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Thermal conductivity and tortuosity of porous composites considering percolation of porous network: From spherical to polyhedral pores

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Abstract: Understanding the effect of percolation behavior of complex geometrical pores on the tortuosity and thermal conductivity of porous composites is very crucial to the design and optimization of porous composites. In this work, we adopt the continuum percolation theory to accurately determine the nonlinear thermal conductivity and tortuosity of porous composites composed of homogeneous solid matrix and three-dimensional pores of geometrical morphologies from the isotropic sphere to anisotropic polyhedra. Through extensive Monte Carlo simulations and the finite-size scaling analysis, the percolation threshold of spherical and polyhedral pores is obtained. Two continuum percolation-based models are respectively presented to derive the tortuosity and thermal conductivity of porous composites over the whole porosities range, including near the percolation threshold. Comparison with extensive experimental, numerical and theoretical results confirms that the present models are capable of accurately determining the percolation threshold and tortuosity of complex geometrical porous networks and the effective thermal conductivity of porous composites as conductor-superconductor and insulator-conductor media. Furthermore, we use the proposed models to probe the influences of pore shape and porosity on the tortuosity and thermal conductivity of porous composites. The results elucidate the intrinsic interplay of component, structure, and thermal conductivity of porous composites, which can provide sound guidance for

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