

CHAPTER V

CONCLUSION AND SUGGESTION

5.1 Conclusion

Major commercial synthetic water soluble polymers are preferably made by solution (aqueous bulk gel), inverse phase (suspension or emulsion) polymerization process. Subsequently, in 1990, the foamed polymerization process was invented for using in the synthesis of water soluble polymers. This process has several distinct advantages. It is a rapid polymerization process due to the autoacceleration reaction taking place without any system overheating to allow high monomer conversion obtained. In addition, the polymer produced contains low water content, of which is much easier to get rid while the other process seems to be more difficult. Therefore this process has been more attractive and used in the synthesis of graft copolymer in many research works. However information on the mechanism and kinetics of polymerization in this process have not been studied before and still unknown. In this research work, the starch-g-polyacrylamide copolymer and homopolymer of acrylamide was also synthesized via the foamed polymerization. The

presence work on the fundamental mechanism and kinetics of the foamed polymerization of acrylamide were carried out.

The new findings from these studies are summarized hereafter.

5.1.1 Starch-g-polyacrylamide and acrylamide homopolymer were synthesized via the foamed polymerization. The chemical structures of these polymers were investigated using a FT-IR spectrophotometer. The peak characteristics correspondent to functional groups of the acrylamide homopolymer obtained are similar to those of the standard polyacrylamide spectrum reported in the literature (36). From the IR spectrum of starch-g-polyacrylamide, the peak characteristics relevant to the functional groups of the graft copolymer and homopolyacrylamide are overlapped so that distinct interpretation of individual peak characteristics could not be made. It is likely to state that the starch-g-polyacrylamide and the homopolyacrylamide are synthesized mutually.

5.1.2 The degradation process of starch backbone by alkali foaming agent was investigated. It was found that the alkaline-catalyzed oxidative degradation of starch by sodium carbonate occurred at high temperature, e.g. at 60,80 and 100 °C leading to the starch chain scission and lowering its molecular weight, which were confirmed using a FT-IR, DSC and TGA techniques.

5.1.3 The kinetics of foamed polymerization of acrylamide in the presence of potassium persulphate initiator under the isothermal condition were investigated. The percentage of monomer conversions and

initial rates of polymerization were determined using differential scanning calorimetry. The studied range of concentration of acrylamide monomer and potassium persulphate initiator were 2.44-3.66 mol/L and 0.0012-0.0001 mol/L, respectively. The polymerization temperature studied ranged from 70 to 90°C. The dependences of initial rate of polymerization on monomer and initiator concentrations were found to be 1.21 and 0.5 power, respectively. The high monomer order greater than 1.0 has been explained due to the monomer-enhanced initiation by a hybrid-cage-complex mechanism.

The initiator order of 0.5 indicates that the termination should be by mutual combination of polymer chain radicals. The gel effect was found when the initiator concentration was above 3.66×10^{-3} mol/L within the tolerance of 5%. The polymerization temperature above 70°C results in quicker rate of polymerization of the foamed system which, in effect, enhanced the autoacceleration reaction under the isothermal condition.

The high limiting conversions were observed because of the hybrid mechanism and the gel effect in the system studied. The rate expression was proposed. The rate of polymerization (R_p) is $R_p = K[AM]^{1.21}[K_2S_2O_8]^{0.5}$. The average overall rate constant at 70°C was found to be 5.45×10^{-3} L/mol.s and 5% conversion. The overall activation energy was found to be 58.48 kJ/mol (13.98 kcal/mol). All of these values are within the tolerance of 5%.

5.1.4 The thermal effects for the foamed polymerization of acrylamide were also investigated. The synthesis of foamed polymerization of acrylamide under the non-isothermal system was carried out in ampoules. The temperature of the system and the conversion during the course of polymerization and the initial rate of polymerization were measured using a thermocouple-datalogger-interfacing computer system and a refractometry technique. It was found that the temperature of system raised up when the amount of heat of polymerization produced. This leads to the occurrence of autoacceleration reaction at the early stage of the polymerization. The high conversion was then reached within a very short time. The foamed system was found to enhance the autoacceleration reaction in the system

The effects of reaction scale, surface area/volume ratio of ampoule and the reaction mass on the temperature of polymerization and conversion during the course of polymerization were also studied. Larger values of those factors enhanced the vital autoacceleration reaction. These effects should be considered in the designing of reactor and scaling up of the foamed polymerization process.

5.2 Suggestions

For further works, there are a number of deficient information concerning the foamed polymerization process, which have been recently

discovered. Further studies should be carried out in order to fully understand the process, and some are suggested here, which result from the work presented here.

5.2.1 The physical properties of polyacrylamide produced should be investigated including : the molecular weight and molecular weight distribution, and the solution properties and rheological behaviors.

5.2.2 The kinetics of foamed polymerization process should be investigated further as follows :

a) The kinetics of foamed polymerization of acrylamide under the non-isothermal condition : especially to create the kinetic expression in non-isothermal system.

b) The kinetics of foamed polymerization of other water soluble monomers : to understand whether or not the kinetics of polymerization of other monomers are as same as that of acrylamide.

5.2.3 Studies on grafting of the acrylamide on to starch backbone at the initiation step of the polymerization should be studied whether or not it is possible. If it is achieved , the suggested method can control the formation of the mixture of starch-g-polyacrylamide and homopolyacrylamide.

5.2.4 In the synthesis of polymers using the non-isothermal foamed polymerization process, the temperature of system should be properly controlled in order to acquire the good reproducibility of the reaction behavior and properties of the polymeric product.