

## CHAPTER V

### CONCLUSIONS AND SUGGESTIONS

#### 5.1 Conclusions

The FT-IR spectrum of  $\text{Al}(\text{OH})_3$  has many interesting peaks. The major absorption peaks are  $3352\text{ cm}^{-1}$  (O-H stretching),  $1653$  and  $1129\text{ cm}^{-1}$  (S=O stretching of the sulphate group),  $981\text{ cm}^{-1}$  (HO-Al) and  $619\text{ cm}^{-1}$  (O-Al). Poly[AM-co-(AA)] exhibits the peak of the O-H stretching at  $3435\text{ cm}^{-1}$ , the C-H stretching at  $2932\text{ cm}^{-1}$  and the peak at  $1447\text{ cm}^{-1}$  for the C-H asymmetric bending. Moreover, the peaks at  $3266$ ,  $1633$ , and  $1330\text{ cm}^{-1}$  indicate the N-H stretching, C=O stretching, and C-N stretching of amide groups, respectively. Considering the FT-IR spectrum of AHAMAA, the major peaks are divided into 2 portions. The peaks at  $620$ ,  $1119$  and  $1658\text{ cm}^{-1}$  indicate the Al-O portion while the other peaks ( $3266$ ,  $1633$ , and  $1330\text{ cm}^{-1}$ ) indicate the poly[AM-co-(AA)] portion. From the  $^{27}\text{Al}$ -NMR spectra of  $\text{Al}(\text{OH})_3$  and AHAMAA, it has indicated that  $\text{Al}(\text{OH})_3$  and Al in AHAMAA are the monomeric and/ or dimeric species because the signal near  $0.0\text{ ppm}$  was found.

The SEM micrographs of poly[AM-co-(AA)] and AHAMAA show the difference of surface morphology. Poly[AM-co-(AA)] has two different surfaces, smooth and porous, whereas AHAMAA has white powder particles widely imbedded on the smooth surface.

The percentage residual acrylamide monomer of poly[AM-co-(AA)] is in the range of  $0.07$ - $0.12\%$  by weight ( $42.6$  to  $67.8\text{ ppm}$ .) and is slightly dependence on the acrylamide concentration. This result indicates that most of acrylamide monomer is

reacted with acrylic acid to become the copolymer and that some AM molecules are removed during the process.

The water absorbency of poly[AM-*co*-(AA)] increased when increasing the acrylic acid concentration. In the case of AHAMAA, when the acrylic acid concentration is  $4 \times 10^{-3}$  mol, the highest water absorbency of AHAMAA is achieved at  $145 \pm 6$  g g<sup>-1</sup> times its dried weight. The highest water absorption values of poly[AM-*co*-(AA)] and AHAMAA are achieved at  $322 \pm 13$  and  $148 \pm 2$  g g<sup>-1</sup> times its dried weight, respectively, when N-MBA concentration is  $1.2 \times 10^{-4}$  mol. In addition, when N-MBA concentration is increased the water absorbency of poly[AM-*co*-(AA)] and AHAMAA is also decreased. At  $1.6 \times 10^{-4}$  mol of APS, the synthesized poly[AM-*co*-(AA)] and AHAMAA can absorb water up to  $235 \pm 7$  and  $158 \pm 7$  g g<sup>-1</sup> times its dried weight, respectively. The optimum concentrations of TEMED for poly[AM-*co*-(AA)] and AHAMAA were  $96 \times 10^{-4}$  and  $36 \times 10^{-4}$  mol which gave the highest water absorbency of  $888 \pm 24$  and  $294 \pm 25$  g g<sup>-1</sup> times its dried weight, respectively. It is found that the residual aluminium concentration in water is in the range of 0.09-0.2 ppm regardless of the soaking time. It indicates that the stability of aluminium in the AHAMAA is high.

The rheological studies indicate the elastic response of poly[AM-*co*-(AA)] and AHAMAA is stronger than the viscous response. The aluminum polymer flocculant has a higher storage modulus which agrees with the lower water absorption. The interaction between the carboxylate anion and aluminium ion in AHAMAA creates the rigid chains and results in the higher storage modulus. It confirms that the low water absorbency is controlled by the rigid polymer chains. The neat polymer and AHAMAA are the strong gel.

The efficiency of Congo red removal by AHAMAA is better than poly[AM-*co*-(AA)] prepared by the fixed concentrations of acrylic acid, crosslinking agent, initiator and co-initiator at  $4 \times 10^{-3}$ ,  $2.3 \times 10^{-4}$ ,  $1.6 \times 10^{-4}$ , and  $12 \times 10^{-4}$  mol, respectively. Poly[AM-*co*-(AA)] absorption of Congo red is possibly attributed by its porous structure whereas AHAMAA absorption obeys the Freundlich model. Poly[AM-*co*-(AA)] obtained from all synthesis conditions cannot remove the direct blue 71 whereas AHAMAA can also remove direct blue 71 and obeys the Freundlich model as well. Both of the Congo red and direct blue 71 are removed by poly[AM-*co*-(AA)] and AHAMAA at pH 5 in both the non-buffered and buffered systems. However, the dye removal efficiency in the buffered system was lower than that of the non-buffered system due to the Al-citrate complex formation. The ionic strength did not affect the Congo red removal by poly[AM-*co*-(AA)]. In the case of AHAMAA, the effect of ionic strength on the dye removal was significant at pH 5 because the high concentration of the cation and anion in the buffered system of Congo red and direct blue 71 may reduce the electrostatic interaction between AHAMAA and the dye molecule.

The relative turbidity values of the kaolin suspension in poly[AM-*co*-(AA)]s are decreased by 82% after three hours of flocculation. Thereafter, the relative turbidity is constant regardless of the longer flocculation time until 24 h. In the case of AHAMAA, the relative turbidity decreases rapidly after three hours of flocculation and insignificantly increases when increasing the flocculation time. In addition, AHAMAA contributes to the higher turbidity removal efficiency than poly[AM-*co*-(AA)] after 9 hours of flocculation.

## 5.2 Suggestions for future work

Synthesis of this type of polymeric flocculant by solution crosslinking polymerization would be further studied as follows: Investigation of the exact roles of the initiation pair and its mechanism; the role of the acidic comonomer and its maximum concentration used to provide the maximum water absorption. The interaction presumed for explanation of causes in water absorption direction should be elucidated to give some basic knowledge. Moreover, the elimination of poly[AM-co-(AA)] and AHAMAA after dye removal would be studied.

Waste managements of the used polymers and the absorbed dyes should be considered. Besides, the polymer waste is landfilled or sinterated, there should be some techniques to reuse it as a secondary application for example usage for a soil erosion material by mixing the polymer waste with concrete, or use as second grade soil conditioner for sandy soil.