Magneto-Dynamic Characterization of a Silicone Filament Embedded with Magnetic Composite Micro-Spheres

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Abstract. In this paper, a stimuli-responsive silicone filament embedded with a composite micro-sphere of alginate and magnetite is produced and then studied in terms of modal and damping response under the influence of a magnetic field. The interaction of the filament with the magnetic field results in a shift of the resonance frequency and a decrease in the damping ratio especially under the application of increasing loads. The latter behavior is observed to oppose that of the unexposed filament.

Introduction

In the past two decades, there has been a growing interest in the use of smart materials or stimuli-responsive materials in high-tech industries and material science technology. These are a new generation of materials that can be controlled and/or act in a predicted manner.[1] These stimuli-responsive polymers can rapidly change their configuration, dimension, or physical properties with small changes in the appropriate stimuli such as heat, pH, electricity, light, moisture/water, magnetic field, etc. One of the remarkable advantages of this new-generation of materials is their capability to be actuated remotely when exposed to external triggering sources. The use of magnetic fields seems to be promising since it allows accurate control of the deformation modes. It has also been proven to be safe and effective, especially in terms of response time. Magnetic actuation has the potential to lead to very fast response times and is very versatile in terms of the external magnetic field.
Stimuli-responsive materials with external magnetic properties can be achieved with a composition of particles of iron oxide, for example. Composites of polymers containing iron oxide were studied, using polymers such as poly(carbonate urethane) (PCU), poly (vinyl chloride) (PVC), PDMS[2], alginate[3], etc.
Alginate is a biopolymer that can be found in the cell of brown algae. It is composed of two residues, a 1,4-linked β-D-Mannuronic acid (M) and 1,4-linked α-L-guluronic acid (G). Alginate properties can be defined with the variation of these sugar residue ratios. Alginate is biocompatible, biodegradable, and easily available. For this reason, is widely used in tissue engineering, drug delivery, wound dressing, food additives, and cell encapsulation. The formation of microspheres of alginate is created by the fast crosslinking of alginate with $CaCl_2$. The microspheres can be prepared depending on the application that is intended.

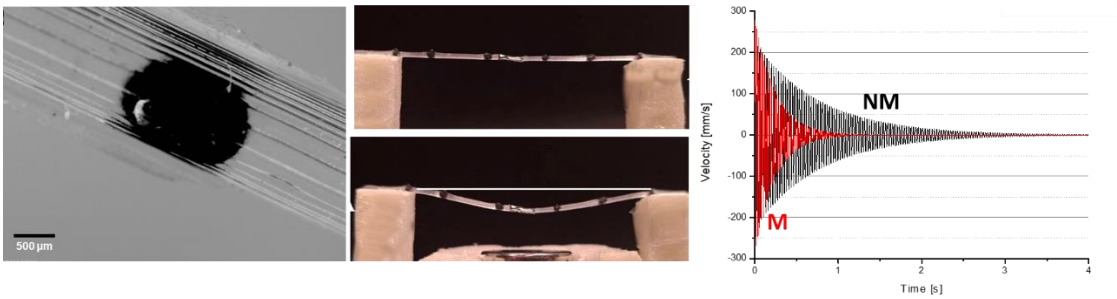

Figure 1: From left to right: Microscope image of a magnetic sphere embedded in a silicone string. Pictures of the filament with and without its exposure to a magnetic field. Time-domain response of the filament with and without the field, acquired with the laser.

Magnetic filament design and results

In this work, a stimuli-responsive material, composed of silicone with embedded alginate micro-spheres with immobilized iron oxide particles, is investigated. The composite is shaped as a filament and its response in terms of frequency and damping ratio is investigated using a laser vibrometer with and without the addition of increasing loads. It is demonstrated that such spheres allow for modification of the filament performance in terms of frequency and damping response when exposed to a magnetic field. In particular, a higher damping factor and a lower resonance frequency are recorded when a magnetic field is applied. Most importantly the study highlights the possibility to fine-tune the material design to reach the desired dynamic response (vibration and damping).

References

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