Chapter V
Conclusions and Recommendations

5.1 Conclusions

The comparative study on mechanical, physical, and thermal properties of colored MDPEs were investigated using various organic pigments. Diarylide yellow (PY83), phthalocyanine blue (PB15), and quinacridone red (PR122) pigments were used and their amount were varied from 0.1 to 0.4 phr of MDPE, with 0.1 phr increasing interval. The effects of pigment contents, pigment types, blending techniques, and manufacturing processes were observed and summarized as follows.

1. The SEM micrographs showed that the dispersion of pigment powder in MDPE is almost consistent for every pigment types. This result can be confirmed that the chosen condition in section of Blending Condition Characterization is the process optimization for blending of the components between pigments and MDPE. Twin screw extruder which has 30 rpm of screw speed and 180 °C in processing temperature, were performed in melt blending technique. Because the properties of colored MDPEs are mainly affected by blending technique, twin screw extruder was employed in melt blending technique to improve the dispersibility and compatibility of pigmented MDPEs. The results showed that the mechanical properties of the colored MDPEs from melt blending technique were superior than those from dry blending technique and rotational molding process.

2. The results on mechanical properties showed that the amount of pigment might be too small to cause any significant changes in those mechanical properties, such as tensile modulus, tensile stress, flexural modulus, and flexural strength. Whereas, the impact strength and %strain at break were slightly decreased when pigment content increased. However, the overall mechanical properties of colored MDPEs were slightly inferior compared to the colorless MDPEs. Especially, the %strain at break of the colored MDPE was apparently lower in comparison to the colorless

MDPE. Possible explanations for these results were discussed in terms of the adhesion between MDPE and pigments. The results might be due to the effect of poor adhesion.

Comparing among three pigment types, the colored MDPEs with PY83 had higher %strain at break and flexural strength. In contrast, the colored MDPEs with PY83 had lower impact strength in every ratios. The mechanical properties of the samples from melt blending technique were higher than those from dry blending technique and rotational molding process.

3. The MFI of colored MDPEs maybe attributed to the effect of the pigment density. Since PB15 has highest density among the three pigments, therefore, the MDPE containing PB15 gives highest MFI value. Nevertheless, upon increasing the amount of pigment the MFI values of colored MDPEs remain unchanged. This is due to the small amount of pigments used compared with the MDPE. The pelletized extrudate from melt blending technique (after twin screw extruder) had slightly higher in MFI, compared to the dry mixture from dry blending technique (before twin screw extruder). Because of the shearing forces in twin screw extruder contributed to the decreasing in melt viscosity and then the increasing in MFI.

4. There was no sign of the melting endotherm of the pigment used due to its small quantity. Melting temperature remained unchanged at approximately 130 $^{\circ}$C. The use of pigment produced the lower in %crystallinity of colored MDPE compared to the colorless MDPE. In addition, an increase of pigment content (0.1 to 0.4 phr) seemed to have no effect on the %crystallinity. Consequently, the three organic pigments acted as interference on the crystal formation in medium density polyethylene.

5.2 Recommendations

Recommendations in this work can be concluded as following.

1. Since a lack of rotational molding machine in laboratory, this work was then performed by compression molding. It is the most similar technique to the rotational molding process when comparing to other plastic processing techniques. Compression molding has low shear forces, variable of stress or pressure to the suitable level that can be a shear-free or pressure-free process, and low residual stresses in product. Nevertheless, the objective of this research was required to compare the properties of

rotationally molded products. These should be prepared with pigments by rotational molding process. Thus, this machine was actually required in this work.

2. For SEM analysis, the preparation of fractured surfaces on compressionally molded sheets which were mixed between MDPE and organic pigments was difficult. In addition, their SEM micrographs were quite unclear and very difficult to determine the dispersibility of pigment in MDPE. Therefore, preparative method for samples should be studied and improved to receive the better results.

3. Generally, thermal properties of samples are varied by a lot of parameters, such as the structural organization of inner and interspherulite regions, crystal perfection, and/or crystallite size [59, 60]. In this work, it was found that other parameters can also affect the thermal properties of the sample as well. The several positions on a compressionally molded sheet (as shown in Figure 5.1) were analyzed since they have differently specific characteristic. Therefore, the samples for DSC analysis should be chosen in the same position on sample sheet.

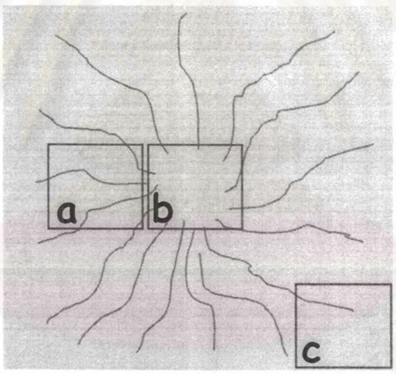

Figure 5.1 Several positions on a sample sheet (a) general area, (b) center, and (c) edge

Moreover, because of slow cooling in compressionally molded sheets was used. The characteristics of each sample were varied by temperature, cooling time, moisture, ventilation, etc., which were occurred in laboratory. Consequently, cooling process for consistent condition should be found. For examples, the slow cooling in controlled room or cabinet and the cooling by air or water in constant rate, should be determined. Furthermore, quenching can not be implemented in this work, because it can cause roughness on the surface of plastic sheet. The amount of pigments might not be enough to significantly change on %crystallinity by DSC. More investigation as X-ray diffractometer (XRD) is needed to be able to understand this phenomena.