Thermoelectric Polymer Nanocomposites

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Polymers are intrinsically poor thermal conductors, which are ideal for thermoelectrics, but low electrical conductivity and thermopower have excluded them as feasible candidates for thermoelectric applications. By adding single-walled carbon nanotubes to a polymer emulsion, we demonstrate that polymer nanocomposites can exhibit true thermoelectric behavior (i.e., generate electricity via a thermal gradient). As the polymer emulsion is drying, the relatively large polymer particles (100 – 1000+ nm) force nanotubes to reside in the interstitial space between them. This creates a segregated network of carbon nanotubes and results in high electrical conductivity at low nanotube concentration. This high electrical conductivity can be obtained while maintaining low thermal conductivity, which is very close to the intrinsic thermal conductivity of the polymer (~ 0.4 W/m-K). When a nanotube-filled composite with an electrical conductivity beyond 400 S/cm is produced, using an intrinsically conductive polymer stabilizer PEDOT:PSS, a thermoelectric figure of merit (ZT) greater than 0.02 can be obtained at room temperature. Aside from thermoelectric applications, these paint-like composites can achieve electrical conductivity greater than 400 S/cm, which may be useful for flexible electrodes or EMI shielding. This level of conductivity is unprecedented for a fully organic composite.

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