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Effect of Sonication Time and HNT Loading on Tensile strength of Epoxy- HNT Nanocomposite

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Abstract— Epoxy-clay nanocomposites have recently gained considerable attention due to their interesting physical, thermal and mechanical properties. These properties, however, depend on a number of parameters such as the clay type, clay modifying agent, polymer matrix and the adopted mixing process. In the current work, nanocomposites were prepared from epoxy resin epoxy resin and Halloysite nano tube (HNT) using different sonication (mixing) periods (5 to 60minutes) and different concentrations of clay (2 to 5%wt). The effect of sonication time and nano loading on the tensile strength of the resulting nanocomposites were investigated. The results showed that the ultimate strength of the nanocomposites were below that of the neat epoxy. Increasing the sonication time enhanced the tensile strength..

Index Terms— Composite, Epoxy , Nanocomposite , Mixing , Polymer, Sonication, Tensile strength.

1 Introduction

The enhanced mechanical properties of nanoclay/polymer nanocomposites with a relatively light weight compared with conventional polymer-based composites have attracted the focus of researchers in the last decade. Polymer nanocomposites, especially epoxy-nanocomposite have grew substantial consideration because of their enhanced mechanical, physical and thermal properties. Investigations on the product developments of the nanoclay/polymer nanocomposites have began explosively in major manufacturing industries in the world [1–2]. Nevertheless, these improved mechanical properties are mainly depended on the fine dispersion of nanoclay platelets inside the nanoclay/ polymer nanocomposites. Ultrasound sonication of premixed nanoclay/polymer samples is always being used in assistance of the dispersion or exfoliation of the nanoclay [3]

These properties are however influenced by a number of parameters such as the nano type, loading, the polymer matrix used and the mixing process employed. Generally, mechanical properties of nanocomposites are linked to, among other things, the mixing method and the parameters of mixing such as speed and time for mixing. Consequently, mechanical properties along with other properties have been investigated in relation with mixing method and the associated parameters. It was reported by Oh [4] that nanocomposite mixed for longer time in a mechanical stirrer had better mechanical properties. Lam et al. [5] assessed the micro-hardness of nanocomposites prepared under different sonication times and reported that 10 minutes of sonication was the optimum mixing time.

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Yasmin et al. [6] found that the low tensile strength recorded for the nanocomposite in their study was due to the processing (mixing) technique utilized. Dean et al [7] concluded that nanocomposite samples mixed by sonicator showed improvement in mechanical properties than those blended by shear mixer. From the above-mentioned studies, the effect of processing parameters seems significant to nanocomposites' properties. In the present study, the variation of tensile strength is investigated with respect to sonication time and clay loading. Polymer-clay nanocomposites, especially epoxy-clay nanocomposite have gained considerable attention because of their improved mechanical, physical and thermal properties. These properties are however influenced by a number of parameters such as the clay type, clay modifying agent, clay loading, the polymer matrix and the mixing process employed. Generally, mechanical properties of nanocomposites are linked to, among other things, the mixing method and the parameters of mixing such as blending force, speed and time for mixing. Consequently, mechanical properties along with other properties have been investigated in relation with mixing method and the associated parameters. It was reported by Oh [4] that nanocomposite mixed for longer time in a mechanical stirrer had better mechanical properties. Lam et al. [5] assessed the micro-hardness of nanocomposites prepared under different sonication times and reported that 10 minutes of sonication was the optimum mixing time. Yasmin et al. [6] found that the low tensile strength recorded for the nanocomposite in their study was due to the processing (mixing) technique utilized. Dean et al [7] concluded that nanocomposite samples mixed by sonicator showed improvement inmechanical properties than those blended by shear mixer. In the present study, the variation of hardness and tensile properties, namely ultimate strength, modulus of elasticity and fracture strain are investigated with respect to sonication time and clay loading.

2 MATERIALS AND FABRICATION OF COMPOSITE LAMINATES

2.1 Materials

Due to several advantages over other thermo set polymers, epoxy LY 556 resin is selected as the matrix material for this research work. Chemically it belongs to the 'epoxide' family and its common name of epoxy is Diglycidyl-Ether of Bisphenol (DGEBA), and corresponding hardener is HY 951. The resin hardener ratio is 100:10 by weight as recommended by the supplier, Plain woven fabric type glass fabrics with an aerial weight of 200 g/m² are used as major reinforcement which was supplied by Saint Gobain. The halloysite nano tube (HNT) was procured from Natural nano, NewYork.

2.1 Fabrication Process

HNT proportion of 1, 3 and 5wt% were hand-mixed differently with epoxy.Epoxy-HNT blend was placed under high intensity ultrasonicator and sonicated for 5, 10, 30 or 60 minutes. The sonicated mixture was degassed under total vacuum for 45 minutes by a vacuum dessicator with vacuum pump setup. The hardener was then added to the epoxy, at room temperature and stirred for 5 minutes until the mixture became homogeneous. The entire blend was poured into an aluminium mold for curing. The complete setup was allowed to cure.

The Fig 1 shows the SEM image of the HNT. Fig 2 and Fig 3 shows the Ultrasonicator and Vacuum designator setups.

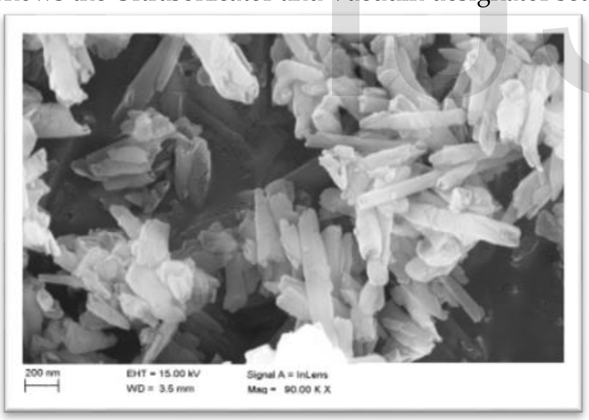

Fig.1 SEM Micrograph of HNT

Fig.2 Ultrasonicator Setup

Fig.3 Vacuum Designator Setup

3. TESTING OF MECHANICAL PROPERTIES

3.1 Tensile strength Studies

Tensile strength was tested by a Kalpak universal testing machine according to the procedure described in standard ASTM D3039-76 with a cross-head speed of 2mm/min.

4 RESULTS & DISCUSSIONS

4.1 Effect of sonication time and clay loading on nanocomposites' tensile strength

The mean value of the tensile properties found for the nanocomposites and the epoxy are given in Table 1.

TABLE 1: AVERAGE TENSILE STRENGTH OF NEAT EPOXY AND NANOCOMPOSITES

Samples	Ultimate Tensile Strength (MPa)
Neat Epoxy	72
1% - 5min	57.6
1%-10min	74.7
1%-30min	63
1%-60min	58.5
3% - 5min	53.1
3%-10min	57.6
3%-30min	53.1
3%-60min	63
5% - 5min	52.2
5%-10min	48.6
5%-30min	53.1
5%-60min	59.4

It can be observed from the result that the addition of HNT to epoxy reduces its strength at all sonication time and clay loadings. It is noticed however that the 1%-clay nanocomposites sonicated for 10 minutes (1%-10min) showed a marginal increase of 3.7 % in tensile strength. Moreover, it is noted that almost all the 1%-HNT nanocomposites have higher tensile

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strength than their 3% and 5% counterparts sonicated for the same duration. This suggests that increasing the HNT concentration will lower the tensile strength. From the data presented in Table 1, the overall trend of ultimate tensile strength with sonication times and clay loadings. It can be seen that while tensile strength increased with sonication time, it decreased with clay loading. The increase in ultimate strength with increasing sonication time can be attributed to the increase in complete HNT distribution.

5 Conclusion

This paper presents the effect of ultrasound sonication time and HNT weight propertions on tensile strength of the epoxy-HNT nanocomposite. It can be observed from the result that the addition of HNT to epoxy reduces its strength at all sonication time and clay loadings. It can be seen that while tensile strength increased with sonication time, it decreased with clay loading. The increase in ultimate strength with increasing sonication time can be attributed to the increase in complete HNT distribution.

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