INVITED ORAL PRESENTATION

Hydroxide derived nanomaterials and their properties

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One- (1D) and two-dimensional (2D) materials offer advantages that their 3D counterparts do not. To produce such materials in *bulk* there are two conventional approaches: bottom-up and top-down. MXenes are an excellent example of the latter. The main drawback of this approach is the high cost in first making the layered solid and then the many steps needed to etch and delaminate them. The bottom-up approach is in principle much more scalable. There are several bottom-up approaches, the one of interest here is a solution-precipitation approach common in the processing of ceramic powders, especially oxides of Ti and Si. The man disadvantages of this approach are the need to rely on the solubility of the precursor salt or compound in water and the need for a calcination and/or hydrothermal step that is usually needed to crystallize the products made at lower temperatures. In trying to etch the MAX phases without HF, we stumbled on a powerful method to make 1D and 2D materials. The general idea is to dissolve inexpensive, non-water soluble, precursors in high pH solutions at temperatures <100 °C under ambient pressures for a 10's of hours. The aim of this talk is to describe the resulting materials and some of their properties in 3 systems: Ti, Mn and Fe. In the Ti case, we converted 10 binary and ternary titanium carbides, nitrides, borides, phosphides, and silicides into lepidocrocite-based, 1D sub-nano filaments, NFs, ≈ 5x7 Å in cross-section by immersing them in a tetramethylammonium hydroxide, TMAH, aqueous solution at ≈ 85 °C range for a few days. Depending on how they are washed, the 1D NFs self-assemble into 2D flakes, mesoscopic particles or nanoparticles. In some cases, the conversion is 100 % precluding the need for centrifuges, filters, etc. We currently routinely make 100 g batches in a lab setting. The photochemical production of H_2 and dye degradation using these 1D NF will be discussed. In the Mn-case, five water-insoluble Mn-bearing precursors, were converted to birnessite 2D MnO_2 flakes, that are quite crystalline. Here again, the precursor powders are immersed in 25 wt. % TMAH aqueous solutions at 50 °C to 80 °C, for 4 to 2 days, respectively. The 2D sheets demonstrate reversible O_2 electrocatalysis with activities comparable to those of a commercial Pt/C catalyst. In the Fe case, we start with FeB and end up with Fe_3O_4 NPs in the 20 nm range. Synthesizing 1D and 2D materials in bulk, at near ambient conditions, starting with non-layered precursors (e.g., TiC, Mn_3O_4, FeB) could usher a new age where 1D and 2D materials can be mass produced inexpensively using earth abundant elements and a green process.