

ABSTRACT

Water soluble polymers based on grafted polysaccharides have drawn much attention in the recent decades because of their controlled biodegradability, shear stability and high efficiency as turbulent drag reducers and flocculants. The graft copolymers show better performance in flocculation compared to their linear counterparts, which is because of the better approachability of the grafted acrylic chains to the colloid particles.

The aim of the present investigation was to synthesize the graft copolymers of polyacrylamide (PAM) with guar gum (GG) and its derivative hydroxypropyl guar gum (HPG). Further in case of HPG, it was envisaged to synthesize a series of graft copolymers with variation in the number and length of PAM chains. The plan was to study the efficacy of the two copolymers among themselves as well as the impact of variation in the number and length of PAM chains in the graft copolymers on flocculation. The drag reduction characteristics of the best performing graft copolymer were also envisaged in the present study.

The graft copolymers were synthesized by solution polymerization technique using ceric ion induced redox method of initiation. The concentrations of acrylamide and ceric ammonium nitrate (CAN) were varied to affect a variation in the number and length of PAM chains in the HPG based graft copolymers. The synthesized products were then characterized by various material characterization techniques like viscometry, elemental analysis, Infrared spectroscopy (IR), thermal, X-ray diffraction (XRD) and Scanning electron microscopic (SEM) studies. Flocculation characteristics of graft copolymers were evaluated in three synthetic effluents, namely, kaolin, iron ore and silica suspension. The results were then compared with various commercially available flocculants. The effect of pH on the flocculation characteristics of grafted and ungrafted polysaccharides has been studied in above mentioned three suspensions.

It was also envisaged to synthesize partially hydrolyzed GG and HPG by the treatment with alkali. A series of hydrolyzed products of HPG was synthesized with varying the experimental conditions in order to establish the flocculation efficiency with expansion and straightening of the grafted flexible PAM chains as $-\text{CONH}_2$ groups of PAM chains are converted to $-\text{COO}^-$ groups upon hydrolysis. Repulsion between adjacent negatively charged groups leads to chain expansion. The hydrolyzed products were characterized by neutralization equivalent, elemental analysis and IR studies.

The drag reduction characteristics of the best performing graft copolymer were studied and compared with the base polysaccharide, i.e. HPG. Along with the drag reduction study in sprinkler irrigation system, the reduction in energy requirement and increment in area of coverage have also been studied.

A series of six graft copolymers based on HPG (HPG-g-PAM 1 to HPG-g-PAM 6) and one based on GG (GG-g-PAM) were synthesized. The variation of synthetic parameters is reflected in the intrinsic viscosity of graft copolymers. Results of elemental analysis, IR, thermal, XRD, SEM etc. establish the proof of grafting. Among the base polysaccharides, such as, GG and HPG, it has been observed that GG shows the better performance when compared to HPG in all the three suspensions. While in case of graft copolymers, HPG-g-PAM shows the better performance compared to GG-g-PAM. When compared with some of the commercial flocculants, HPG-g-PAM was found to be best in performance except in few cases. In the series of graft copolymers based on HPG, the one with fewer and longer PAM chains was found to be most effective in all the three suspensions. The effect of pH has pronounced effect on the flocculation characteristics of the graft copolymers. At acidic pH, the flocculation characteristics are better than in alkaline suspension in iron ore and silica suspensions, while an opposite trend is observed in kaolin suspension.

During partial alkaline hydrolysis of HPG grafted PAM, it is possible to control the carboxyl content by controlling the reaction parameters, e.g. time, temperature and concentration of alkali. All the hydrolyzed products showed better flocculation performance than the unhydrolyzed product in kaolin suspension. In iron ore suspension an opposite trend is observed, which also confirmed the results obtained in pH study. However, in silica suspension no settling behaviour is observed due to high turbid of the resulting suspension. The hydrolyzed product, which has certain amount of carboxyl content but is still having flexible grafted chains showed better flocculation performance than others having the higher carboxyl content and complete loss of flexibility.

When the drag reduction, power reduction and enhancement in area of coverage were studied in sprinkler irrigation system, it was observed that the graft copolymer shows better performance than the base polysaccharide.