Physicochemical properties of Ti-based MXenes obtained from SHS synthesized MAX phases and their application for energy storage

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Abstract

MXenes attract attention as electrodes for energy storage applications e.g. for supercapacitors due to combine 1) large theoretical electrochemically active surface, 2) high theoretical conductivity and 3) hydrophilic nature of their surfaces. The problem is that the methods of MXenes preparation described in the literature are often multi-stage and complicated. So the purpose of our work is the development of more simple and technologically acceptable method of MXenes preparation. In the literature the synthesis of MAX phases (precursors for MXenes synthesis) has been realized by different methods. So we used one stage self-propagating high-temperature synthesis (SHS) that seems most suitable because of this method has several advantages 1) simplicity 2) short reaction time 2) cost-effective 3) little demand on external energy. For SHS commercially available Ti, Al and carbon black powders were used. Several phases (mainly Ti_3AlC_2, Ti_2AlC, TiC, Al_2O_3) were among the products after SHS. Obtained products are crushed in a roll crusher and then automatic agate mortar. For Al etching from the MAX phase a dilute solution of HF was used. Then delamination of MXenes in N,N-dimethylformamide and isopropanol mixture with sonication were lasted during 3 days. The content of unreacted MAX phase particles in MXene powder can be reduced by using hydrocyclone assembly and alcohol medium instead of water. Suspension stability of MAX phase particles decreases rapidly while suspension of MXene particles is fairly stable. Also alcohol medium can protect $Ti_3C_2T_x$ Mxene from oxidation. Then MXene powder was washed with water several times and to remove residual water vacuum filter was used. Since both layered $Ti_3C_2T_x$ and Ti_2CT_x obtained can be used as electrodes for supercapacitors SHS method is suitable for $Ti_{x+1}AlC_x$ phases preparation. In neutral aqueous electrolyte (1 M solution of Na2SO4) obtained electrodes demonstrated gravimetric capacitance up to 220 Fg^{-1} at charge-discharge rates $2mVs^{-1}$.

Image

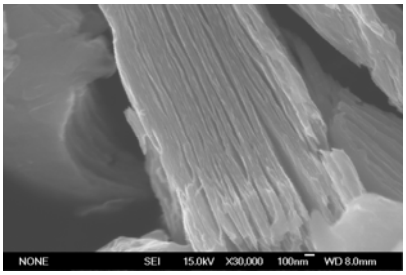


Figure 1: SEM images of Ti_3C_2 MXene

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Biography

Sergii A. Sergiienko has ten years of working research experience at L.V. Pisarzhevskii Institute of Physical Chemistry of the National Academy of Sciences of Ukraine. Research projects mainly devoted to synthesis and investigation of functional properties of ordered porous materials. Published 14 international research papers. Current research project: “Synthesis and Characterization of Novel Nano-Hetero-Structured MXene-based materials for electrochemical energy storage” at National University of Science and Technology «MISiS».

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NOTES/ COMMENTS: