Abstract

MXene, due to their unique chemical structure, have been recognized as a potential material, having high surface area, high thermal and electrical conductivity, and a tunable band gap, showing great hydrophilicity and stability. The adsorption and reducing properties of MXene-based 2D nano-materials make them efficient photocatalysts for degrading organic pollutants. Various MXene-based photocatalysts have been inventively constructed for a variety of photocatalytic applications ranging from pollutant degradation to hydrogen evolution. They can be applied as co-catalysts in combination with assorted common photocatalysts such as metal sulfide, metal oxides, metal-organic frameworks, graphene, and graphitic carbon nitride to enhance the function of photocatalytic removal of organic/pharmaceutical pollutants, nitrogen fixation, photocatalytic hydrogen evolution, and carbon dioxide conversion, among others. High electrical conductivity, robust photothermal effects, large surface area, hydrophilicity, and abundant surface functional groups of MXene makes them as attractive candidates for photocatalytic removal of pollutants as well as improvement of photocatalytic performance of semiconductor catalysts. The fabrication of nanoparticles on the surface of MXene sheets impart excellent photocatalytic properties. Herein, low-cost environment-friendly method involving the use of electrostatic force of attraction was used to grow metal nanoparticles on the surface of fluoride-etched MXene sheets. The negative zeta potential of the MXene sheets allow the metal ions to be reduced on the surface which also renders the restacking of sheets that eventually provide a high surface area to interact with dye molecules to interact thereby transforming in to less toxic form. In contribution to the development of a novel low-cost photocatalyst, MXene/silver nanoparticles-based nanocomposite were synthesized by fabricating the silver nanoparticles over the MXene sheets. Two different concentrations of silver nanoparticles were grown (1:50 and 1:20 by weight to silver salt) using polyvinyl pyrrolidone as a dispersant medium. The elemental composition and morphology of the nano-catalysts Ag20@$Ti_3C_2T_x$ and Ag50@$Ti_3C_2T_x$ were analyzed by X-ray diffraction (XRD) analysis, X-ray photoelectron spectroscopy (XPS), energy-dispersive X-ray (EDX) spectroscopy, and field-emission scanning electron microscopy (FESEM). FESEM micrographs reveal porous exfoliated $Ti_3C_2T_x$ sheets obtained by continuously stirring Ti_3AlC_2 for 44 h at 60 °C, providing a platform for the growth of Ag nanoparticles. Diffused reflectance spectroscopy (DRS) indicates that the bare silver nanoparticles show a decrease in the band gap value from 2.4 to

1.35 and 1.41 eV in Ag50@$Ti_3C_2T_x$ and Ag20@$Ti_3C_2T_x$, respectively, which enables the nanocomposites to show excellent catalytic performance and degrade around 99% of safranin dye within 15 min at a concentration of 5 mg Ag50@ $Ti_3C_2T_x$. Furthermore, Ni_2P based MXene photocatalyst was also synthesized using hydrothermal method by reacting the metal precursor with phosphorus source in the basic medium. The fabrication of the Ni_2P also effects the band gap which ultimately lead to the degradation of Reactive black 5 dye with in 60min. The reusability of the catalyst confirms the stability of the nano catalyst.

Apart from that this study emphasize the synthesis of metal selenides on MXene nano structure to investigate the electrochemical properties. Ruthenium doped Nickle selenide and Tungsten doped cobalt selenides were synthesized using hydrothermal method. Advanced characterization techniques were applied to investigate the phase, morphology and oxidation station of the elements. The electrochemical properties of Ru doped Nickle Selenide were investigated by cyclic voltammetry using 0.1M KOH solution. It was found that MXene sheets show a high over potential value i.e., 580mV as while NiRuSe/MXene show 324mV with a lower tafel slope of 192mVdec^{-1}. In comparison the that, NiRuSe show such an overpotential of 392mV which shows that NiRuSe/MXene nanocomposite is a potential candidate show better OER properties. The incorporation of tungsten in cobalt selenide fabricated on the MXene sheets also showed an overpotential of 359mV with a lower tafel slope of 201mVdec^{-1}.