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EFFECT OF PARTICLE SIZE COMPATIBILIZER AND WASTE MELAMINE FORMALDEHYDE CONTENT ON CHARACTERISTICS OF HIGHDENSITY POLYETHYLENE MATRIX COMPOSITES

Somsak Siwadamrongpong*, Janjira Aphirakmethawong
School of Manufacturing Engineering.
Institute of Engineering. Suranaree University of Technology.
111 University Avernue, Muang District, Nakhonratchasima 30000, Thailand.
* E-mail: somsaksi@sut.ac.th. Tel: 0-4422-4236, Fax: 0-4422-4566

Abstract

Waste melamine formaldehyde powder (PWMF) was generated by grinding process of Melamine products and there are cannot be melted to reformed or reused. The aims of research is seek way to use PWMF to reuse therefore, PWMF was used as filler of HDPE matrix by various 3 factors, particle size compatibilizer and content of PWMF. HDPE/PWMF composites were prepared using internal mixer and test specimens were formed by injection machine. Characteristics of HDPE/PWMF composites including thermal and tensile properties were investigated. Influences of 3 factors on mechanical properties were examined by using the analysis of variance (ANOVA) with the level of significant 0.05. The results of thermal properties found that HDPE/PWMF composite have %crystallinity higher than pHDPE which compatibilizer (HDPE-g-MA) effect to to %crystallinity of HDPE/PWMF decreased on the other hand particle size effect to %crystallinity of HDPE/PWMF increased when increasing particle size. Mechanical properties consider the results from tensile testing the results found that %Elongation of HDPE/PWMF composite higher than pHDPE when content of PWMF is 5wt% however if increasing PWMF content to 20wt% leads to %elongation are drop less than pHDPE, Tensile strength when adding HDPE-g-MA leads to tensile strength decreased.

Keyword: Melamine formaldehyde resin, factorial design, particle size, particle reinforced, HDPE composites.

1. INTRODUCTION

Nowadays, Polymers have used widely and more desire to use especially plastic because light low-cost and suitable for various application. So, could increasing concern regarding the environment and plastic waste disposal problem. The alternative methods for handle plastic waste and decreasing environment problem from plastic include burial, incineration, de-polymerization and recycling which recycling is convenient way to manage waste problem. (Rapisa & Kasama, 2013) The interest in recycled materials has been growing rapidly during recent year cause of environment concern and wish to reduced energy consumption. (Chaitongrat, C. et al., 2013).

High density polyethylene (HDPE) is the most of thermoplastics used. HDPE is chosen to produce the composites since it is a major portion of used. In addition, HDPE outstanding properties such as high toughness, good impact resistance etc.

Melamine formaldehyde (MF) resin commonly known as melamine is one of famous thermosetting plastic which cannot be melted and re-shaped after it cured. Thermosetting plastic are generally excellent hardness, high thermal resistance (Phaiboon & Malika, 2008) low cost, relatively light weight and unbreakable characteristics (Chao-Yi Chien, et al., 2011) which suitable to use for Tableware products. Hence, waste melamine powder was generated in manufacturing process and it is cannot reformed or reused. Therefore, it needs to disposal by landfills or burning (S.J. Pickering, 2006) that leading to degradation of environment and cost for disposal. S.J. Pickering (2005) carried out studied on technologies for recycling thermoset composite materials by use of grinding techniques to comminute the scrap material for reuse as fillers or reinforcement in new composite. Hasan S. Dweil, Mohamed M. Ziara& Mohammed S. Hadidoun (2008) have studied to improve structural concrete properties with ground melamine. The waste was used as a sand replacement. The results, waste melamine that replacing sand can improve the mechanical and thermal properties of light weight concrete. In the same way Phaiboon and Mallika (2008) studied the utilization of waste melamine by filled waste melamine in mix proportion of lightweight concrete. The results, waste melamine can reduce light concrete density due to low specific gravity of melamine. So, waste melamine powder was chosen as filler.

In this study, consider the effect of waste melamine powder on thermal and tensile properties by various particle size compatibilizer and content of waste melamine powder.

2. EXPERIMENT PROCESDURE

2.1 Materials

Matrix composite is high density polyethylene (HDPE, EL-Lene H6007JU, SCG). Filler content used waste melamine powder (PWMF) generated by grinding process in Tableware manufacturer was with two difference particle sizes consist 23 and 36 µm, Code P1 and P2 respectively (ready mixed with cellulose and formaldehyde). Compatibilizer is one type of substance to a blend of polymers that will increase their stability. High density polyethylene graft maleic and hydride (HDPE-g-MA, Fusabone® M603, Dupont) were used to compatibilizer in this study.

2.2 Design of experiment (DOE)

2^k factorials Design of experiment (DOE) was used to design experimental of 3 factors summarized in Table 1 Therefore, total of 8 runs are shown in Table 3.

Influences of 3 factors on tensile properties were examined by using the analysis of variance (ANOVA) with the level of significant 0.05. The significant effect was calculated by Minitab16 software.

Table 1 Factor

Factor	Name	Low level (-)	High level (+)
A	Content of PWMF (%wt)	5	20
B	Particle size (µm)	23	36
C	Compatibilizer (phr)	0	5

2.3 Preparation of Test Specimens

The specimens were mixed by internal mixer (HAAKE PolyLab OS, RheoDrive7). Formed by Co-injection molding machine (TEDERIG, TRX-60C). Conditions are shown in Table2.

Table 2 Condition for Preparation of Test Specimens

Method	Conditions
Mixing	
- mixing temp (^{o}C)	170
- mixing time (min)	15
- rotor speed (rpm)	70
Injection	
- melting temp (^{o}C)	180
- molding temp (^{o}C)	30
- cooling time (min)	30
- holding pressure (bar)	100
- injection pressure (bar)	80

2.4 Properties of HDPE/PWMF composites

Tensile tests according to ASTM D638 using a universal testing machine (Instron, 5565) with 5 kN load cell and crosshead speed of 50 mm/min. Ten samples were tested.

Thermal properties of HDPE/PWMF composites were investigated using a differential scanning calorimeter (PerkinElmer, Pyris Diamond). All samples were heated from room temperature to 200°C with a heating rate of 10°C/min (1st heating scan) and kept isothermal for 5 min under a nitrogen atmosphere. Then, the sample was cooled to room temperature with a cooling rate of 10°C/min and heated again to 200°C with a heating rate of 10°C/min (2nd heating scan). The crystallinity of HDPE was estimated using the following equation

$$\chi_c = \frac{\Delta H_m}{W_f \times \Delta H_m^*} \times 100$$

Where

χ_c = Crystallinity of HDPE

ΔH_m = Enthalpy of melting during the heating

ΔH_m^* = Enthalpy for 100% crystalline of HDPE (293.6 J/g) (Wunderlich, 1990)

W_f = Weight fraction of HDPE component in composites

Table 3 the design of 2^k factorials for 2 factor (k=3)

Run	Design Code			PWMF (wt%)	Particle size (µm)	Compatibilizer (phr)	Name
	A	B	C				
1	-	-	-	5	23	0	HDPE/5PWMF/P1
2	-	+	-	5	36	0	HDPE/5PWMF/P2
3	+	-	-	20	23	0	HDPE/20PWMF/P1
4	+	+	-	20	36	0	HDPE/20PWMF/P2
5	-	-	+	5	23	5	HDPE/5PWMF/5HDPE-g-MA/P1
6	-	+	+	5	36	5	HDPE/5PWMF/5HDPE-g-MA/P2
7	+	-	+	20	23	5	HDPE/20PWMF/5HDPE-g-MA/P1
8	+	+	+	20	36	5	HDPE/20PWMF/5HDPE-g-MA/P2

Table 4 Summarize properties of HDPE/PWMF composites

Name	Tensile strength (MPa)	%Elongation	χ_c (%)
HDPE	21.80 ± 2.57	532.94 ± 125.08	69.91
HDPE/5PWMF/P1	24.84 ± 0.52	818.54 ± 93.70	72.17
HDPE/5PWMF/P2	23.67 ± 0.46	835.35 ± 72.29	71.58
HDPE/20PWMF/P1	25.73 ± 0.72	36.37 ± 8.87	68.66
HDPE/20PWMF/P2	23.15 ± 0.34	38.04 ± 7.80	78.84
HDPE/5PWMF/5HDPE-g-MA/P1	22.80 ± 0.31	745.26 ± 237.66	62.96
HDPE/5PWMF/5HDPE-g-MA/P2	22.90 ± 0.46	683.70 ± 112.24	67.41
HDPE/20PWMF/5HDPE-g-MA/P1	25.14 ± 1.03	42.84 ± 12.14	64.66
HDPE/20PWMF/5HDPE-g-MA/P2	25.27 ± 0.28	29.56 ± 1.85	65.45

3. RESULTS AND DISCUSSION

3.1 Tensile Properties

The Tensile properties of HDPE/PWMF composites by mean of tensile strength and %Elongation are shown in Table 4

Fig.1 is shown box plot of tensile strength of HDPE/PWMF composites. It was found that tensile strength increased with adding PWMF content, PWMF is high stiffness than HDPE which matrix (S-Y Fu, et al., 2008) and PWMF that restrict movement of polymer chain that can improve overall of tensile strength. Moreover, not only PWMF content as main effect to tensile strength but interaction between compatibilizer and particle size, compatibilizer and PWMF content are also effect.

%Elongation was shown in Table 4 and Fig 2. It was found that when a adding PWMF content from 5wt% to 20wt% %Elongation were decreasing because filler as prevent of rotational and movement of matrix that leads to ductility decreased. However, when adding 5wt% PWMF content were increased %Elongation when comparing with pure HDPE.

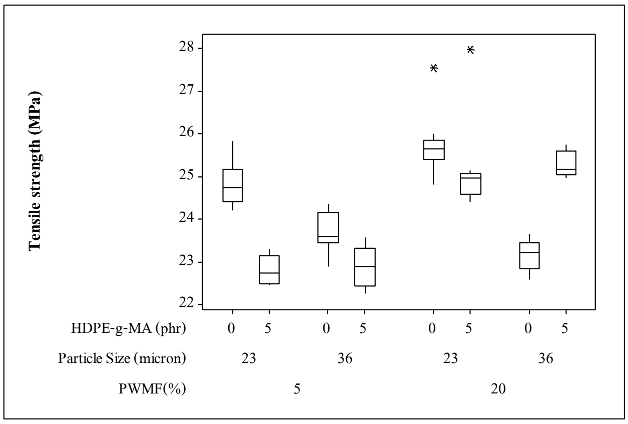

Fig. 1 Box plots of Tensile Strength

3.2 Thermal Properties

DSC Thermograms was shown the Fig. 3. It was found that all case is the same trend that T_m was not significant different. From Table 4 uncompatibilizer and adding PWMF content leads to %crystallinity of HDPE/PWMF increased when comparing pure HDPE that one of cause why strength of HDPE/PWMF are increasing. In the other hand case adding compatibilizer effect to %crystallinity drop less than %crystallinity of pure HDPE.

4. CONCLUSION

Thermal properties of HDPE/PWMF composite in case uncompatibilizer have %crystallinity higher than pHDPE which compatibilizer (HDPE-g-MA) effect to to %crystallinity of HDPE/PWMF decreased on the other hand particle size effect to %crystallinity of HDPE/PWMF increased when increasing particle size. Mechanical properties consider the results from tensile testing the results found that %Elongation of HDPE/PWMF composite higher than pHDPE when content of PWMF is 5wt% however if increasing PWMF content to 20wt% leads to %elongation are drop less than pHDPE, Tensile strength when adding HDPE-g-MA leads to tensile strength decreased.

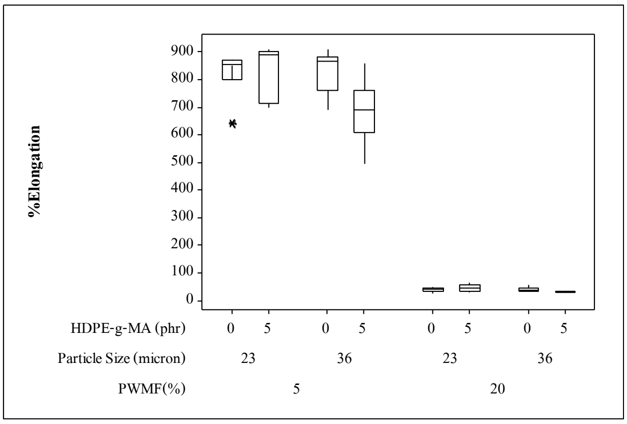

Fig. 2 %Elongation

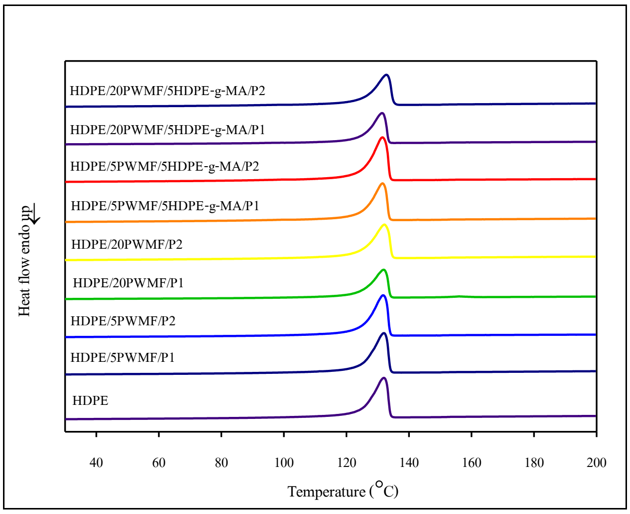

Fig. 3 DSC Thermograms of HDPE/PWMF composites

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Somsak Siwadamrongpong received the B.Eng. (2004) degree in Mechanical Engineering from Chulalonglorn University, M.Eng. (2001) degree in Environmental System from Nagaoka University of Technology, and D.Eng. (2004) degree in Energy and Environment from Nagaoka University of Technology.

He is a Professor, Department of Manufacturing Engineering, Suranaree University of Technology. His current interests include material characteristics, recycle of industrial waste and manufacturing productivity improvement.

Janjira Aphirakmethawong received the M.Eng. (2015) degree in Manufacturing Engineering from Suranaree University of Technology..