Viscoelastic and electro-active composites towards enhancing acoustic absorption in mechanical and civil structures

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Abstract

A combination of solution based processing have been used to synthesize and fabricate viscoelastic polymer composites with embedded electro-active materials such as Epoxy matrix based $BaTiO_3$, ZnO and ZnO nanowire composites. These materials will enhance mitigation of impact and acoustic disturbance by means of absorption of vibrational energy and eventual energy conversion to electrical energy. The electron transport properties of these materials were enhanced and tailored by addition of conductive phases such as graphene and carbon nanotubes. The geometry and composition of the components are varied in the composite systems to optimize the electro-mechanical coupling, dielectric and piezoelectric properties of these materials. Micro-plasma based corona discharge techniques are used to align the dipoles of the electro-active component and also for localized surface modification towards variation in surface energy of these visco-elastic composites.

Introduction

Viscoelastic polymer composites are highly touted specimens due to their ability to convert mechanical energy directly into electrical energy. Due to this characteristic, the latter have become increasingly useful in applications including impact absorption, acoustic absorption, and energy conversion. Through the use of an impedance tube , which is used to measure the acoustic impedance and sound transmission loss of a material, scientists are able to quantify and list materials whose characteristics are highly applicable [7].

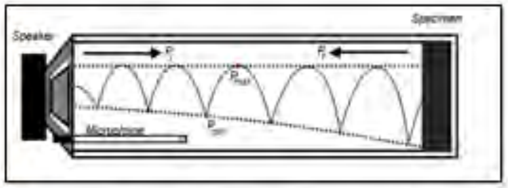

Figure 1: SWR Impedance Tube with a standing wave created by the incident and reflective pressure waves

Another possible application if these highly regarded materials is the possibility for reduction of noise pollution. This will be due to the acoustic energy being converted into vibrational energy, and finally being harvested in the form of electrical energy. Applications such as these would be highly sought after in locations with dense population such as cities and large towns.

Four Microphone Method

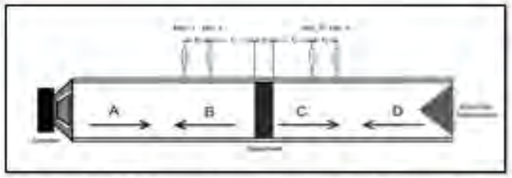

Figure 2: Four Microphone Impedance Tube Diagram

Figure 3: Four microphone tube with open termination and microphones positioned in locations 1 and 2 upward section at Rutgers University

Design of Experiments/Four Microphone Specimen Test

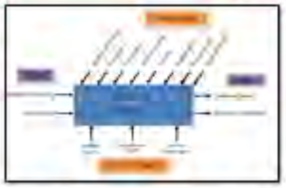

Figure 4: Impedance Analyzer System Diagram

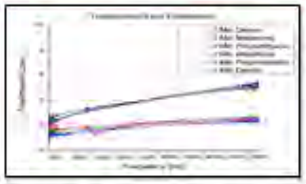

Figure 7: Transmission Loss of Samples in Three and Four Microphone Tubes

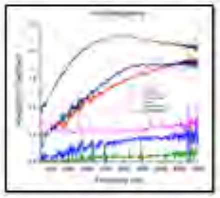

Figure 5: Specimen Test with Four Microphone Method

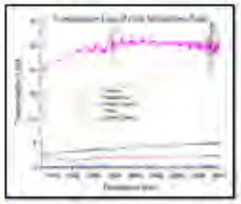

Figure 6: Transmission Loss of Four Microphone Tube

Results/Analysis

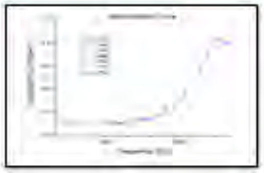

Figure 8: Multi-Position Test with Polyurethane Sample on Logarithmic Scale

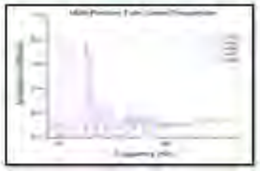

Figure 9a: Low Frequency Multi-Position Test with Polyurethane Sample on Logarithmic Scale

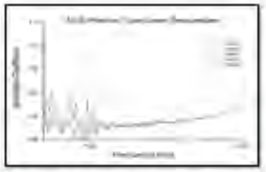

Figure 9b: Low Frequency Multi-Position Test with Polyurethane Sample on Logarithmic Scale

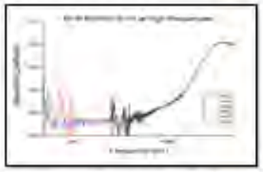

Figure 10: High Frequency Multi-Position Test Polyurethane Sample on Logarithmic Scale

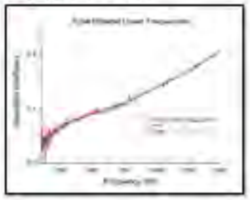

Figure 12a: Tube Material Effect on Absorption Coefficient for Polyurethane, Low and High Frequencies

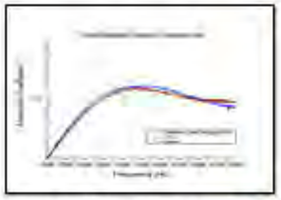

Figure 12b: Tube Material Effect on Absorption Coefficient for Polyurethane, Low and High Frequencies

Acknowledgements/References

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