CHAPTER X
CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

Our approach in this research can be contributed to the achievement of reactive processing with innovative operations. All experimental works can be concluded as follows;

10.1.1 Reactive Blending of LLDPE/NR System with ENR and Maleic Anhydride

10.1.1.1 The variation of process parameters applied to the system including the mixing speed, draw ratio as well as the blend formulae influenced significantly to the product performance.

10.1.1.2 Reactive blending system with small content of reactive sites and/or reactive agents was able to produce the foam-like structure with specific product performance. By controlling such parameters, the high oxygen permeability film was prepared by micro-voids generation due to the interaction of reactive species in the system.

10.1.1.3 The blended films can screen-off short-wave UV radiation while maintaining the translucency with good barrier property, for binary and ternary blend films, and with breath ability for reactive blend film. Therefore, our procedure can prepared the films which are well suitable for agricultural applications.

10.1.2 Rheological Modification of LLDPE through Reactive Processing with Peroxide

10.1.2.1 Reactive processing of single-phase LLDPE with the presence of low-dose chemical peroxide performed well to prepared the long-chain branches with high entanglement resulting in high resistance to flow.

10.1.2.2 The modified products were significantly affected by the concentration of peroxide used. Not only the amount of peroxide was important for product properties but also the method of peroxide addition.

10.1.2.3 The most efficient peroxide addition technique was the dry state mixing of both solid peroxide and LLDPE pellets prior to heating. Once they are molten, the peroxide was decomposed inside and readily reacted with molten LLDPE.

10.1.2.4 Processing temperature and rotor speed become more influence at low amount of peroxide but at high peroxide content they show less important effects on extent of reaction in terms of viscosity and elasticity of the reacted LLDPE.

10.1.3 The Effects of Processing Parameters on Rheological Properties of Low-Dose Peroxide Modified LLDPE

10.1.3.1 The estimated effects of process parameters were evaluated, and the greatest influence of peroxide concentration on the MFI values was confirmed statistically.

10.1.3.2 The best fitted model of measured MFI, consistency, and power law index showed that the content of peroxide incorporated in the single-phase reactive processing system ranked first to play an important role on the response values.

10.1.3.3 Getting higher in both shear viscosity and storage modulus implied to the occurrence of long-chain branches or broad molecular mass distribution. In addition, the crossover modulus shifting to lower frequency would refer to the presence of long chain branches.

10.1.4 Atmospheric Pressure Plasma Device as an Effective Tool for Surface Modification

10.1.4.1 Both nitrogen APPJ and air-plasma DBD were successfully utilized to render the treatment of LLDPE pellets as confirmed by the presence of chemically active species, radicals, on the treated surface. Therefore, they can be used as an innovative physical method to provide free radicals at the pellet surface which act as initiating sites for functionalization or reactive processing of polymer.

10.1.4.2 The important external plasma processing parameters of APPJ were the applied voltage and ratio of gas flow rates which was predominately dependent on processing gas flow rate rather than feeding gas flow rate. On the other hands, those of air-plasma DBD were the applied voltage for fixed plasma treatment time and aging time in ambient air.

10.1.4.3 The surface radicals stimulated by nitrogen-APPJ were much higher than that using air-plasma DBD. This was due to the superior of jet design which can expand the high volume of energetic gaseous species incorporated with the high power supply system.

10.1.4.4 Although the nitrogen-APPJ performed better than the air-plasma DBD, the overall system design should be concerned, hence, the air-plasma DBD was selected according to the no-cost of ambient air as a process gas.

10.1.5 Surface Modification of Polyethylene using Atmospheric Air Dielectric Barrier Discharge

10.1.5.1 Nitrogen and oxygen-based functional groups generated on the DBD treated LLDPE surfaces implied to the chemical modification due to the plasma treatment.

10.1.5.2 The irregularity found on the treated surface was defined as the physical alteration or etching process of the DBD treatment.

The change in surface morphology as well as polar sites formation resulted in the increase in hydrophilic property of the treated surface as the decrease in contact angle was observed.

10.1.5.3 As the plasma process parameters were highly system dependence, the optimum DBD treatment condition was varied depending on the requirement of further specific processing.

10.1.6 Plasma-Assisted Continuous Modification of Polyethylene

10.1.6.1 Plasma pretreatment of LLDPE pellet for the continuous reactive processing was applied successfully since the functional groups were found inside the bulk polymer. It also contributed to increasing viscosity due to the interaction amongst them.

10.1.6.2 The DBD device performed well to initiate grafting, in melt state, or to functionalize oxygen-based species on the polymer chain. The preferable product properties could be occurred during mixing in the presence of plasma-induced radicals.

10.1.6.3 The plasma pre-treatment was as good as using chemical peroxide to modify of LLDPE pellets by rendering the improvement in melt-strength, increase in elongational viscosity, oxygen barrier property enhancement, increase in the ultimate tensile strength, as well as elastic modulus improvement. The proposed system was suitable for continuous reactive polymer processing since it was operated at the atmospheric pressure condition with the used of ambient air as a processing gas.

10.2 Recommendations

10.2.1 In this work, the LCB characteristic of LLDPE modified with both ordinary and plasma-assist methods should be concerned and studied further in terms of molecular characterization.

10.2.2 Utilization of plasma technique on the surface treatment of materials is an effective method, especially to operate at atmospheric pressure. Thus, it can be employed as plasma-assisted blending or recycling as well. However, to enhance the efficiency of the plasma process, the DBD device can be re-designed to properly use for the intended applications and the power supply is another key factor to play with. The development of both should be continued.

10.2.3 Since the plasma system is quite complex and the plasma process parameters are significantly system dependence. The characterization of plasma process such as the plasma spectroscopy should be studied in details.