EFFECTS OF THE PROCESSING PARAMETER ON THE FIBRE LENGTH AND PHYSICAL PROPERTIES OF SHORT GLASS REINFORCED TPNR COMPOSITE

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ABSTRACT

Blends of thermoplastic natural rubber (TPNR) reinforced composite with 10% volume fractions non directional short glass fibre were prepared by melt blending in a plasticorder mixer at various temperatures, times dan mixing rates. The optimum processing conditions were determined from the highest value of the tensile strength and was found that temperature was 135°C, mixing rate of 11 rpm and mixing time of 11 minutes. The tensile properties of the blend had decreased significantly with increasing amount of glass fibre. The SEM micrograph has shown that the distribution of fibre in the TPNR matrix was quite uniform.

INTRODUCTION

Fibre reinforced composites are practical and useful, but there has always been a problem with understanding how they work. Various kind of short fibre reinforced composites have been developed so far including glass reinforced composites which are among the most popular and important worldwide. However only a small number of studies have been reported related to the effect of processing parameters on the physical properties of nondirectional short glass reinforced TPNR composites.

Short fibre reinforced composite offers the potential for high volume processing combined with high end use property levels at lower manufacturing costs. However this high performance level can only be obtained if the reinforcing fibres in the final products have high aspect ratio[1]. Since the

fibre length and its' orientations can influenc the physical properties of short-fibre reinforced composite, it is important to control the mixing process by an appropriate choice of processing conditions[2,3]. In this study, we incorporated nondirectional short glass fibre of 6 mm in length into a TPNR matrix to investigate the effects of several processing parameters on the physical properties of short fibre reinforced composite.

EXPERIMENTAL PROCEDURES

Materials

The matrix used in this work was TPNR (Thermoplastic Natural Rubber) which was prepared using LLDPE/NR with LNR as compatibiliser. The samples were prepared at optimum processing parameter as reported by Borhan[4]. Short glass fibre of type E-glass with 6 mm initial length was used as reinforcement. The average fibre diamater was approximately 13 um[5].

Processing

In order to determine the effects of mixing time, the mixer was set at 135°C and mixing speed at 10 rpm. When the desired temperature was reached, the matrix was charged into the mixing chamber and was mixed for three minutes. The glass fibre was then added and compounding was carried out for 9 -12 minutes. After the mixing time was over, the blend was removed and subsequently compressed at temperature 135°C and 8 KN pressure for about 2 minutes nto a thin sheet of 1 mm thickness. The sheet was allowed for 24 hours of maturation period. A similar procedure was employed to obtain a optimum mixing temperature and mixing speed. The mixing temperatures were varied from 130 -150°C at constant time. By using the optimum time and temperature the mixing speed was varied from 9-12 rpm in order to determine the optimum mixing speed.

PHYSICAL MEASUREMENT

Tensile test

Each sample for tensile test was cut into dumbell shape according to ASTM D412. The tensile test was conducted at room temperatures using a Lloyd Instruments materials testing machine, Model PL 2000. This machines was linked to a remote microcomputer for data analysis. Force at the cross head was set at 5 KN and speed 50 mm/min. Six specimens were tested for each mixing parameter involved. The maximum values of stress and strain will give the optimum tensile properties.

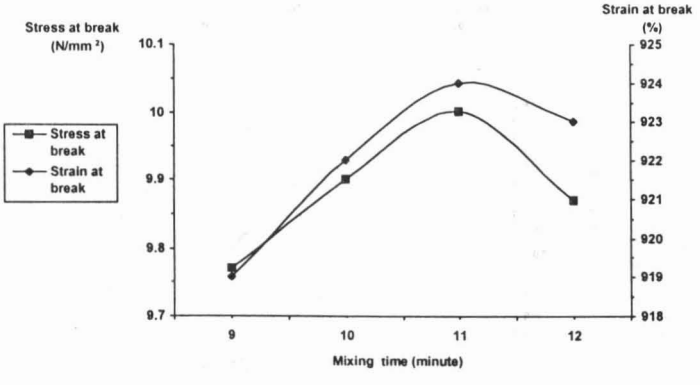
Fibre length determination

Samples with dimension 1 cm x 1 cm were cut from the sheet of 1 mm thickness. It was followed by the separation of fibres from matrix involving burning process at temperature about 450°C in oven. The final fibre length was determined by measuring the length of each fibre from the printed images from an optical microscope.

RESULT AND DISCUSSION

The results of the tensile stress and strain at break as a function of mixing time are shown in Figure 1 . Mixing temperatures and mixing speeds are set at 135°C and 9 revolution per minute (rpm).

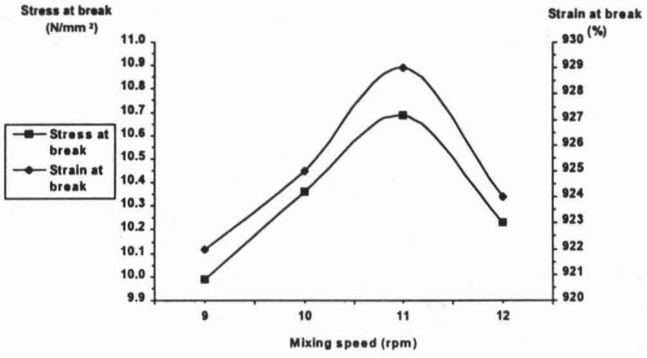
Figure 1: Tensile properties of undirectional short glass reinforced TPNR composite at various mixing time



The stress and strain increased with mixing time and reached the maximum values of about 10 MPa after 11 minutes respectively and decreased thereafter. These observations indicate that the glass fibres required certain duration of time to disperse into the matrix.

Figure 2 depicts the tensile stress and strain versus various mixing rate. This result was obtained at the previous mixing time of 11 minutes and mixing temperature of 135°C.

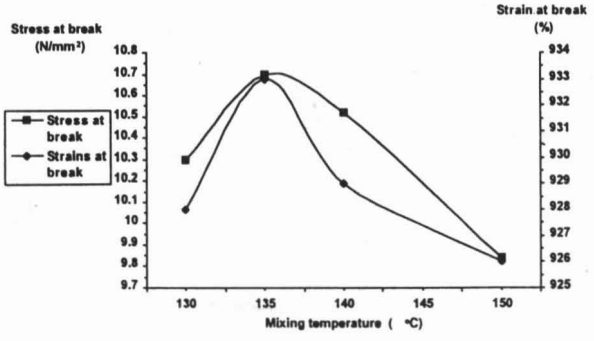
Figure 2 : Tensile properties of undirectional short glass reinforced TPNR composite at various mixing speed



The curve in Figure 2 shows the same pattern as observed in Figure 1. The maximum stress of about 10.6 MPa and strain of about 927% was achieved at a mixing speed of 11 rpm.

The influence of mixing temperatures on the tensile properties was shown in Figure 3. The result shows that the mixing temperature is found to be optimized at temperature of about 135°C.

Figure 3 : Tensile properties of undirenctional short glass reinforced TPNR composite at various mixing temperatures



From this figure, it can be seen clearly that when the temperatures are higher than the optimum mixing temperature the tensile stress and strain of the composite decreased as a result of phase separation[6].

It can be concluded that the physical properties of TPNR reinforced composite with 4.09% volume fraction of nondirectional short glass fibre with an initial length of 6 mm has obtained its optimum values at a mixing time of 11 minutes, mixing rate of 11 rpm and mixing temperature at about 135°C.

At an optimum mixing temperature, the TPNR matrix is in a viscous state with high viscosity and by using suitable mixing rate and mixing time, the maximum mixing effect between glass fibre and matrix can be obtained[7]. In this condition the glass fibre can be dispersed into the matrix more easily and the composite with good homogeneity can be produced. However during the mixing process, the probability of fibres crossing each other will increase as the mixing rate and mixing time are increased. If these values are too large as compared to the optimum values, the length of the fibre will decrease drastically and reduce the average length of glass fibre. This phenomena will overcome the effects of homogeneity and weaken the physical properties of composites.

The strength of a fibre reinforced composite depends on several factors such as the degree of an applied load transmitted to the fibre. This capability is a function of fibre length and the interfacial bond between fibre and matrix[8].

The mixing process will involve large shear field which will result in fibre breakage due to tensile, crossing and bending stresses. As mentioned earlier, the physical properties of composites are dependent on fibre length and it is important to monitor the fibre length distribution. Table 1 and 2 show the influence of mixing rate and time on the fibre length after the processing operation. The number, average length, is defined as[9] :

$$L_n = \frac{\sum N_i l_i}{\sum N_i}$$ Where N_i is the number of fibres of length l_i.

Table 1 : Average fibre length distribution with 11 rpm mixing rate at various mixing time.

Mixing rate (rpm)	Mixing time (minutes)	Average length
11	9	0.937
	10	0.837
	11	0.740
	12	0.732

Table 2 : Average fibre length distribution with 11 minutes mixing time at various mixing rate.

Mixing time (minutes)	Mixing rate (rpm)	Average length (mm)
11	9	0.834
	10	0.820
	11	0.740
	12	0.706

Both tables show that the fibre length was reduced by approximately 87% at a mixing rate of 11 rpm and mixing time of 11 minutes as compared to the initial length. The maximum final length of the fibre is only 0.937 mm and 0.834 mm respectively.

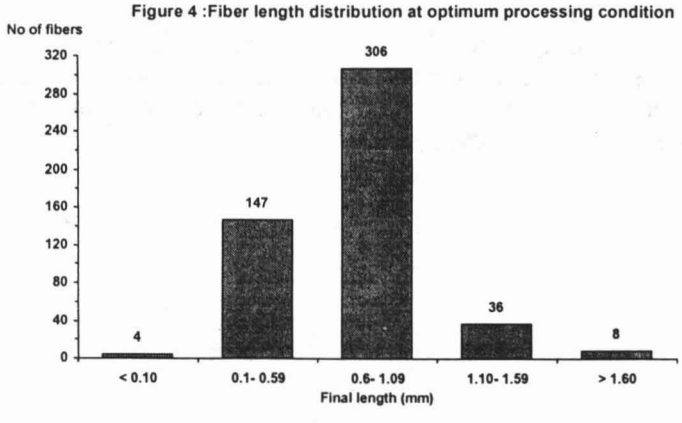


Figure 4 :Fiber length distribution at optimum processing condition

Histogram in Figure 4 show a distribution with a tail at both ends and none of fibres have survived unbroken after mixing prosess as compared to initial length. The amount of fibre broken down depends on the processings parameter such as mixing time, mixing rate, melt viscosity and fibre volume fraction. Filbert suggested that, the fibre breakage was related to the wiping action generated by the screw in the mixer. It had also been suggested that the fibre dispersion or breakage varied with the fibre surface treatment .

CONCLUSION

This study leads to a better understanding of the effect of processing parameter on the physical properties of short glass fibre TPNR composite. It has been shown that the maximum tensile strength can only be obtained at the optimum processing parameters.

REFERENCE

1. Thomason J.L and Vlug M.A. (1996). Influence of Fibre Length & Concentration On The Properties of Glass Fibre Reinforced Polypropylene : 1. *Tensile & Flexural Modulus Composite* : Part A (27A) : 477-484.

2. Curtis P.T, Bader M.G and Bailey J.E (1978). The stiffness and strength of a Polymide Thermoplastic reinforced with glass and carbon fibre. *J. Mat. Sci* (13): 377-390.

3. Folkes M.J.(1982). *Short Fibre Reinforced Thermoplastics*, John Wiley & Sons Ltd.

4. Borhan B. (1997), M.Sc Thesis. Universiti Kebangsaan Malaysia.

5. Qiu.Q and Kumosa.K. (1997), Corrosion of E-Glass fibres in acidic environments. 57: 497-507.

6. Ibrahim A, Sahrim A and Che Som S. (1985) Blending of Natural Rubber with Linear Low Density Polyethylene. *J. of Applied Polymer Science*, Vol 58 : 1125-1133.

7. Al-Malaika S and Amir E.J. (1986) Thermoplastic Elastomers I. Effect of Processing Variables on Tensile Properties of Natural Rubber/Polypropylene Blends. *J. Nat Rubb.* Res. 1 (2) : 104-121.

8. George and Thomas. (1997). Short fibre-reinforced Plastic Composite Nicholas.P. *Handbook of Engineering Polymeric Materials* Marcel Dekker Inc.

9. Hull.D. 1981. (1981). *An Introduction to Composite Materials.* Cambridge University Press.

10. Filbert W.C, (1969). Reinforced 66-nylon molding variables vs fibre length vs physicalproperties. *SPE Journal* (25) : 65-69.