A Scalable, Facile, Bottom-up Synthesis of Nanostructures

Synthesis protocols of 1D and 2D materials that are readily scalable, cost-effective, eco-friendly has triggered a global interest from both the scientific and industrial viewpoints. Nevertheless, the making of such structures has been always either selective etching expensive layered solids through acid treatments, or autoclaving metal salts or organic compounds under certain pressures and temperature conditions. Herein we present a powerful pathway to convert – through a bottom-up approach – 20 different precursors including metal oxides, carbides, borides, phosphides, silicides, aluminides, and even the metals themselves into 1D nanofilaments and 2D flakes. The precursor is simply mixed with common, cheap salts – in one pot – at near ambient conditions for a few days. The structure, composition, oxidation state, and morphology of the synthesized flakes are determined by density functional theory, X-ray diffraction, X-ray photoelectron, electron energy loss, Raman, X-ray absorption near edge structure spectroscopies, atomic force microscope, scanning, transmission and high-resolution transmission electron microscopies and selected area diffraction. The resulting nanofilaments and 2D sheets of various compositions and intercalants enabled the fabrication of electrodes that performed well – in various electrolytes – as cathodes in Li-ion battery, Li-S battery, and supercapacitors. Some of these materials also reduce the viability of cancer cells thus showing potential in biomedical applications. The developed protocol to synthesize 2D materials, at near ambient conditions, with non-layered, inexpensive, precursors is paradigm shifting and will undoubtedly open new and exciting avenues of research and applications.