MXenes – 2D Materials for Epidermal Electronics, Sensors, Actuators and Soft Robotics

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Abstract

Many 2D materials emerged following the graphene breakthrough. Although quite a few remain subjects of purely academic interest, others have jumped into the limelight due to their attractive properties. Among the latter are 2D carbides and nitrides of early transition metals known as MXenes [1]. The family of MXenes has been expanding rapidly since the discovery of Ti3C2 at Drexel University in 2011. More than 30 stoichiometric MXenes (from hundreds of possible compositions) have been reported, about the same number of solid solutions studied, and at least 10 different surface terminations demonstrated, further expanding the range of properties offered by MXenes. This presentation will describe the state of the art in the synthesis of MXenes, their delamination into single-layer 2D flakes and assembly into films, fibers and 3D structures. The versatile chemistry of the MXene family renders their properties tunable for a large variety of applications. MXenes can be processed in pure water, they have higher electronic conductivity and mechanical properties compared to all other solution-processed 2D materials, and can act as host structures for ions. They can be further combined with polymers and gels to produce functional nanocomposites. Chemical and electrochemical insertion of ions and molecules between the MXene layers allows electrochemical sensing and actuation. Plasmon resonances in visible and IR range make optical (thermal) actuation possible. Low-impedance epidermal electrodes and microelectrode arrays with tunable optical properties based on Ti3C2 MXene have been developed. MXenes have found use in a wide range of other applications ranging from energy storage and harvesting to electromagnetic interference shielding, communication, strain sensing, optics, electronics, plasmonics, and medicine [1].

1. A. VahidMohammadi, J. Rosen, Y. Gogotsi, The World of Two-Dimensional Carbides and Nitrides (MXenes), Science, 372, eabf1581 (2021)