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Polymer and Colloid Highlights

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Novel Multi-phase Materials Combining High Viscoelastic Loss and High Stiffness

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The development of new advanced materials with reduced noise and vibration levels is a dynamic area of research due to growing concerns in various aspects of environmental noise pollution and its possible effects on human health. Excessive vibrations can decrease the service life of the structures and also limit the areas of their use. In steady-state oscillations, the viscoelastic moduli of a material are complex and it is their loss part – the product of the stiffness modulus and the loss tangent – that is frequently considered as a practical figure of merit in noise and vibration damping applications. The stiffness modulus and loss tangent are usually mutually exclusive properties so it is a technological challenge to design and produce advanced viscoelastic materials that combine high stiffness and loss.

In our recent study[1] we showed that a rare combination of high stiffness and high loss could be achieved by filling a solid polystyrene matrix with stiff spheres coated with a thin (~200 nm) layer of a viscoelastic material (Fig. 1). This was direct experimental validation of the loss amplification effect originally proposed by Gusev using a combination of micromechanical modeling and finite element numerical calculations,[2] where an optimum ratio of the coating thickness to the particle radius was proposed. It was then demonstrated in our next study[3] that a comparable loss amplification effect could also be achieved by dispersing stiff uncoated particles in a phase-separated blend of polystyrene (PS) and a polystyrene/polyisoprene/polystyrene triblock co-polymer (SIS). The motivation for using the PS/SIS blend as the matrix came from our previous work[4] where we experimentally studied and modeled the viscoelastic properties of these phase-separated polymer blends. In this latest work[3] we have found that the key to seeing this novel loss amplification effect is the fact that during processing the SIS rubber phase formed a thin coating on the surface of the filler particles. It was also shown that the experimentally measured effects could be accurately predicted by numerical micromechanical modeling based on the measured bulk properties of the components.

This latest study[3] has suggested a novel technological way to achieve such advanced viscoelastic multi-phase materials,[5] which can be viewed as alternatives to the traditionally used laminate technique of sandwiching a thin viscoelastic layer between two stiff layers. While the traditional laminate approach is intrinsically limited in terms of shape and anisotropy, our novel multi-phase materials exhibit such advanced viscoelastic behavior in isotropic manner and they can also be injection molded into various complex shapes if required.

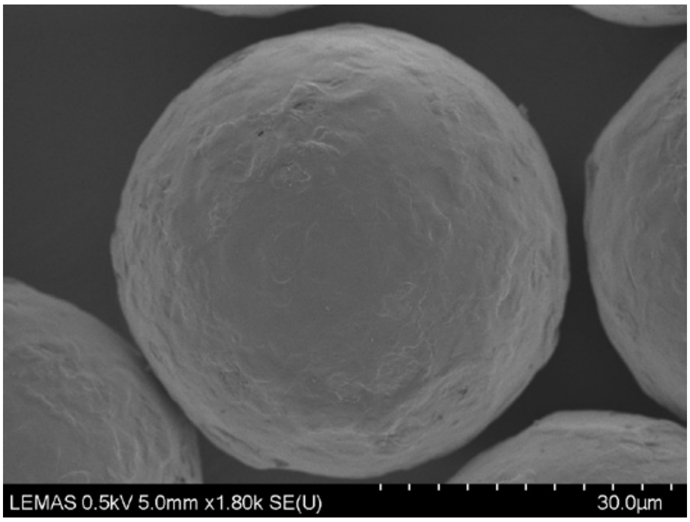

Fig. 1. Scanning electron microscope image of typical barium titanate beads after spray coating using a water emulsion of viscoelastic polyurethane coating.

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