PARTIAL REPLACEMENT OF TOLUENE DIISOCYANATE (TDI) ON MECHANICAL PROPERTIES OF OLD NEWSPAPER FILLED DIPHENYLMETHANE DIISOEYANALE (MDI) FOAM COMPOSITES

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ABSTRACT

The mechanical properties of partial replacement of toluene diisocyanate (TDI) in diphenylmethane 4,4'-diisocyanate of old newspaper (ONP) foam composite based on polyurethane (PU) was investigated. The results indicate that an increase of ONP filler content leads to an increased compressive strength, elastic modulus and hardness. At constant ONP content, foam composites produced by partial replacement of TDI in MDI result in higher values of hardness, compressive strength and elastic modulus compared to the ONP foams control.

KEYWORDS*: polyurethane, foam, old newspaper*

1.0 INTRODUCTION

The isocyanate reacts with hydroxyl groups from alcohols, amine groups, water, urethane groups and urea-groups to form urethanes, ureas, allophanates and biurets (Saunders *et.al*., 1967). The reaction of isocyanate with water liberates a primary, aromatic amine as an intermediate, which will instantaneously react further with another isocyanate-group. Amines are much more reactive to isocyanates than are alcohols and water (Mormann *et.al*., 2006). Polyurethane based on diphenylmethane-diisocyanate (MDI) is opaque and MDI monomer requires cold storage. On the other hand, the toluene diisocyanate (TDI)-based polyurethane has been used exclusively by a simple casting process (Hsu *et.al*., 1999). Although both systems contain aromatic diisocyanates, soft segments and chain extenders, the MDI system often possesses the microphase separation (Pandva *et.al*., 1988) and (Spathis *et.al*., 1994). The TDI-system contains no known hard and soft segments in the separated domains. The transparency of TDI-based polyurethanes has been attributed to the well-mixing of the hard to soft segments in the amorphous phase (Schneider *et.al*., 1975). The

increase in NCO/OH ratio of TDI based polyurethane has shown the improvement in mechanical properties, tensile strength, hardness and tear strength (Nalepa *et.al.*, 1988). This research is focus to study the effect of partial replacement of TDI in MDI of old newspaper foam composites on mechanical properties.

2.0 EXPERIMENTAL

Polyethylene glycol (PEG) 400 was supplied by Fluka Chemie from Belgium and Diphenylmethane 4,4'-diisocyanate (MDI) and toluene 2,4-diisocyanate (TDI) for synthesis was obtain from Merck Schuchardt OHG, Germany. The typical value for density of MDI is 1.239-1.241 g/mol. The old newspaper (ONP) was used as filler in this research. ONP as a waste was firstly cut into small pieces. Then, the ONP were soaked to the different bucket of water mixed with 10% solution of sodium hydroxide. After that the ONP was dried in an oven at 80°C for 24 hours to eliminate moisture and was then ground into powder form. An Endecotts sieve was used to obtain an average filler size of 63 μm (a density of 2.2 g cm^{-3}). The organic content of ONP about 90% and the inorganic content is 10%.

2.1 Mixing Procedure

ONP foam based on MDI was prepared using a 1:2 ratio and the PU with PEG is 1:2 and the ONP contents of 0, 10, 20, 30 and 40 php was directly used as reaction with diisocyanate. Formulation of ONP foam with different filler loading for combination of MDI and TDI was similar preparation of waste paper foam. Two types of polyurethane which was MDI and TDI has been mixed with ratio 1:1. Three drops of water were then added as the blowing agent, and the combination was rapidly stirred (WiseStir DAIHAN scientific HS-30D) and then set to 400 rpm until it became warm. The mixture was immediately poured into a box and was left to equilibrate to room temperature. The resultant foams were allowed to cure at room temperature for one hour before being removed from the box.

TABLE 1
Formulation of MDI/ONP foam composites

Materials	ONP Foam				
MDI: PEG (1 : 2) (php)	100	100	100	100	100
Waste paper (WP) (php)	0	10	20	30	40

TABLE 2
Formulation of MDI/TDI/ONP foam composites

Materials	ONP Foam MDI/TDI				
MDI:TDI:PEG (1 : 1 : 2) (php)	100	100	100	100	100
Waste paper (WP) (php)	0	10	20	30	40

2.2 Compression Test

The mechanical properties of the foams were measured according to ASTM D695 using an Instron Machine 3366. A piece of foam (12.7 x 12.7 x 25.4 mm) was compressed between two flat plates at a cross-head speed of 5 mm min^{-1} until the specimen reached 70% of its original thickness. The test was performed at 25 ± 3°C. Five samples used and each composition has been repeated two times.

2.3 Hardness Test

The Tecklock FO GS-710G durometer was selected for the hardness measurements since it is specifically designed for testing relatively soft materials,which includes the softness range of the foams. Its measuring concept is differentfrom standard durometers in that it is placed on the top of the specimen so thatthe applied load in the test is its own weight and the dial reading indicates how far the probe has been pushed back into the durometer body by the stiffness of the material under test. The measurements of softness were made according to the standard measuring procedures for durometers, ASTM D2240-03 (ASTM, 2003). The specimens had, as required, a minimum size of 50 mm × 50 mm with a thickness in the range of 25–30 mm. The softness measurements were taken at six different locations. The maximum readings were recorded with the aid of the peak pointer of the durometer, which indicates the maximum indentation reading during the measuring period.

3.0 RESULTS AND DISCUSSION

Fundamental studies of liquefaction behavior were conducted with old newspaper (ONP). The differences in liquefaction behavior of ONP are due to their different chemical composition of polyurethane which is ONP foam composite based on MDI as a control and ONP foam composite with partial replacement of TDI in MDI. The comparison of compressive strength between control and partial replacement

of TDI in ONP foam are shown in Figure 1. The addition of filler of the foam significantly increased the value of compressive strength. This investigation indicates that ONP plays an important role in modifying the mechanical properties of foam. The presences of fillers in polyurethane foam had reinforced the foam and thus increase the mechanical properties. It shows that ONP foam partial replacement of TDI in MDI has high value of compressive strength compare to MDI/ ONP foam.

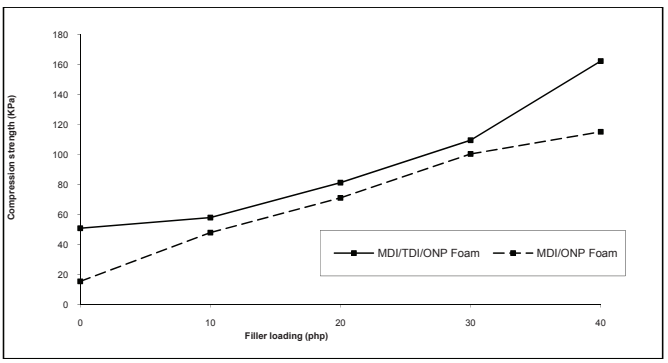

FIGURE 1
Compressive strength of MDI/ONP foam and MDI/TDI/ONP foam composites with different filler loading

Figure 2 showed the elastic modulus of MDI/ONP foam and MDI/TDI/ ONP foam with different filler loading. This plot clearly indicates that the elastic modulus of all of the ONP foam increased with increasing filler content. This due to the addition of ONP, which contains of higher organic components, improves the stiffness of the foam. It is because the higher cellulose content in ONP as a source of polyhydric alcohol can give higher rigidities of the foam.

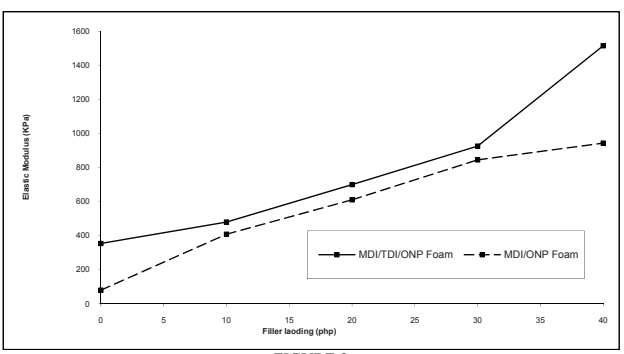

FIGURE 2
Elastic modulus of MDI/ONP foam and MDI/TDI/ONP foam composites with different filler loading

Results of hardness of MDI/ONP foam and MDI/TDI/ONP foam are shown in Figure 3. The result show that the increasing of filler loading the hardness of both foam composites. It can be seen from Figure 3 the MDI/TDI/ONP foam composites exhibit higher hardness than MDI/ ONP foam composites. This indicates that the partial replacement of TDI react with the MDI to produce a closer packed structure, which could lead to an increase in the hardness of the foam. A higher crosslinking level can lead to the production of smaller cells of foam composites.

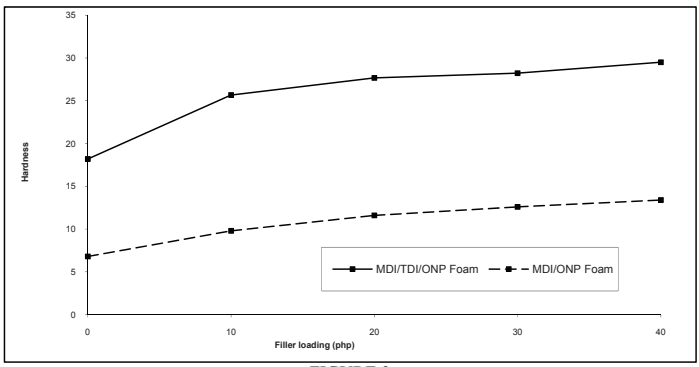

FIGURE 3
Hardness value MDI/ONP foam and MDI/TDI/ONP foam composites with different filler loading

4.0 CONCLUSION

The mechanical properties of partial replacement of TDI in MDI of ONP foam have been investigated. The results indicate that increasing the ONP filler content leads to an increase in compressive strength, elastic modulus and hardness of the foam. In addition, at similar filler content, the waste paper foam composites produced using the partial replacement of TDI in MDI result in higher values of hardness, compressive strength and elastic modulus compared MDI/ONP foam composites.

5.0 ACKNOWLEDGEMENT

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