

## CHEPTER V

### CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Conclusions

This study has demonstrated the preparation of Poly (ethylene terephthalate)/montmorillonite nanocomposite films by solution technique using ultrasonic power to promote the compatibility and dispersion of montmorillonite in the PET solution. The 50/50 v/v of 1,1,2,2 tetrachloroethane and phenol was used as a mixed solvent. Two types of montmorillonite, unmodified-montmorillonite and modified montmorillonite with dioctadecyl dimethyl ammonium chloride, were used at various amount (1, 3, and 5 phr). Nanocomposite films were prepared by casting method using an auto film applicator with film thickness range of 20-30 micron. The effects of type and amount of montmorillonite on physical, mechanical, thermal, and optical properties of nanocomposite films were investigated. The results from each characterization were summarized as following;

1. The x-ray diffractograms of PET nanocomposite films containing 1 to 5 phr of unmodified-MMT show no peak of clay probably due to the fact that the added amount of clay is too low to detected, whereas, the XRD pattern of 10 phr unmodified-MMT contained nanocomposite shows clay peak at  $2\theta = 5.5^\circ$  (15.9 Å). Comparing with the clay peak of unmodified-MMT occurring at  $2\theta = 7.0^\circ$  (12.5 Å), the shift of a diffraction peak towards lower angle value [ $2\theta = 7.0^\circ$  (12.5 Å) to  $2\theta = 5.5^\circ$  (15.9 Å)] is likely due to the further expansion of layered silicate platelets occurring during the processing. This result can be indicated that intercalation occurred. Besides this, the XRD pattern of 10 phr 2C18-MMT PET film still shows the same as those of lower organoclay content(1-5 phr). It might be assumed that most silicate layers lose their crystallographic ordering in the nanocomposite and the exfoliation of organoclay occurs. Moreover, the nanofiller; montmorillonite, can act as a nucleating agent for PET matrix at a few clay content resulting in higher degree of crystallinity compared with the pure PET film.

Further increase in the amount of clay decreased the nucleating function of nanofiller because of the clay agglomeration

2. The transparency of nanocomposite films was dependent upon the clay dispersion and amount of clay. At the clay content up to 1 phr, the % transmittance dramatically increased because of the nucleating agent effect of clay loading to the smaller crystals size than the wavelength of visible light. However, further increase in the clay content up to 5 phr, the % transmittance decreased because of the clay agglomeration resulting in the larger crystals size than the wavelength of visible light. Nevertheless, the % transmittance of 2C18-MMT nanocomposite films was higher than those of unmodified nanocomposite films due to the compatible of 2C18-MMT with the polymer matrix.

3. The water absorption values of PET/MMT nanocomposite films dramatically decreased when adding lower amount of clay (1 phr). The decrease in water absorption upon is due to the addition of clay particles which obstruct the passage of water molecules through the PET matrix. In addition, organoclay/PET nanocomposite films had lower water absorption values than the unmodified-MMT/PET nanocomposite films due to the higher hydrophobicity of organoclay compared to the unmodified-MMT.

4. The results on mechanical properties indicated that 2C18 modified montmorillonite has highly efficient compared with unmodified montmorillonite. At low montmorillonite content, approximately at 1 phr, an increase in clay content resulted in an increase in the tensile strength and Young's modulus. These can be resulted from the increase in the interfacial properties of polymer composites due to the intercalation and exfoliation structure. Further increase in clay content up to 5 phr led to a decrease in both tensile strength and Young's modulus. The % elongation at break decreased when increasing the clay content of both clay types. It can be explained that the decrease in % elongation at break is due to the natural rigidity of silicate-sheet nanofiller.

5. The results on thermal stability of PET/MMT nanocomposite films by TGA analysis showed that the nanoclay has two functions which are a good thermal barrier and a catalyst for the degradation of polymer matrix. When adding a low fraction of clay

(1 phr), the clay layer can be dispersed well in the PET matrix, the good thermal barrier is predominant, but further increasing clay content up to 5 phr, the catalyzing effect rapidly rises and becomes dominant, so the thermal stability of nanocomposite decreased. However, the enhancement of nanocomposite's thermal stability is also probably due to the barrier effect of silicate layer and char formation on oxygen permeability. The increased of char resulting in higher heat-resistance.

6. The nucleating effect of nanoclay, montmorillonite, was revealed by XRD and DSC analysis. A low fraction of clay (1 phr) clay can act as the nucleating agent resulting in the fine crystal formation. The fine crystals also enhance the mechanical properties of PET/MMT nanocomposite films.

## 5.2 Recommendations

Due to the limitation of the instruments and the period of time for this investigation, not all of the desired experiments and experimental analysis could be conducted. Recommendation for further studies can be concluded as follows;

The morphology of nanocomposite which analyze by SEM in this work is not enough evidence to deeply confirm that the prepared nanocomposite film has nanocomposite structure. It could be further studied by TEM or polarized optical microscopy (POM) to convince these result with XRD analysis. Although the used solvent might be a limit for some characterization and/or using in packaging application. The residual solvent in nanocomposite film prepared by this method should be wholly eliminated. For packaging application, other testing should be performed such as gas permeability ( $O_2$ ,  $CO_2$ ) and other nessessary properties testing for right used selection as well.