Innovation nanocomposites-based on large-size defect-free monolayers of MXene with enhanced hydrogen barrier properties

As a new member of the two-dimensional (2D) material family, MXene (particularly $Ti_3C_2T_x$) has been widely studied. However, the preparation of large, defect-free $Ti_3C_2T_x$ with high yields is still challenging, which is critical for the development and applications of MXene. Here, a method utilizing the volume expansion of low-freezing-point mixed solvents (LFPM) for the efficient, gentle, and uniform exfoliation of large, defect-free $Ti_3C_2T_x$ flakes is proposed. The exfoliated MXene flakes have an average size greater than 10 μm, feature defect-free surfaces, exhibit a conductivity of 6000 S/cm, and achieve a yield as high as 61%. This study paves the way for a novel, green, and pollution-free method for exfoliating large, defect-free $Ti_3C_2T_x$ and other 2D materials, facilitating their large-scale application.

Hydrogen energy is considered the optimal energy source for the next generation due to its high combustion heat value, wide availability, and environmentally friendly, pollution-free nature. However, because hydrogen atoms are the smallest atoms, they can easily penetrate pipeline materials during hydrogen energy transportation, leading to hydrogen embrittlement. This phenomenon poses significant challenges to the safe transportation of hydrogen energy. To address this issue, researchers have developed a hydrogen barrier coating with excellent hydrogen-blocking capabilities by combining large-sized, defect-free MXene nanosheets with PVA (polyvinyl alcohol) and PAA (polyacrylic acid). The best results, at 50°C and 50% relative humidity (RH), were obtained with the system containing 3 phr of MXene (HAVOH/PAA 50/50 3MX), which showed a significant 70% decrease in the hydrogen transmission rate (HTR) compared to the HAVOH/PAA system. The development of this coating provides an effective solution for the safe transportation of hydrogen energy.