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Variation of Energy Density in Thermoplastic Starch-Cellulose Microcomposites with Humidity and Temperature. A new sensing capability?

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Abstract:

Thermoplastic starch composites attracted the scientific interest due to their abundance in nature and their potential applications. In the present study, thermoplastic starch composites reinforced with microfibrillated cellulose were prepared and their electrical behaviour was investigated. The specimens were prepared via twin-screw extruder, internal mixer and compression molder, varying the filler concentration. Dielectric properties and related relaxation phenomena were studied via Broadband Dielectric Spectroscopy in the temperature range from 30 to 65°C and in the frequency range from 10^{-1} to 10^{6} Hz. Each specimen was tested at least twice in the same frequency-temperature profile, in order to investigate the effect of the adsorbed water.

In the past few decades, considerable part of the scientific interest was focused to biodegradable plant-originated polymers, which exhibit renewable and ecologically friendly behaviour. Starch is one of the most examined agro-based polymers, which is abundant in nature, inexpensive and biodegradable.[1,2] The dielectric properties and swelling characteristics of chemically modified starches have been studied before, but only for higher water-to-starch ratios.[3] The past decade, the electrical response of agro-based biopolymers has attracted the research interest. The increasing energy requirements demand more efficient energy-conversion and storage systems with more affordable and environmentally friendly characteristics.[4] The multifunctionality of some of these materials can be applied in more demanding applications requiring materials with smart behaviour. Here, we investigated the ability of thermoplastic corn starch to absorb and loose water depending on the current temperature and humidity, causing a variation in the energy density. In addition, microfibrillated cellulose was added as a reinforcement agent in order to improve this ability.

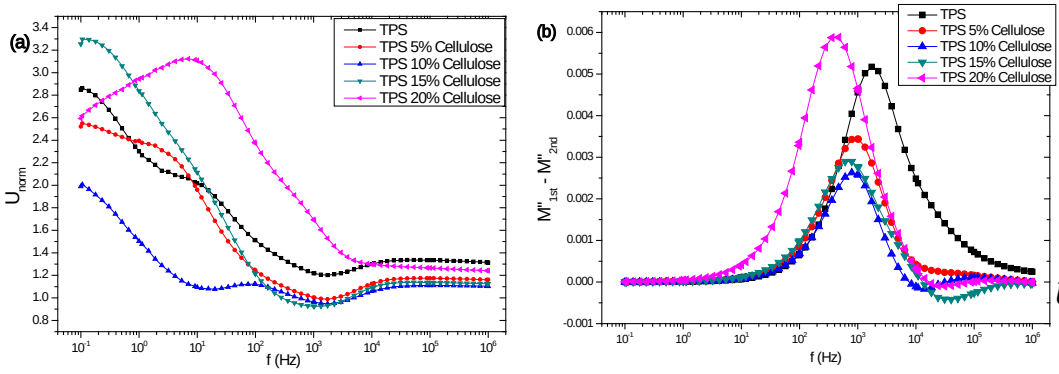

Fig.1. Variation of (a) the normalized energy density (Eq.1) and (b) the difference between the 1st and 2nd thermal cycle in the imaginary part of electric modulus for all specimens.

$$U_{norm} = \frac{U_{2nd}}{U_{1st}} \quad \text{(Eq.1)}$$

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