Fully Organic Water-Based Coatings, with High Thermoelectric Power Factor, that Convert Waste Heat into Useful Voltage*

The thermoelectric properties of fully organic nanocomposites were investigated, for which *meso*-tetra(4-carboxyphenyl) porphine (TCPP) and poly(3,4-ethylenedioxythiophene):poly(styrene sulfonate) (PEDOT:PSS) were used as instrinically conductive and semiconducting stabilizers, respectively. The electrical conductivity (σ) of these dual-stabilizer organic composites increased to approximately 9500 S m^{-1}as the concentrations of both the multiwalled carbon nanotubes (MWNTs) and PEDOT:PSS were increased. The thermopower (or Seebeck coefficient, S) and thermal conductivity, however, remained relatively unaffected by the increase in concentration (≈40 μV K^{-1} and ≈0.12 W m^{-1} K^{-1}, respectively). Replacing MWNTs with double-walled carbon nanotubes (DWNTs) increased σ and S to approximately 96 000 S m^{-1} and 70 μV K^{-1}, respectively, at 40 wt % DWNT. This study suggests that σ and S can be simultaneously tailored by using multiple stabilizing agents to affect the transport properties of the junctions between nanotubes. Combining semiconducting and intrinsically conductive molecules as CNT-stabilizers has led to a power factor that is among the best for a completely organic, free-standing film (≈500 μW m^{-1} K^{-2}). These flexible, segregated-network nanocomposites now exhibit properties that rival the more conventional inorganic semiconductors, particularly when normalized by the mass. This work represents a relatively low cost water-based “paint” that can generate electricity from waste heat, so in the future the body heat of a lecture audience could power the lights in a room through the thermoelectric painted walls.

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