CHAPTER X
PC/PLA BLENDS WITH SELECTED COMPATIBILIZERS

10.1 Abstract

PC/PLA blends with various types and amount of compatibilizers exhibited the different advantage and disadvantage properties of each compatibilizer. The optimum formulas of PC/PLA blends with compatibilizers were screened by mechanical properties especially impact strength to do further experiment which are heat distortion temperature (HDT) and weather ability. PC70E1, PC70L0.1, and PC70G0.5 are the optimum formulas with good mechanical properties. PC70E1 has the highest Young's modulus. PC70L0.1 has the highest flexural strength. PC70G0.5 has the highest impact strength. PC70G0.5 has the high HDT closed to neat PC. After QUV test, all selected formulas of PC/PLA blends exhibited lower mechanical properties compared to the blends before QUV test. Finally, adding 0.5 phr PS-g-GMA can improve the impact strength and HDT of PC/PLA blends closed to neat PC which are the accepted properties for specific applications. Therefore, PC70G0.5 is the best formula for automotive and mobile device applications.

10.2 Introduction

All composition of PC/PLA blends without the compatibilizers are generally immiscible, which cause low mechanical properties especially impact strength. To improve the mechanical properties of the PC/PLA blend, additional compatibilizers are used to improve mechanical properties of the blend. Poly(styrene-co-acrylonitrile)-g-maleic anhydride (SAN-g-MAH), Poly(ethylene-co-octene) rubber-maleic anhydride (EOR-MAH) and poly(ethylene-co-glycidyl methacrylate) (EGMA) (Lee, J. K., 2011) were the examples of additional compatibilizers in PC/PLA blend. Khowanit, M. *et al.*, (2012) found that ethylene methyl acrylate copolymers (EMA) can dramatically improve the impact strength of PLA/PC blends but HDT were not significant improved compared to PC70.

PC70 has the highest mechanical properties such as tensile strength and flexural strength in the all ratio of the PC/PLA blends. Furthermore, the composition of the PC/PLA blend from the commercial grade is approximately PC70. Therefore, PC70 is the optimum composition of the PC/PLA blends to do further experiment.

The properties of PC/PLA/compatibilizers were investigated and screened by mechanical properties to select the optimum formulas to examine HDT and weather ability. Three optimum formulas of PC/PLA blends are PC70E1, PC70L0.1 and PC70G0.5. The best formula of PC/PLA blends was selected to compare the mechanical properties to the benchmark.

The purpose of this study was to select the best formulas of PC/PLA blends in order to compare to the benchmark.

10.3 Results and Discussion

10.3.1 Mechanical properties

10.3.1.1 Tensile and Flexural testing

The tensile strength at yield, Young's modulus, flexural strength and flexural modulus of PC, PLA, PC70 and selected formulas are shown in Figure 10.1-10.4, respectively. The tensile strength of the selected formulas were slightly different. All selected formulas has the higher tensile strength compared to neat PC. By tensile modulus, PC70E1 has the highest young's modulus. PC70G0.5 has the young's modulus similar as neat PC which are the accepted properties for specific applications.

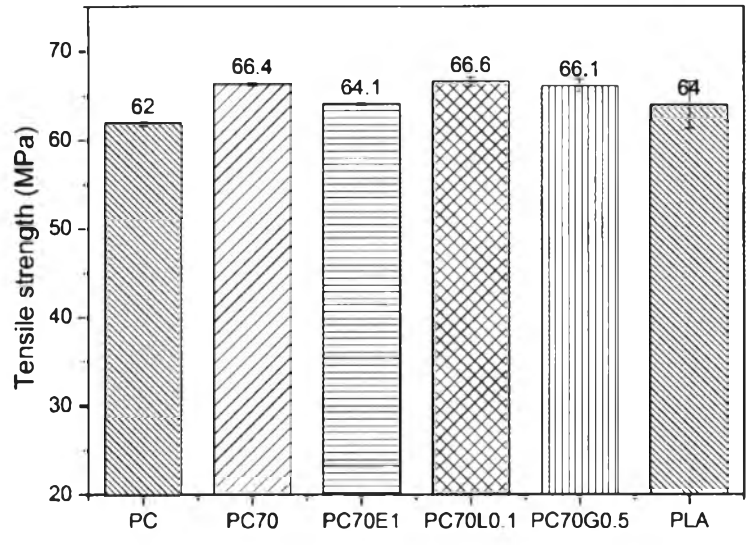

Figure 10.1 Tensile strength at yield of PC, PLA, PC70 and selected formulas.

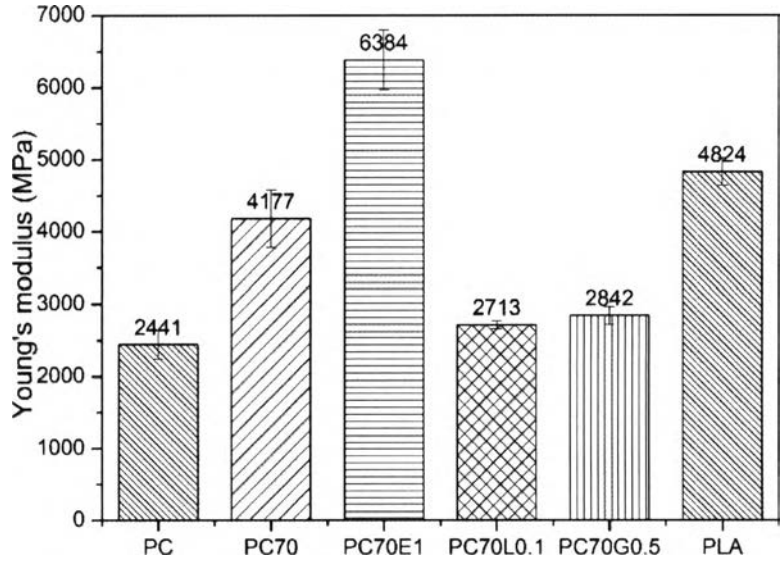

Figure 10.2 Modulus of PC, PLA, PC70 and selected formulas.

For the flexural strength, From fig. 10.3 – 10.4, flexural strength of PC70L0.1 and PC70G0.5 are significantly higher than other formulas while The flexural modulus of PC70G0.5 are indifferent compared to PC70 and PLA which are accepted properties. PC70G0.5 are the best formulas for improving the flexural properties.

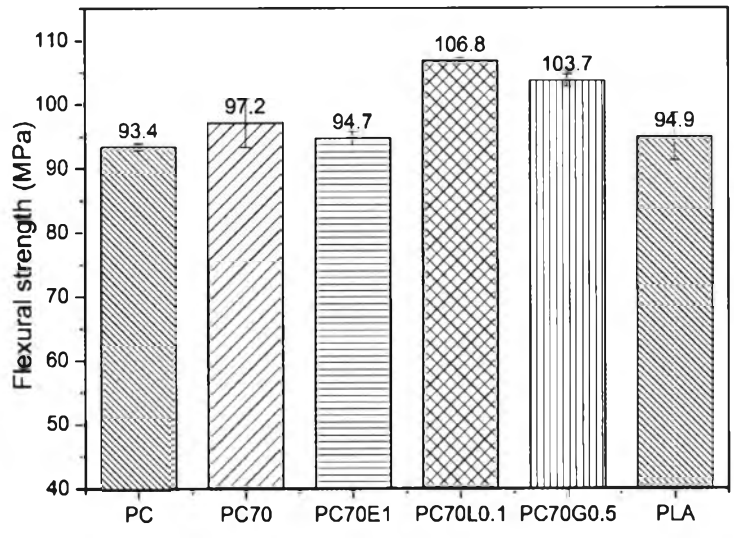

Figure 10.3 Flexural strength of PC, PLA, PC70 and selected formulas.

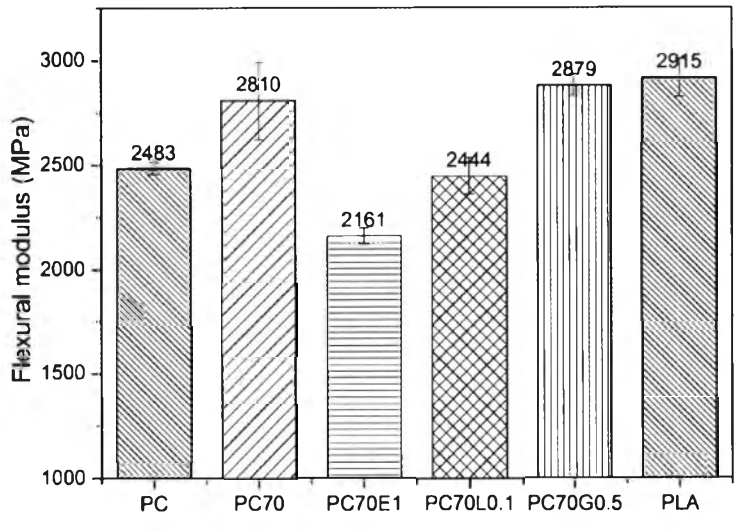

Figure 10.4 Flexural modulus of PC, PLA, PC70 and selected formulas.

10.3.1.2 Notched izod impact

Figure 10.5 reported Notched izod impact of PC, PLA, PC70 and selected formulas. The impact strength of PC70G0.5 has the high impact strength closed to neat PC which are the accepted properties for specific applications.

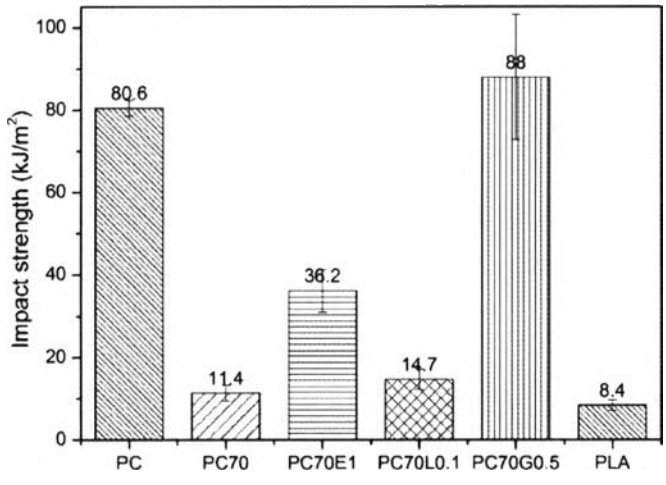

Figure 10.5 The impact strength of PC, PLA, PC70 and selected formulas.

10.3.2 Heat distortion temperature (HDT)

All specimens were prepared in bar shape followed by ASTM D648. Figure 10.6 reported HDT of PC, PLA, PC70 and selected formulas. PC has the highest HDT which are the advantage of PC. On the contrary, PLA has the lowest HDT. HDT of PC/PLA blends without compatibilizer was drastically lower than that of neat PC. PC70G0.5 has high HDT (around 113 °C) closed to HDT of neat PC which is accepted properties for automotive and mobile device applications. The results implied that adding PS-g-GMA can improve the interfacial adhesion of PC and PLA phases under high temperature.

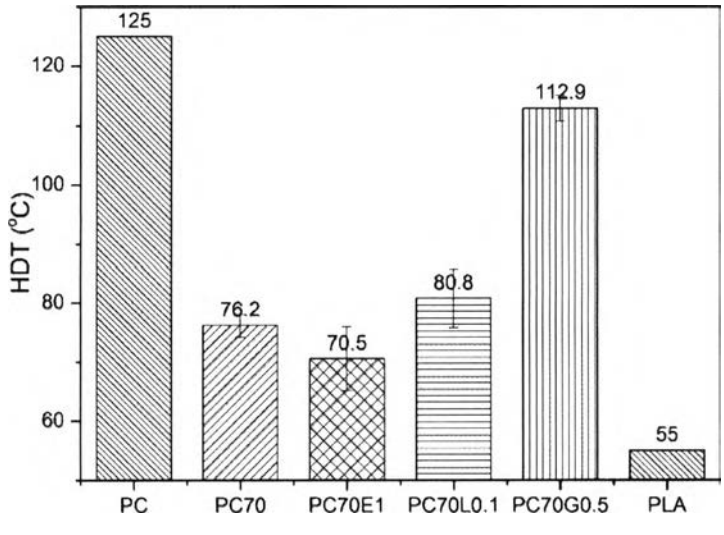

Figure 10.6 HDT of PC, PLA, PC70 and selected formulas.

10.3.3 Weather ability

10.3.3.1 Tensile and Flexural modulus

After QUV test, The mechanical properties of the tested samples were investigated followed by same conditions of untested samples. The tensile and flexural properties of PC70 and selected formulas was studied and the result shown in Figure 10.7 and 10.8. The Young's modulus of PC70 and PC70E1 were drastically decreased while Young's modulus of PC70G0.5 was slightly dropped after QUV test. During the QUV test, UV environment in QUV machine led to the carbonyl bond of the PC was destroyed and the oxidation of the main chain was occurred that generate the shortening PC chains. The flexural modulus of all formulas were drastically dropped compared to the untested samples implied that the direction of incident UV light has the huge effect on the mechanical properties. In this case, the direction of incident UV light is the same as the direction of applied force of flexural test. The explaination may answer why the flexural modulus of PC70G0.5 was drastically dropped while the tensile modulus of the blends was sligthly dropped after QUV test.

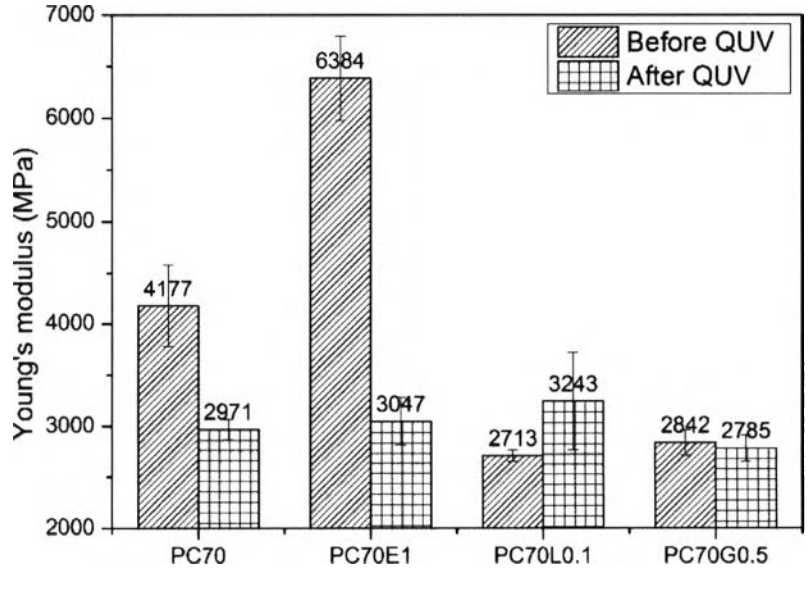

Figure 10.7 Young's modulus of PC70 and selected formulas after QUV test.

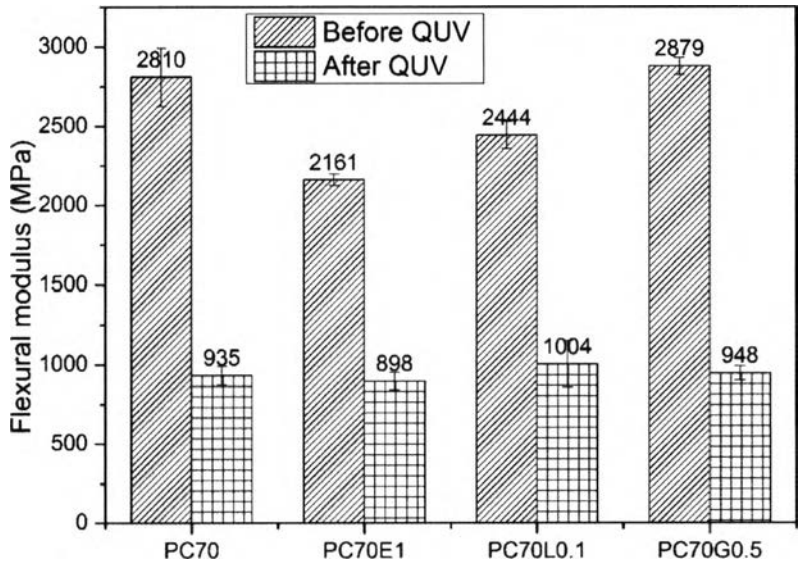

Figure 10.8 Flexural modulus of PC70 and selected formulas after QUV test.

10.3.3.2 Tensile and Flexural modulus

After QUV test, The impact strength of the tested samples were investigated followed by same conditions of untested samples. The impact strength of PC70 and selected formulas was studied and the result shown in Figure 10.9. The impact strength of all formulas were dropped after QUV test. In case of PC70G0.5, the impact strength of the blend insignificant dropped implied that UV light did not affect to the impact strength of PC70G0.5.

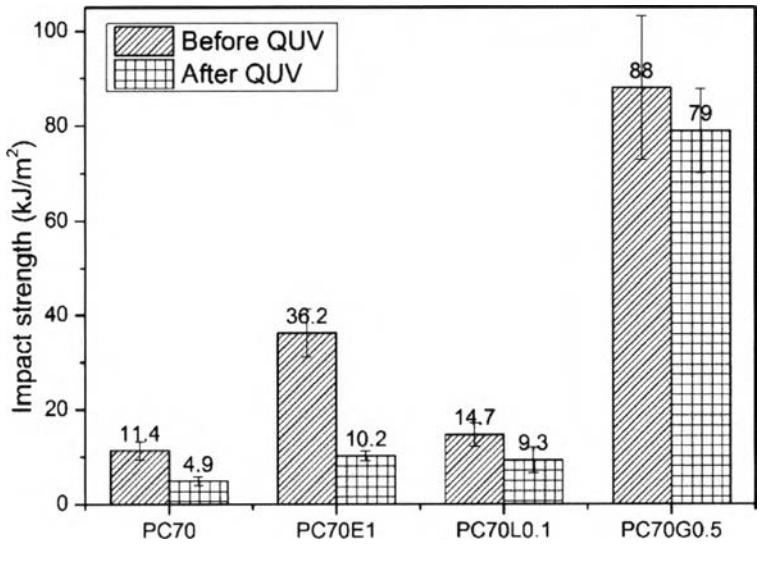

Figure 10.9 izod impact strength of PC70 and selected formulas after QUV test.

10.4 Conclusions

To select the best formula of PC/PLA blends for automotive and mobile device applications to compare to benchmark. The mechanical properties especially impact strength and HDT of PC70E1, PC70L0.1 and PC70G0.5 were investigated. By tensile properties, PC70G0.5 has high tensile strength and accepted Young's modulus. By flexural properties, PC70G0.5 has higher flexural propertes compared to other formulas. By impact strength, PC70G0.5 has high impact strength similar to neat PC. HDT of PC70G0.5 was higher than other formulas closed to neat PC. After QUV test, the tensile and flexural properties of all formulas were dropped. The impact strength of PC70G0.5 insignificantly dropped after QUV test. Therefore, PC70G0.5 is the suitable formula to improve the impact strength and HDT for automotive and mobile device applications.

10.5 Acknowledgements

The author would like to thank PTT Phenol Company Limited for supporting the thesis work.

Finally, The authors are thankful to PTT research and technology institute for analytical support.