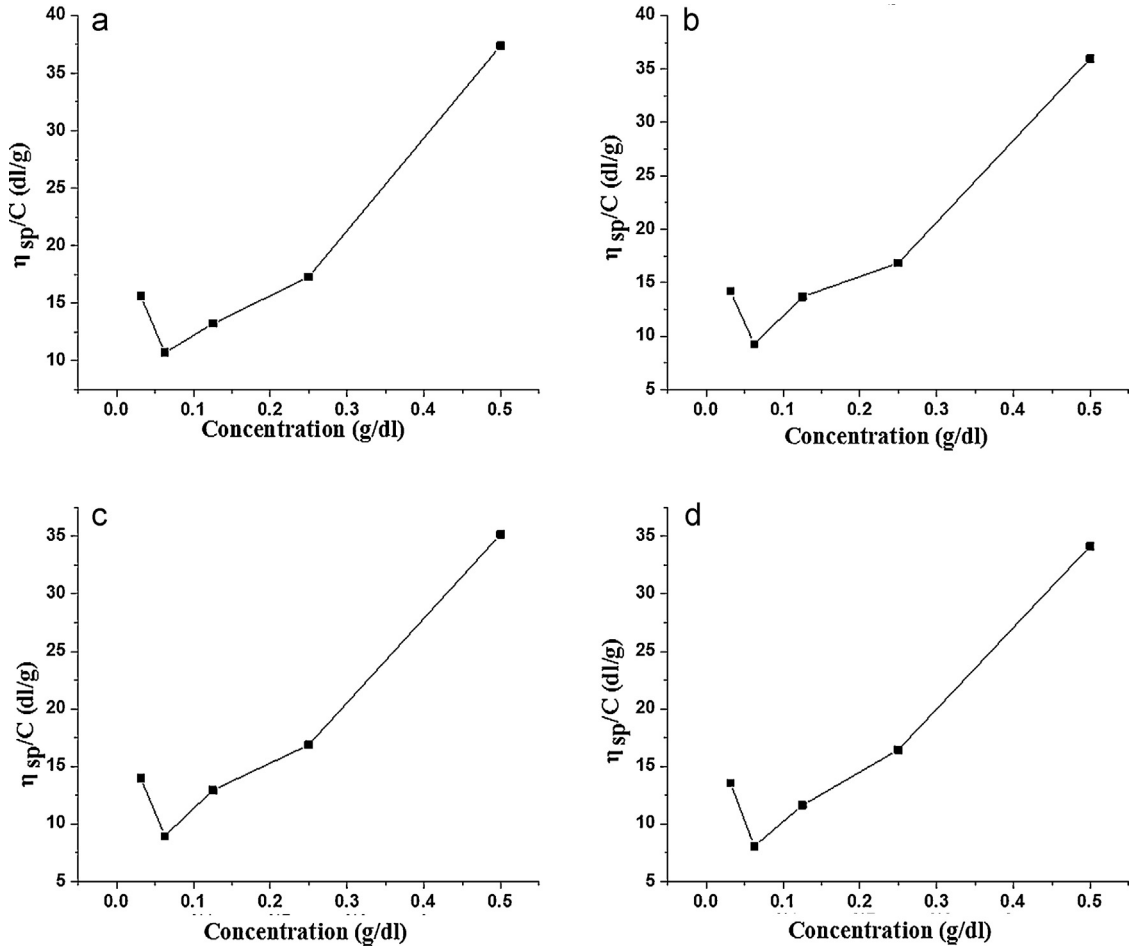

Fig. 2. Reduced viscosity versus concentration plots of neat GG at: (a) pH 7.0, (b) pH 5.0, (c) pH 3.0 and (d) pH 2.0.