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INFLUENCE OF MWCNT DISPERSION ON ELECTRIC PROPERTIES OF NANOCOMPOSITES WITH POLYESTER MATRIX

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Abstract: *Commonly, the polymers present low electric properties. For their improvement, using an appropriate dispersion technology, polymer materials are added with nanoparticles having superior electric properties. In this way, multiwall carbon nanotubes (MWCNT) and an unsaturated polyester resin were used. In order to relieve physical and chemical processes that induce the improved electrical properties to polyester/MWCNT nanocomposite material, the results obtained for different MWCNT concentrations (0,10%; 0,15%; 0,20%) are comparative presented. The contribution of multiwall carbon nanotubes concentration and their dispersion technology on nanocomposite material obtaining with improved electric properties was analyzed. Both SEM and electric conductivity analysis confirms MWCNT optimum concentration in unsaturated polyester matrix.*
Key words: *MWCNT, polyester, dispersion, electric properties, nanocomposite*

1. INTRODUCTION

Nanocomposite materials can have physical and chemical properties controlled by predesign process (Cui S., 2003). This aspect is obtained by reinforcement and matrix properties knowledge and also by a manufacturing technology applying in accordance with the studied aim. Nanocomposite materials properties are the result of the interactions from matrix - reinforcement interface level (Duk Yang B. et al., 2004).

The manufacturing technology realizes a compatibility process between primary components and facilitates a correspondingly dispersion obtaining at reinforcement nanometric dimensions (Hone J. et al., 2000). The electrical conductivity improvement in carbon nanotubes composite materials can be justified by a percolation stage assessment directly influenced by an appropriate dispersion phenomenon (Gojny F.H. et al., 2003).

2. EXPERIMENTAL

2.1 Materials

In order to obtain improved carbon nanotubes dispersion in a polyester matrix, it was used the following materials (Hone et al., 2000):

- unsaturated polyester resin AROPOL^{TM} M105;
- MWCNTs from Cheaptubes Inc. USA;
- sodium dodecyl sulphate (SDS) from Sigma Aldrich.

2.2 Methods

Carbon nanotubes dispersion at different concentrations in polyester resin was realized by a successive mechanical and ultrasound stirring. These different methods of stirring are usually used in order to obtain good dispersions of particles into polymer matrix (Fan Z.H. et al., 2004). It was realized the dispersion process considering a self-technology represented by two different types of stirring, starting with a mechanical stirring and followed by an ultrasonic one (fig.1).

Precursor solutions samples of polyester/MWCNT nanocomposite material were tested using a rheological analysis. At 0,175% MWCNT in polyester matrix, the highest viscosity increase was obtained. The precursor solutions were polymerized using a promoter/initiator catalyst system represented by cobalt octoate/P-MEK and molded in silicone rubber moulds. The samples obtained were analyzed for electrical conductivity and SEM analysis.

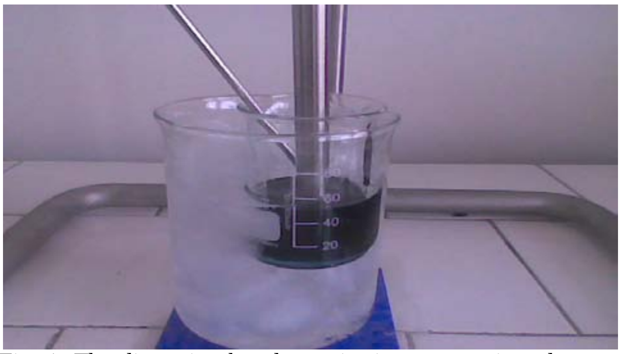

Fig. 1. The dispersion by ultrasonication process in polyester matrix

3. RESULTS AND DISCUSSIONS

3.1 Analysis of the electrical conductivity of the polyester / MWCNT nanocomposite

In fig.2 is plotted the variation of volume electrical conductivity depending on the MWCNTs concentration from polyester/MWCNT nanocomposite material at three concentrations of MWCNT (0,10%, 0,15%, 0,20%) in comparison with standard (not added polyester resin). It was used a current frequency of 100 kHz. A big increase in volume electrical conductivity of the polyester/MWCNT nanocomposite systems was observed. This increase was about four times at 0,20% MWCNT (fig.2).

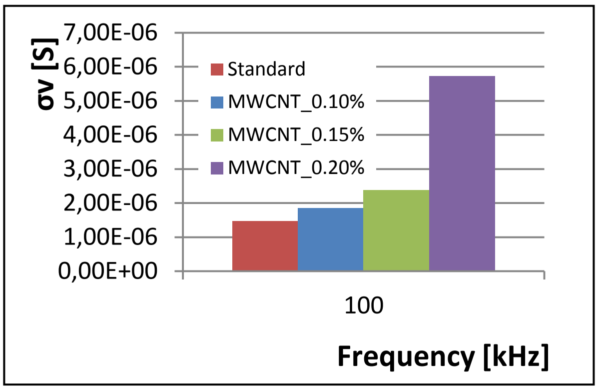

Fig. 2. Variation of volume electrical conductivity depending on MWCNTs concentration

In fig.3, variation of surface electrical conductivity is plotted depending on MWCNT concentration for polyester/ MWCNT nanocomposite materials. It was used a current frequency of 100 kHz. Similarly, an important increase in surface electrical conductivity at polyester/MWCNT nanocomposite systems was observed, about four times at 0,20% MWCNT in comparison with standard (fig.3).

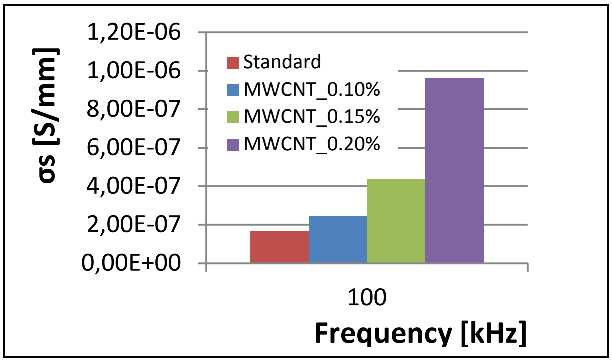

Fig. 3. Variation of surface electrical conductivity depending on MWCNTs concentration

3.2 SEM analysis of polymer/MWCNT nanocomposite material

SEM analysis highlighted carbon nanotubes dispersion degree in pure state at different MWCNT concentrations (0,10%; 0,15%; 0,20%).

Fig.4 presents SEM analysis of polyester/MWCNT nanocomposite material (0,10% MWCNT).

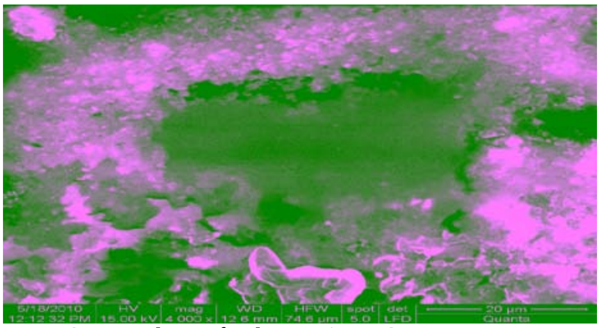

Fig. 4. SEM analysis of polyester / MWCNT nanocomposite material (0,10% MWCNT)

In this case it is seen a fairly large cluster of carbon nanotubes that can be explained by weak interactions between carbon nanotubes and polymer matrix and the action of mechanical and ultrasonic dispersion is not able to make a breakage of the strong links between carbon nanotubes.

Fig.5 shows SEM analysis of polyester/MWCNT nanocomposite material with 0,15% MWCNT. In this case, the area occupied by carbon nanotubes clusters is obviously increased.

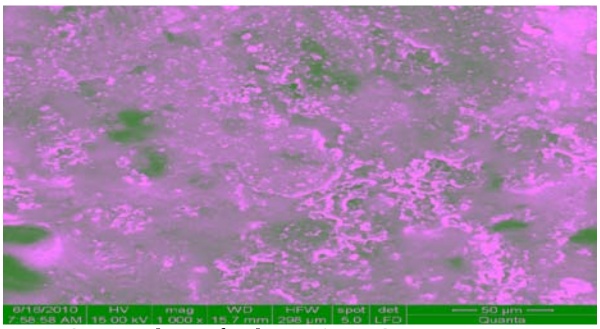

Fig. 5. SEM analysis of polyester/ MWCNT nanocomposite material (0,15% MWCNT)

At a concentration of 0,20% MWCNT, which is higher than optimum concentration value of 0,175% MWCNT (determined by the rheological analysis), polyester/MWCNT nanocomposites show bigger clusters but the distances between them are smaller (fig.6). Considering these decreased distances among all clusters, the interaction forces between isolated carbon nanotubes are increased. The percolation stage obtained for a concentration of 0,175% MWCNT is maintained also for a concentration of 0,20% MWCNT in polyester matrix.

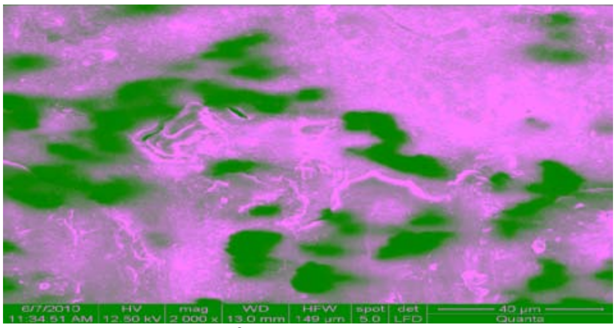

Fig. 6. SEM analysis of polyester/MWCNT nanocomposite material (0,20% MWCNT)

4. CONCLUSIONS

In terms of electrical conductivity increase is observed both at volume and surface electrical conductivity the highest value at 0,20% concentration, a very close value to the optimal concentration value obtained from rheological analysis.

This growth is four times for volume and surface electrical conductivity at polyester/ MWCNT nanocomposite with 0,20% MWCNT in comparison with standard.

The SEM analysis reveals the fact that the amount of 0,10% MWCNT, due to its small value highlights many interactions that occur between the polymer matrix and carbon nanotubes. At low concentrations these interactions are dominant. At 0,15% MWCNT, the concentration of MWCNT clusters obtained is higher.

At polyester/MWCNT nanocomposite with 0,20% MWCNT, that exceeds the optimum concentration of 0,175% in accordance with rheological analysis, it is clearly seen that the number of carbon nanotubes clusters is increasing but the distances among them is decreasing. This is explained by the fact that it exceeds the percolation limit and results an increase of interactions number between carbon nanotubes.

5. ACKNOWLEDGEMENTS

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