Proceedings of the 7th World Congress on Recent Advances in Nanotechnology (RAN'22)
~~Lisbon, Portugal~~ Virtual Conference – April 04 – 06, 2022
Paper No. ICNNFC 159
DOI: 10.11159/icnnfc22.159

Influence of Diatomaceous Biosilica on the Properties of Composites Based On Dielectric Elastomers

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Extended Abstract

Electroactive polymers (EAPs), which respond with shape changes to electrical stimulation, emerged in the early 1990s and have stimulated the creativity of many researchers [1]. These polymers are soft, strong and typically provide greater deformation at higher currents than conventional piezoelectrics. This makes them a better alternative for many applied applications. A particular class of electroactive polymers are dielectric elastomers (DE). Currently, researchers are still looking for new polymeric materials with improved mechanical [2], thermal and dielectric properties. Special attention should also be paid to increasing the dielectric permeability of a given elastomer, which can be achieved by using elastomer composites. The concept of this approach is based on the combination of high values of the dielectric constant [3] of certain fillers [4] with high mechanical strength of the polymer matrix. However, this involves the possibility of increasing dielectric losses as well as tensile stress values, which can reduce the electromechanical performance of the elastomer used. Aiming to obtain elastomeric composites with high electrical permeability, composites based on poly(dimethylsiloxane) with the addition of a unique representative of silicate materials [5], i.e. diatomaceous biosilica, were synthesised.

To obtain composites based on dielectric elastomers, poly(dimethylsiloxane) with the commercial name Sylgard was used as a polymer matrix. It is a two-component silicone elastomer, consisting of a liquid base and a catalyst. The synthesis was started by mixing the filler with an organic solvent, n-hexane. This allowed for better dispersion of the silicate material particles in n-hexane. The Sylgard A component was then added to the filler-solvent mixture. The mixing was carried out under elevated temperature and ultrasonic conditions. After a certain amount of time, depending on the amount of filler used, Sylgard component B was added and mixing was continued. The ratio of Sylgard A to Sylgard B was 10:1. When all elements of the composite had been combined, the mixture was poured onto polystyrene dishes with a surface area of approx. 58 cm^2 and left for 24 hours in a drying oven until cross-linking took place. The materials thus obtained were tested for their morphology, thermal and mechanical properties. Furthermore, the dielectric constant of the obtained materials was evaluated.

Investigations of the mechanical properties illustrated an increase in the value of the breaking stress of the polymeric matrix filled with the above-mentioned silicate material in comparison with the unfilled silicone elastomer, irrespective of the amount of the filler added, which indicates the attainment of appreciated functional qualities characterizing the composites obtained. The elastomers containing an additive in the form of diatomaceous biosilica were characterised by high elasticity, which is evidenced by the obtained increased value of the force needed to break the obtained composite. Analysis of the dielectric constant values showed an increase in electrical permeability of the filled polymer matrix in comparison to

pure Sylgard. Thermogravimetric analysis showed that the addition of diatomaceous biosilica to the poly(dimethylsiloxane) matrix increases its thermostability and indicated the unique properties of silica extracted from diatoms, revealing in the composite containing 3 wt. % of diatomaceous biosilica a shift in thermostability by as much as 150 degrees compared to the unfilled polymeric matrix, at the level of 30 wt. % loss of the composite. It should be emphasised that the analyses carried out provide a valuable source of knowledge on the effective modification of the thermal and dielectric properties of the newly obtained materials.

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