Effect of protocol optimization for MXenes synthesis on their photocatalytic activity toward hydrogen production

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Photocatalytic hydrogen generation using various 2D materials appears to have fascinating premises as a promising strategy for solar-driven water splitting. Titanium-based MXene ($Ti_3C_2T_X$) materials are anticipated to be applied as photocatalysts thanks to their remarkable properties, such as excellent conductivity, exceptional hydrophilicity, large electrochemically active surface, and tailored structure. These materials are expected to replace noble Pt in photocatalysis [1,2]. Nevertheless, there are many factors that can affect the photocatalytic activity of MXenes. Primarily, their synthesis and subsequent procedures applied for their purification are very important. In our investigation, we obtained various fractions of $Ti_3C_2T_X$ MXenes via differential centrifugation with decreasing RPMs. All the isolated fractions differed in terms of lateral sizes of MXene flakes, the number of intercalant layers, the amount and the kind of impurities. All the above-mentioned factors can strongly influence the photocatalytic activity of a given MXene fraction for hydrogen generation. We investigated and compared the achieved fractions of titanium-based MXenes using the most essential instrumental techniques, namely, X-ray diffraction, scanning electron microscopy, and Raman spectroscopy. Subsequently, we compared the photocatalytic activity of each of the fractions in dye-sensitized systems. It appeared that depending on the kind of impurities and their presence or absence the activity of MXenes can either dramatically decrease or remain almost without changes. For instance, the purification of the sample from a small amount of parental MAX-phase didn't influence their activity, whereas a significant reduction of lithium salts in the sample of MXenes led to its notable decrease. It is likely that the degree of oxidation of the sample influences the intrinsic and co-catalytic activity of MXenes in photocatalytic systems in opposite ways: either increasing or decreasing it, respectively. The most active MXene fraction exhibited the hydrogen evolution rate of 89,1 mmol h^{-1} g^{-1} for EY/$Ti_3C_2T_x$/$CoSO_4$ system. Our work shows huge potential of 2D MXenes used in dye-sensitized photocatalysis for hydrogen evolution.

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References

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