Chapter 6:
Summary and conclusion

6.1. SUMMARY/CONCLUSION

The current study delineates the synthesis of VAc-based co- and terpolymers, VAc-based terpolymer/clay composites and their subsequent characterizations. Emulsion polymerization was used to prepare all those co- and terpolymers. The copolymerization was carried out using two initiators: KPS and APS. The resultant colloidal latexes of the copolymer, poly(VAc-*co*-BA) and terpolymers, poly(VAc-*t*-BA-*t*-AA) and poly(Sty-*t*-BA-*t*-VAc) were stable for several weeks and were nearly transparent as evident by the UV-Vis analyses. In the UV-visible plot, a shift towards a higher wavelength is observed with the increase of BA content in the copolymer. ^{1}H NMR analysis is performed to determine the monomers' composition in the co- and terpolymer via the calculations of areas under the characteristic peaks of the different repeating units present in the copolymer and terpolymer. FTIR along with NMR analyses also confirm the successful incorporation of monomers in the co-and terpolymers. GPC analysis shows uni-modal GPC traces for all the cases indicating the absence of homopolymers. The TEM micrographs of terpolymer latex show that the particles are nearly monodispersed and spherical.

A requisite amount of clay is mixed directly with the terpolymer latexes to prepare terpolymer/clay composites. Thus this way prepared poly(VAc-*t*-BA-*t*-AA) terpolymer/kaolin clay composites are characterized by various techniques. FT-IR study shows the presence of interaction between the >Al=O groups of the clay with that of the carbonyl groups in the polymer. The bonding of clay to the polymer chain was confirmed by observing an increase in the T_g of the composites. The T_g also varies with the clay loading as observed in the DSC analysis. The TGA and DTG analyses show that the degradation temperature rises with increased clay content, indicating that clay improves the thermal stability of the composites. As a result, the thermal properties of the composites are improved. The interaction between the polymer and clay was also established via the measurement of tensile properties. The tensile strength varies with kaolin loading. With the increase in filler loading, the adhesion of clay into the polymer matrix is improved which raises the tensile modulus. Consequently, clay-based composites enhance the physicomechanical properties of polymer films. RPA analysis using strain sweep mode shows that the addition of clay improves the viscous properties of the polymer composites in the molten state. Frequency sweep experiments demonstrate that the complex viscosity of all composites decreases as the frequency range increases. As a result, polymer composites exhibit pseudoplastic or non-Newtonian fluid behaviour. Therefore, it can be concluded that polymer composites have good processing properties and may have a variety of potential applications as adhesives. TGA study proved that the composites are more thermally and mechanically stable than the terpolymers.

Poly(Sty-*t*-BA-*t*-VAc) based terpolymer/kaolin clay composites were also prepared at different clay loading. The prepared terpolymer/clay composites were examined by various analytical techniques, like FT-IR, PXRD and SEM. FT-IR study establishes the interaction between the >Al=O groups of the clay with that of the carbonyl groups of the polymer in polymer/clay composite. From the SEM analysis, the surface morphology of the terpolymer/clay composites is observed which is found to be rougher than the neat terpolymer. The augmentation of roughness increases with the clay loading. However, clay loading enhances the polymer/clay composite's degradation nature. The crystalline nature of the polymer/clay composites can be seen in their respective XRD plots. The crystalline nature of the composites increases with the increase in the amount of clay. The chemical interaction that exists between the monomers' unit and the clay moieties in the composites is supported by all the analyses. This confirms the formation of true composites.

The overall study demonstrates that VAc-based/kaolin composites have good mechanical and thermal properties which may be enhanced further with the use of nanoclay and organically modified nanoclay.

6.2. FUTURE SCOPES

Vinyl acetate is an interesting monomer for the production of new polymeric materials. VAc polymers are eco-friendly and known for their strong adhesive and binding abilities. Therefore, the use of vinyl acetate polymer is on the rise in different areas.

Vinyl acetate-based polymers are an important class of polymers that have several outstanding characteristics including lower volatility, improved film-forming ability, higher softening temperature, and green credentials. They also exhibit good thermal stability, low viscosity, and good adhesive properties. Due to all these outstanding properties, VAc-based polymers find a variety of applications

In most cases, vinyl acetate is copolymerized with various types of acrylate and methacrylate monomers. They are widely used in adhesives, carpet backing, and exterior and interior paint applications. These VAc-based co- and terpolymers are manufactured mostly by emulsion polymerization in industry. Moreover, the obtained latexes are eco-friendly.

Further enhancement of properties of these VAc-based co- and terpolymers may be observed through the preparation of composites of these polymers with clays. Kaolin is one of the most valuable clay minerals that have a wide range of industrial uses. It is readily available in nature, environmentally friendly, has good thermochemical stability, good corrosion resistance, and has remarkable radiation shielding power. Kaolin may be a good filler for VAc-based polymers for the enhancement of properties.

Different speciality monomers may be used to prepare VAc-based terpolymers. Various such VAc-based terpolymers may be used for the preparation of terpolymer/clay composites.

The reinforcing effect of clay in these polymer/clay composites may be observed through the enhancement of properties like electrical conductivity, and mechanical properties. The prepared terpolymer/clay composites may have several beneficial properties. A good amount of knowledge and understanding may be developed through a systematic mechanical, thermal stability and rheology study of these composites. This kind of study could find a solution for the development of low-cost sensors and adhesive materials. The study can also be extended to find a way to recycle waste plastic or non-biodegradable polymers from the environment.