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Short Communication

A NEW PVC-GLASS MATERIAL TO BE USED IN MULTIPURPOSE APPLICATIONS

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ABSTRACT

In the present study, a mixture of two waste materials glass and PVC were used with three different percentages (namely: 30% glass 70% PVC, 50% glass 50% PVC, and 70% glass 30% PVC), hardness, macrostructure, density, and thermal conductivity were investigated. Based on results, it was revealed that as the glass content increased, there is an enhancement in the hardness, where the thermal conductivity was decreased as the glass percentage increased this lead to use the new material as an insulator material.

Keywords: PVC, glass, thermal conductivity, microstructure, microhardness.

INTRODUCTION

A composite material is basically a combination of two or more materials, each of which retains it own distinctive properties. Composite structures, such as fibre-reinforced plastic laminates and sandwich panels made with laminate skins and light-weight cores, are widely used in the aerospace, marine, aeronautical, automotive and recreational industries (Imielinska and Guillaumat, 2004; Li and Weitsman, 2004; Bull and Edgren, 2004). Their superior bending stiffness, low weight, excellent thermal insulation, acoustic damping, ease of machining, corrosion-resistance and stability offers advantages over traditional metallic materials. However, shortcomings of fibre-reinforced plastics are their low translaminar (through thickness) mechanical properties and susceptibility to failure by impact loading – by hard objects or wave slamming. Wood fibres were initially used for reducing and disposing of large amounts of natural fibre waste materials and for cost reduction. But, they are now preferably used as reinforcing materials in polymers, and offer low cost and low density products (Imielińska *et al*., 2008).

Beirnes and Burns (1986), Scandola *et al*. (1982), Fried and Lai (1982), Mauritz (1990) and Ceccorulli *et al*. (1987) reported that the improvement of mechanical properties for structural engineering applications can be obtained if the wood fibers are properly blended with the polymers.

The most significant monomeric plasticizer family is the phthalates, which constitute about 70% of the plasticizers used. There have been many studies on the glass transition temperature of PVC phthalate mixtures. The objective in this study is to produce a new composite material from waste materials, then investigate its hardness, strength, and its thermal conductivity.

MATERIALS AND METHODS

Materials

A set of materials was used throughout this study namely; waste glass, waste PVC.

1- Waste glass is shown in figure 1, thickness of glass that was used 4 mm (broken cups, waste glass bottles).

Fig. 1. Waste glass.

2- Waste plastic (PVC)
The plastic waste is shown in figure 2.

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Fig. 2. Waste plastic bottle.

Equipment

The following set of equipment was used in this study:

1- Electric furnace carbolite 1450 ˚C
3- Electronic balance
4- Microscope type NIKON 108.
5- Digital micro hardness tester

Experimental procedures

The material was prepared through these steps:

1. Crashing the glass to small pieces as shown in figure 3.

Fig. 3. Crashed glass.

2. Cutting PVC bottles to small pieces.
3. Mixing PVC pieces with glass pieces at percentage of mixing (30%: glass, 70% PVC) 5 grams glass with 15 gram PVC.
4. Heating the mixture at temperature 1400˚C for three minutes in electric furnace.
5. Mixture will melted as shown in figure 4.

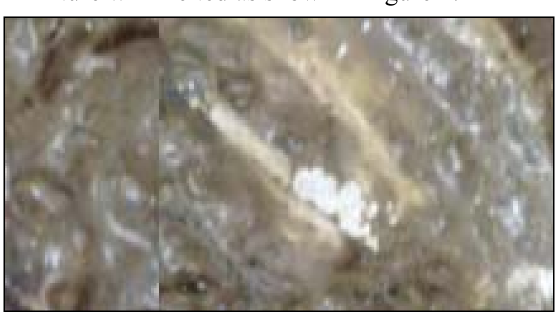


Fig. 4. Mixture of melted composites.

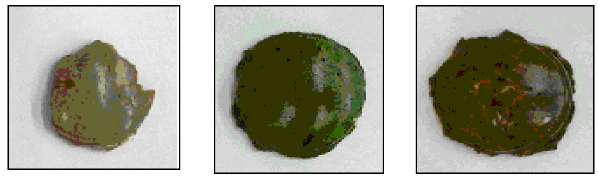
6. Filling the mixture of glass and PVC in special die.
7. Repeating this procedure with different composition

Three specimens were performed with different glass composition as shown table1.

Table1. The composite composition

Specimen #	% Composition
1	30 glass + 70 PVC
2	50 glass + 50 PVC
3	70 glass + 30 PVC

The produced three composites are shown in figure 5.



1 2 3

Fig. 5. The produced composites percentages (1-30% glass, 2-50% glass, 3-70% glass).

RESULTS AND DISCUSSION

The effect of different glass percentages on the hardness of new composite materials

These specimens were test by using brinell hardness tester in order to obtain the hardness of each specimen as shown in Table 2, by comparing these results with glass and PVC hardness which are 1550 HB, 12 HP respectively (CES software), there is a large different between them, where the value of hardness was reduced under glass hardness and over PVC.

Table 2. Hardness of the three composites.

% Composition	Hardness (HB)
30 % glass + 70 % PVC	52
50 % glass + 50 % PVC	73
70 % glass + 30 % PVC	97

Hardness values give an indication about the magnitude of yield strength by using CES software Tables the yield strength for each specimen (approximately) is shown in Table 3.

Table 3. Yield strength of the three composites.

% Composition	Yield strength MPa
30 glass + 70 PVC	125
50 glass + 50 PVC	200
70 glass + 30 PVC	250

The effect of different glass percentages on the compression modulus of new composite materials

It can be seen from figure 6 the compression modulus increased as the glass content was increased. The maximum enhancement was 62.5% which achieved at 70 % glass addition. This can be attributed to the general increase in the mechanical behavior as the glass increases, however the glass have a high hardness values compared to PVC materials.

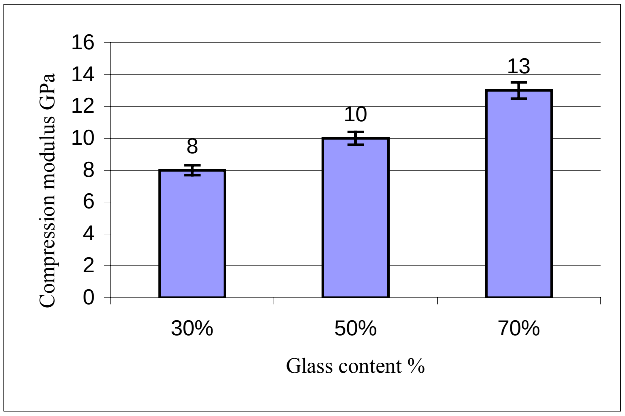
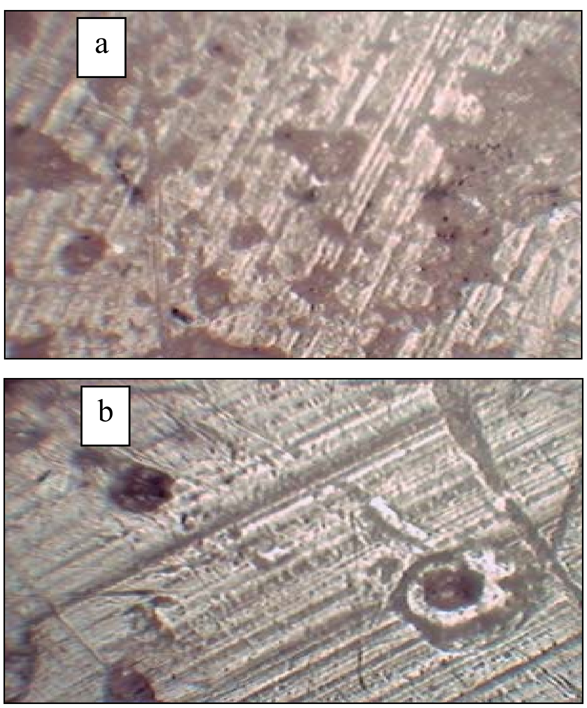


Fig. 6. The compression modulus of the new glass polymer composite.

The effect of different glass percentages on the microstructure of new composite materials

The photomicroscan were taken for the three percentages as shown in figure 7.



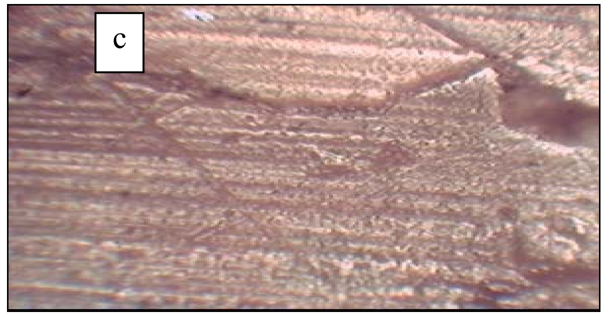


Fig.7. Photomicroscan of **a**) 30% glass **b**) 50% glass and **c**) 70% glass additions at 200x.

The effect of different glass percentages on the thermal conductivity of new composite materials

Thermal conductivity was obtained based on simple experiment as following:

Thermal conductivity can be measured referring to heat transfer equations which are:

$Q = k * \Delta T / \Delta X$

Where,

Q: Amount of heat

Where, K: thermal conductivity, ΔT: difference in temperature, and ΔX: Material thicknesses, the difference in temperature at each specimen are shown in table.4.

Table 4. The difference in temperature for the composite materials.

% Composition	Difference in temperature (˚C)
30 glass + 70 PVC	31
50 glass + 50 PVC	28
70 glass + 30 PVC	24

However,

$Q = m * cp * \Delta T$

m: mass of heated water which is 0.2 kg

cp: water specific heat which is 1.004 kj / kg

$\Delta T = 32$

So

$Q = 6.4256 \ W / m^2$

The magnitude of thermal conductivity at each spacemen are shown in Table 5

Table 5. Thermal conductivity of three composite

% Composition	Thermal conductivity ($w/(m^2.k)$)
30 glass + 70 PVC	0.001004
50 glass + 50 PVC	0.001147
70 glass + 30 PVC	0.00133

Where the thermal conductivity of glass and PVC are 1.75 , 0.2 respectively (CES software), all values in Table are less than these values , which means this polymer can be used as insulter material with low thermal conductivity.

The effect of different glass percentages on the density of new composite materials

Density of each specimen can be calculated as following:

Specimen density = glass percentage * glass density + PVC percentage * PVC density

Where:

Glass density: 2510 kg/m^3

Specimen 1 density = 0.30 * 2510 + 0.7 * 1240

Specimen 1 density = 1621 kg/m^3

Specimen 2 density = 0.50 * 2510 + 0.5 * 1240

Specimen 2 density = 1875 kg/m^3

Specimen 3 density = 0.70 * 2510 + 0.3 * 1240

Specimen 3 density = 2129 kg/m^3

The Specimen's density increased as the glass content increased as shown in figure 8.

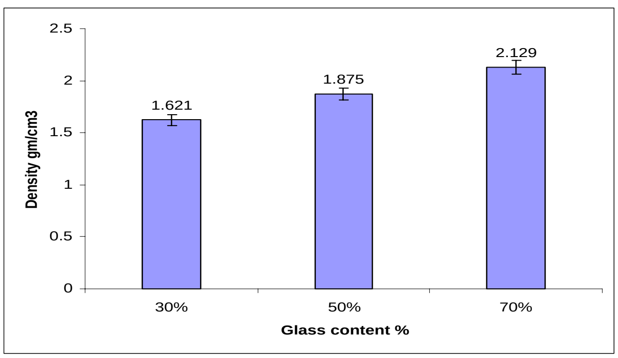


Fig. 8. The effect of glass addition on the density of new composite materials.

CONCLUSION

Based on present study, it can be conclude that the hardness and the thermal conductivity were increased as the glass percentage increase, while yield stress and the density were increased as the glass percentage increased.

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