

CHAPTER VIII

CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

In this dissertation, two types of layered inorganic clays: layered silicate and layered double hydroxide (LDH) were chosen as nanofillers for the preparation of polyolefins nanocomposites. Both nanocomposites were successfully prepared by melt intercalation technique. The polyolefins grafted maleic anhydride (i.e. PP-g-MAH and PE-g-MAH) were used as an effective compatibilizer. For polypropylene (PP)/layered silicate nanocomposite, the layered clay was modified with various cationic surfactants (organoclay) to enhance the compatibility between the hydrophilic clay and the hydrophobic polymer. It was found that, the nanocomposites prepared from surfactant having two alky tails and with the longer chain length (i.e. Methyl di-[(partially hydrogenated) tallow carboxyethyl]-2-dihydroxyethyl ammonium methyl sulfate (DOEM)), revealed a good morphological and mechanical properties due to the better clay dispersion. Two distinct groups of the PP nanocomposites were obtained. The nanocomposites prepared with lower amounts of organoclay (i.e. 1 and 2 wt%) provided an exfoliated/intercalated mixed morphology and were characterized by a significant improvement in thermal stability compared to that of the polymer matrix (PP/PPMAH). The intercalated/flocculated morphologies were obtained when the organoclay concentration was beyond the threshold composition of 3 wt% and was characterized by the slight increase in the thermal property. The morphological stability of one series of the PP/layered silicate (modified by Hexadecyltrimethylammonium bromide, CTAB) nanocomposites was studied using the extraction process with hot toluene to evaluate the polymer-clay interactions. It was found not only that the solubility in hot toluene depended on the nanocomposite composition and interactions between polymer chains and silicate layers, but also that the solvent was able to differentially split polymer chains and clay layers as a function of the morphology. The extraction process preserved and in some case improved, the morphology of composites having a quasi-exfoliated structure prepared with a lower amount of organoclay, thus obtaining two fractions

(soluble and insoluble) having similar morphologies and polymer/clay ratios. For samples containing higher organoclay concentration (i.e. 3, 5, and 7 wt%) with having an intercalated morphology, the extraction promoted the formation of a residue fraction containing almost the total amount of the clay and showing a collapse of the inorganic structure with a further reduction of the basal spacing. The solvent was unable to break apart “discriminate” polymer–chains and clay layer bundles dispersed tightly within the matrix at the nanodimension and far-between. In contrast, the larger amount of the intercalated structures was preferentially maintained in the residue fraction where polymer chains were confined between the layers. In this case, an appreciable increase of the glass transition temperature (T_g) of the residue fraction was observed due to the strong interactions between polymer chains and clay layers. Study on the melt rheological properties and extrudate swell behavior of these PP nanocomposites revealed that the exhibited shear-thinning behavior. With increasing layered silicate concentration, the shear stress/viscosity increased, while the power law index (n) decreased and this effects was more significant at higher layered clay concentration (>3 wt%). The activation energy (E_a) decreased with an increase of shear rate and increased sharply with layered clay concentration at or above 3 wt%. The extrudate swell was reduced by the addition of layered silicate clay and particularity when the concentration beyond 3 wt%. This effect was clearly attributed to the limitation of the elastic recovery of the confined polymer chains by highly orientated silicate layers.

For the case of low density polyethylene (LDPE)/layered double hydroxide (LDH) nanocomposites, the polyethylene grafted maleic anhydride (PE-g-MAH) was used as a compatibilizer. The LDH was modified with various anionic surfactants (organo-LDHs). The result revealed that the size of the anionic surfactants played a vital role for the difference in morphology and thermal property. The obtained nanocomposites established partially exfoliated/intercalated mixed morphology. The degree of exfoliation and intercalation depended not only on the chain length of the anionic modifiers used but also the interactions between the alkyl chains of anionic modifiers and the LDH layers. Either exfoliated or highly intercalated structure was preferable when the number of alkyl chain length was larger ($n \geq 12$). Incorporation of the organo-LDHs enhanced both thermal and dynamic mechanical properties. The

LDPE/organomodified LDHs composites exhibited remarkable improvement of the thermal properties such as the decomposition temperature was 20–33 °C higher than the pure matrix. Both storage modulus and glass transition (β relaxation) temperature for the nanocomposites were also improved. With increasing the concentration of the organo-LDHs, the thermal properties and the storage modulus were significant enhanced, but the large aggregated-LDH platelets instead were observed.

8.2 Recommendations

In this research work, the results indicated the good mechanical and thermal properties for both polymer/layered clay nanocomposites. However, study on other variations in the melt compounding conditions such as screw type, screw speed and temperature profile of the extrusion was not conducted. The effect of these variations should be further investigated in order to obtain the optimal processing condition that would give both nanocomposites with the best physical and mechanical properties.

For LDPE/layered double hydroxide nanocomposites, since the preparation was done by small batch Brabender mixer, so the further study should be considered to use the twin screw mixing in order to obtain the better dispersion of LDH particles in the LDPE matrix. The effect of compatibilizer (functionalized polyolefins) such as grafting level, structure and molecular weight should be considerably studied to improve the property of nanocomposites. Moreover, in order to make this material suitable for food packaging, the MAH functionalized polyolefin should be changed to IA functionalized polyolefin, which is non-toxic and good for food packaging application.

In addition, the potential applications such as gas barrier properties as well flame retardant ability for both nanocomposites should be further investigated.