MULTIWALLED CARBON NANOTUBE - ELASTOMERIC NANOCOMPOSITES FOR UNDERWATER SENSOR APPLICATIONS

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ABSTRACT

The performance of underwater acoustic sensor systems for detection of targets is influenced by the effectiveness of vibration damping interfaces, on which these sensors are mounted. Conventionally, elastomeric materials with vibration damping capability are used as the interface, to damp structural vibrations emanating from the onboard machinery. In this thesis, the preparation and characterization of an advanced nanocomposite for use in these systems is elaborated. The research work established that the incorporation of multiwalled carbon nanotubes (MWNT) into a matrix of carboxylated nitrile rubber (XNBR) led to increase in different mechanical properties as well as vibration damping capability. The incorporation of 0.050 volume fraction (v_f) of MWNT was found to enhance tensile strength by 430%, modulus by 230% and tear strength by 260%. Electron microscopy analyses showed a uniform distribution of MWNT in the matrix. Decrease in length of nanotubes and agglomerate formation were observed at higher loading of filler. The differential scanning calorimetry, X-Ray diffraction, infrared spectroscopy, equilibrium solvent swelling and dynamic mechanical analyses revealed the presence of thermally labile ionic cluster formation in the material. A significant enhancement in hysteresis damping was observed, the magnitude of which depend on the type and amount of strain applied. The tensile hysteresis damping reached a maximum of 37% for 0.050v_f of MWNT, at a medium strain of 25% and then decreased at higher strain. The compressive hysteretic damping increased upto 38% at 0.035 v_f MWNT for 25% strain, and leveled off on further loading of MWNT. In the frequency domain, the position of damping peak shiftedto high-frequency region with an increase in MWNT concentration, which would be advantageous and helpful to tune the operational frequency range of underwater acoustic sensors. The enhanced damping in these nanocomposites was explained based on the deformation of ionic multiplets and clusters, breakage of MWNT aggregates and slippage of nanotubes at interfaces. A model for the change in the microstructure of the nanocomposites due to the application of heat and mechanical stress was proposed. The addition of MWNT was found to decrease the acoustic absorption of nanocomposites by 6 dB at 0.025 v_f of MWNT and leveled off after that. The high vibration damping combined with low acoustic absorption make the nanocomposites a likely choice in underwater acoustic sensor systems for damping structural vibrations, without losing any incoming acoustic energy.

Keywords: MWNT, Nanocomposites, Vibration damping, Acoustic sensors, Ionic crosslinks.