Chemical Tuning of Zintl Phases for Thermoelectric Applications: Direct Heat to Energy Conversion

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There are many areas of science where progress is materials limited. The synthesis and identification of new compounds that can lead to enhancements in existing technologies, or serve as the basis of revolutionary new technologies, is essential for developing new and improved technologies. Approximately 85% of energy comes from fossil fuels that are burned in order to produce electricity through the Carnot cycle. Approximately half that energy is wasted in terms of heat and other energy losses. Zintl compounds can be described by a combination of ionic and covalent bonding, composed of electropositive cations which donate electrons to the more electronegative components that utilize the electrons to form various bonding motifs. Zintl phases have been shown to be ideal for thermoelectric applications such as waste heat to electrical power conversion. Increasing efficiency of thermoelectric materials requires the simultaneous optimization of the Seebeck coefficient (S), electrical resistivity (ρ) and thermal conductivity (κ). The figure of merit, $zT = S^2T/\rho\kappa$, where T is the absolute temperature provides a measure of the efficiency of a material: the higher the zT, the better. I will present how we can tune the carrier concentration in the high temperature high zT compound, $Yb_{14}MnSb_{11}$, by substituting 3+ rare earth cations for Yb. I will discuss the synthesis, structure, and thermoelectric properties of these materials and their potential for thermoelectric energy conversion.