Anisotropic Nanocomposites for Multifunctional Thermal Management

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Abstract— Thermal managements play a key role in many emerging technologies, requiring materials with directional thermal conductivities ranging from ultralow to extremely high values to precisely control the heat flow depending on the applications. Polymer nanocomposites containing two-dimensional (2D) fillers such as graphene, boron nitride nanosheets (BNNS), and MXene are ideal for anisotropic thermal conduction by exploiting the intrinsic anisotropy of the fillers. The key is to rational assembling these fillers into three-dimensional (3D) structures with preferred alignment based on the applications.[1] Here, we present the rational design of two anisotropic nanocomposites for thermal managements in dielectrics and interfacial solar vapor generation. First, BNNS-polyimide (PI) and reduced GO (rGO)-PI layers are alternatingly stacked to form aligned laminates using a novel sequential freeze-casting technique followed by compaction.[2] The alternating, distinctively separated rGO and BNNS layers give rise to a high in-plane thermal conductivity of 1.49 $Wm^{-1}K^{-1}$ and excellent electrical insulation in the thickness direction, contributing to high-energy-density dielectric energy storage. Then, we report the development of 3D MXene/polyvinyl alcohol (PVA) composite aerogels with hierarchical pore channels for highly efficient solar vapor generation. An MXene/PVA aerogel with hierarchical porous channels consisting of long horizontal tubular pores and short vertical microchannels are developed for highly efficient solar vapor generation. Its unique pore structure gives rise to both excellent sunlight absorption rate and an ultralow thermal conductivity, contributing to a high evaporation rate of 1.89 kg m^{-2} h^{-1} with an over 90% energy efficiency.[3] The anisotropic composites can enable efficient dissipation and utilization of thermal energy for sustainable applications.

References

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