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Abstract

We provide a perspective on a series of materials that we have termed tetrahedral transition metal chalcogenides (TTMCs), which have a common layered structural motif that could carry novel functionalities on account of the d-orbitali filling. While strong covalent bonding predominates within the TTMC layers, the layers themselves can be held together by van der Waals interactions, Coulombic forces, or even hydrogen bonding. Although similar to transition metal dichalcogenides (TMDs) in some respects, TTMCs have been less explored in their synthesis and materials properties. Unlike TMDs where the transition metal is typically tetravalent and in a 6-coordinate environment, TTMCs contain the transition metal in a tetrahedral environment and in a low valent state of I or II. Structurally, TTMCs crystallize in tetragonal or orthorhombic structures on account of the square lattice formed by the transition metal centers. We present our work on the synthesis and characterization of novel iron chalcogenides utilizing hydrothermal and topochemical methods to study the effects of interlayer species on superconductivity and magnetism. Additional work aimed at expanding this new class of materials past iron chalcogenides with the synthesis of the cobalt analogues to superconducting FeSe and FeS. Our results have broad implications for the rational design of new two-dimensional building blocks for functional materials utilizing the tetrahedral transition metal chalcogenide motif.