Cellulose microfibers as a versatile support for shape-stable phase-change composites for thermal energy storage

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Phase change materials (PCMs) offer an exciting way to facilitate the consumption of renewable and develop responsive energy management by storing and releasing thermal energy as latent heat of reversible phase transitions. Organic PCMs are attractive due to their high latent heat storage capacity and reliability of thermal properties, however, they lack shape stability. In our study, we propose a facile approach for the preparation of that shape-stable phase-change composites by simple adsorption of organic PCMs (as exampled by fatty acids) onto the surface of the supporting cellulose microfibrils (MFC). The proposed method is simple, cheap, sustainable, and can be easily upscaled for mass production of the phase-change composites with tuneable thermal properties for energy storage applications. Cellulose is attractive due to its abundance, good mechanical properties and high specific surface area. We have demonstrated the preparation of shape-stable phase-change composite fibers containing 60, 65, and 70 wt% stearic acid with the latent heat storage capacity of 108 – 125 J/g with only 2% fluctuation in melting and freezing enthalpies during cyclic heating/cooling tests.

Additionally, the cellulose surface is rich in active hydroxyl groups. This allows for chemical modification of cellulose fibers to prepare the phase-change composites with enhanced functional properties. In particular, magnetite-modified MFC was employed for the preparation of multifunctional phase-change composites for bimodal thermal/electromagnetic energy storage. In particular, MFC was modified with magnetite nanoparticles in a tunable way via co-precipitation of Fe2+ and Fe3+ salts of various concentrations. The saturation magnetization of 23 emu/g was achieved in MFC with 31 wt% of magnetite. The phase-change composites were prepared by adsorption of lauric acid onto magnetite-modified MFC. The resulted composites demonstrated the saturation magnetization of 11.2 emu/g and latent heat storage capacity of 90 J/g corresponding to the loading efficiency of lauric acid of 49 – 51%. The IR-imaging revealed the efficient accumulation of the latent heat in the phase-change composite under the simulated sunlight and high frequency alternating magnetic field along with the excellent shape-stability of the composites during the melting of lauric acid.

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