The effects of additives on the actuating performances of a dielectric elastomer actuator

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Abstract
This paper presents a comprehensive study of the effects of additives on the performance of a dielectric elastomer actuator. Previously, a new dielectric elastomer material, called ‘synthetic elastomer’, was presented for the means of actuation, which permits changes in the mechanical as well as the electrical properties in order to meet the requirements of certain applications. This work studies how the electromechanical properties of the synthetic elastomer can be adjusted by combining two additives, namely dioctyl phthalate (DOP) and titanium dioxide (TiO₂). Experiments are carried out and the effects of each additive are compared to one another based on the actuation performances.

(Some figures in this article are in colour only in the electronic version)

1. Introduction

For decades, electroactive polymers (EAPs) have been considered the emerging substitutes for existing actuators (e.g. electromagnetic motors), since these polymers can provide various benefits such as softness, cost-effectiveness, manufacturability, lightweight, etc [1–3]. Up to now, there has been a wide variety of polymeric materials applicable to actuation as well as sensing. Dielectric elastomers can be some of the most feasible materials for actuation because of their large deformation and large force capabilities at a moderate cost [4–6]. There are various dielectric elastomers that are commercially available, such as silicone, polyurethane, and acrylic elastomer (3 M), etc. Our previous work proposed a new material called a synthetic elastomer [7]. This newly developed material is capable of having its material characteristics modified to meet the requirements of specific applications, which currently has extended its applicability in going from macro to nano applications.

A dielectric elastomer actuator (abbreviated as DEA in this paper) can only work efficiently if the material properties such as the elastic modulus, viscosity, dielectric constant and breakdown voltage meet the requirements of the applications. Most applications require the dielectric elastomer to generate a larger deformation and obtain a higher energy density with a lower driving voltage than the current dielectric elastomer. The details surrounding this analysis are described in the following section.

An important feature of a dielectric elastomer actuator is the ability to modify its attributes in the presence of additives while maintaining its ease of processing. To date, there has been a large body of literature discussing the mechanical and the electrical characteristics of polymer systems [8–10]. The additives play an important role in adjusting the properties of a polymer in general and particularly that of a dielectric elastomer. A number of previous studies have reported on changing the dielectric constant of a dielectric elastomer. Zhang et al. reported that the EAP composites fabricated