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ABSTRACT:

Assembling the Future Materials Using 2D Nanobricks (MXenes)

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More than 50 stoichiometric MX compositions and dozens of solid solutions and MXene structures with various terminations have been reported since the first report on $Ti_3C_2T_x$ in 2011 [1]. The number of possible compositions is infinite if one considers solid solutions (more than 50 have been made in our lab), high-entropy MXenes, and combinations of surface terminations. New subfamilies of in- and out-of-plane ordered MXenes, oxycarbides, 2D borides, and silicides further expand the family of non-oxide 2D materials based on transition metals. They can be made using a wide variety of methods, including direct synthesis from metal chlorides and carbon sources and the selective etching of layered ceramics in aqueous etchants, molten salts, or halogen-containing gases [2]. MXenes have opened an era of computationally driven atomistic design of 2D materials, and we are just starting our journey into the world of atomistically designed materials. MXenes possess electronic, optical, mechanical, and electrochemical properties that differentiate them from other materials. MXenes are 2D building blocks for the assembled materials and devices that will power future technologies. Chemically tunable superconductivity has been demonstrated in Nb- and Mo-based MXenes. Highly nonlinear optical properties of MXenes are being explored. Several MXenes have been predicted to exhibit topological insulator behavior. MXenes are metallic conductors but with a tunable density of states at the Fermi level, like semiconductors. Moreover, their properties are tunable by design. They can be modulated using an ionotronic approach [3], leading to breakthroughs in fields ranging from optoelectronics and electromagnetic interference shielding to communication, energy storage, catalysis, sensing, and healthcare. In several applications, such as electromagnetic interference shielding and thermal insulation, MXenes have already outperformed all other materials [4]. In this talk, I'll discuss the emerging synthesis methods of MXenes and the effect of synthesis on composition and properties, and assembly of MXenes into multifunctional structures. I'll also outline prospects for applications of MXenes in electronics, healthcare, thermal management, communication, and energy generation and storage [5].

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