Mxene-based Composites for Energy Conversion and Storage Application

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The emergence of new multifunctional materials continuously increases the expectations for the performance of energy conversion and storage devices. The exploitation of renewable energy for sustainable development is an important part of national and international energy policies. Nowadays there are several technologies that are considered for energy storage. The production of hydrogen by water electrolysis is now considered one of the most promising technologies. Ammonia is considered as a potential hydrogen carrier, while the NH_3 electrosynthesis from N_2 and H_2O looks attractive currently limited by its low efficiency. All these technologies require efficient and cheap electrocatalysts for successful industrial implementation.

MXenes, a family of two-dimensional transition metal carbides has been discovered as candidate for these applications [1], [2]. MXene/metal composites are considered as promising electrocatalysts for several processes. Ni and Ni-based alloy (Ni-Cu) electrodes have been employed as non-precious metal catalysts for hydrogen production owing to their substantial catalytic activity in hydrogen evolution reaction (HER) in alkaline media. This work proposes a concept of composite structures composed of MXene/metal as functional materials. The concept is based on the combination of the initial MAX phase with metal alloys (Ni, Cu), tuning MAX phase and metal-Al alloy ratio and synthesis conditions, followed by Al etching. In more details this work explores the possibilities for the processing of Ni/MXene or Cu/MXene - containing composite electrodes. It was found that the presence of Cu and Al excess in the reaction mixture promotes the formation process of conventional MAX phases due to generating Al-rich metal-Al alloys with a lower melting point. Further etching of these sintered products in HF or alkaline solution allowed the direct formation of electrodes with active surface containing MXene and nanoporous metal (Cu, Ni) composites with good electrical conductivity and catalytic activity in hydrogen evolution reaction [2, 3].

References

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[3] Sergii A. Sergiienko et al., Int. J. of Hydrogen Energy, 46 (2021) 11636–11651