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ABSTRACT

Elastocaloric Effect in Natural Rubber and Natural Rubber based Composites

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Sustainable energy technology and materials recycling are two fundamental topics that aim to contributing to reduce the environmental impact of materials and energy production. Caloric materials can contribute to achieve this aim. Among them, natural rubber (NR) is soft, cheap and biodegradable, simultaneously solving some of the major engineering and sustainability issues of artificial heating and/or cooling. The rubber heating and cooling induced by tensile deformation, so-called elastocaloric effect (eC) is partly ascribed to the strain induced crystallization (SIC) and melting, respectively. We have prepared NR materials with a simple process: rubber mastication, blending and vulcanization. Tensile tests have been performed on vulcanized NR and NR-based composites by using infrared thermography. The degree of vulcanization by varying the quantity of vulcanizing agents, the type of vulcanizing agent (dicumyl peroxide or sulfur) [1] or the vulcanization time [2], have been studied. NR vulcanized with 1.5-2 phr of sulfur agent show optimum eC effect. The effect of the NR origin (guayule or Hevea) has been investigated. Guayule-based NR is found to be an interesting alternative as it shows similar eC effect as compared to Hevea-based NR, but in a lower range of deformation. SIC and by inference the eC effect can then be further enhanced by preparing NR-based composite. To maintain a high level of sustainability, natural fillers such as the cellulose nanocrystals [3] or waste such as ground tyre rubber (GTR) particles [4] were used as reinforcing fillers. Both show a nucleating effect on SIC and on the eC effect. Given their coefficient of performance, calculated at around 3.8-4.5, NR-based composites are promising caloric materials for their integration in heat pump systems.

[1] N. Candau et al. Polymers 15 (11), 2566 (2023).
[2] N. Candau et al. Polymer 312, 127628 (2024).
[3] N. Candau et al. Polymer 236, 124309 (2021).
[4] N. Candau et al. Soft Matter, 2022,18, 8663-8674 (2022).