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PREPARATION AND CHARACTERIZATION OF WATERBORNE POLYURETHANE AND MULTI-WALLED CARBON NANOTUBE NANOCOMPOSITES

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Abstract – Waterborne polyurethane (WPU)/multi-walled carbon nanotube (MWCNT) nanocomposites with 0.1 wt% e 1.0 wt% of MWCNT have been prepared. The aqueous polyurethane based on hexamethylene diisocyanate (HDI), poly(propylene glycol) (PPG-1000) and dimethylol propionic acid (DMPA) was prepared following a prepolymer mixing process. MWCNT from Nanocyl™ presents -COOH functionalization, average diameter 9.5nm and average length <1µm. The nanocomposites were obtained after sonicating the MWCNT in the WPU dispersion. FTIR spectra, thermal properties (DSC and TG), Atomic Force Microscopy (AFM) and Electric Force Microscopy (EFM) have been used to characterize these systems.

Polyurethane-based coating systems have a proven record in the coatings industry dominating the market in some applications because they exhibit a high level of quality. In addition, polyurethane coatings are solvent and chemical resistant offering good weather stability [1]. In order to reduce environmentally undesirable emissions of volatile organic compounds, a big effort has been made by industry and academic field to develop waterborne materials [1]. These new materials must fulfill the property profile of similar solvent-borne systems. On the other hand, carbon nanotube (CNT) generates a great potential in the synthesis of polymer composite due to its excellent axial tensile strength. In addition because of the exceptional mechanical properties, CNT presents superior thermal and electrical properties [2].

In this work the waterborne polyurethane (WPU) was synthesized following a prepolymer process. Hexamethylene diisocyanate (HDI), poly(propylene glycol) (PPG-1000), dimethylol propionic acid (DMPA) and dibutyltin dilaurate (DBTDL, catalyst) were mechanically stirred in nitrogen atmosphere at 60^0C for 2 hours. After that, triethylamine (TEA) was added in order to neutralize the DMPA carboxylic groups for 50 minutes. An aqueous dispersion was obtained by adding this polyurethane prepolymer to the water at 30^0C for 30 minutes where hydrazine monohydrate (HZM) was added to extend the chain. The concentration of 0.1 wt% and 1.0 wt% of thin multi-walled carbon nanotubes (Nanocyl™, NC3151), which is functionalized with -COOH groups, were added in the WPU dispersion. After one hour sonicating, homogeneous nanocomposites were obtained. Nanocomposite films were formed by casting on Teflon substrates at 100^0C for 1hour.

FTIR spectrum for WPU film has showed typical bands corresponding to the hard and soft segment groups [1]. The thermal properties for the systems have been studied by Thermogravimetry (TG) and Differential Scanning calorimetry (DSC). The glass transition temperatures (Tg) for WPU film observed by DSC measurements are in approximately -50^0C corresponding (to the soft segments) and 38^0C (to the hard segments). No significant changes were observed to the Tg for nanocomposites with 0.1 wt% and 1.0 wt% of MWCNT. Atomic Force Microscopy (AFM) has been used in order to observe the topography and phase contrast of the nanocomposites. Electric Force Microscopy (EFM) has been applied to probe the distribution of carbon nanotubes in the WPU matrix. These Microscopic techniques have been important to correlate the morphology and structural features of the nanocomposites.

The results obtained for these organic solvent-free systems are really promising and present a great opportunity to contribute to the global tendency in developing materials that do not threaten the environment.

References

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