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Organic Nanostructured Crystals for Thermoelectric Cooling in Medical Applications

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Abstract

In this study we performed theoretical calculations and numerical modelling of a thermoelectric p-n pair composed of organic nanostructured crystals. Specifically, we focus on two highly promising materials: TTT2I3 and TTT(TNCQ)2 crystals, which exhibit promising thermoelectric properties attributed to their unique molecular arrangements and electron-phonon interaction mechanisms. Our theoretical investigations demonstrate that tuning the concentration of charge carriers can significantly enhance the thermopower and electrical conductivity of these materials. However, such manipulations can also introduce impurities and lattice dislocations that affect the thermoelectric properties. Through detailed numerical calculations, we explored the thermoelectric characteristics of these crystals within specific temperature ranges, charge carrier concentrations, and impurity scattering parameters. Numerical calculations reveal that, within a certain range of temperature, charge carrier concentration, and impurity scattering parameters, these crystals exhibit highly promising thermoelectric characteristics. Building on these findings, we investigate the cooling properties of a thermoelectric device composed of these materials, with potential applications as local cooling systems for medical use or accurate temperature controllers for biomedical laboratories. Our results demonstrate the potential of these organic nanostructured crystals as small-scale, efficient, reliable, and environmentally friendly cooling devices. Moreover, their non-toxic nature makes them particularly suitable for diverse medical and biomedical applications, such as localized cooling systems and precise temperature controllers.

Keywords: organic nanostructured crystals, thermoelectric coefficient of performance, · thermoelectric coolers, medical applications, temperature control, local cooling systems

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