Synthesis and Optimization of $Ti_3C_2T_x$ MXene Materials and Their Integration into PANI/MXene Composites

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MXene materials represent a modern class of two-dimensional (2D) materials obtained by the selective removal of the A-layer from corresponding MAX phases [1]. Owing to their layered structure, large specific surface area, and outstanding electrical, mechanical, and chemical properties, MXenes have attracted significant research interest, particularly in the fields of energy storage, catalysis, and sensing applications. A key challenge in their application lies in controlling the synthesis process and morphology, as these factors directly influence the final material performance [2].

In this study, the synthesis parameters of Ti_3C_2 MXene material derived from the Ti_3AlC_2 MAX phase were optimized using a molten-salt-assisted etching method followed by a post-annealing treatment (Fig. 1). The synthesis was carried out under various experimental conditions, with key process parameters varied to investigate their influence on the structural properties and phase composition of the obtained material. Particular attention was given to the efficiency of Al layer removal from the initial MAX phase, which is a crucial step in forming the characteristic layered MXene structure. The obtained samples were analyzed by X-ray diffraction (XRD), enabling monitoring of changes in the crystal structure and identification of optimal synthesis conditions for achieving desirable structural characteristics.

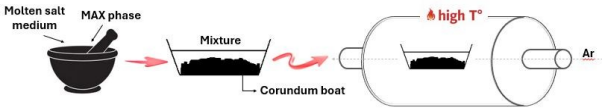


Figure 1. Schematic illustration of the molten salt-assisted synthesis of Ti_3AlC_2 MAX phase.

Based on the optimized synthesis parameters, composites based on polyaniline (PANI) and $Ti_3C_2T_x$ MXene were prepared with the aim of improving their structural and interfacial properties. The formation of PANI/MXene composites enables the combination of the conductive properties of the polymer with the unique characteristics of MXene materials. The obtained composites were further characterized using XRD and FTIR spectroscopy, confirming intermolecular interactions and the successful integration of the polymer and MXene components into a composite structure.

The results of this study indicate that optimization of synthesis parameters has a significant impact on the structure and quality of the obtained MXene material, as well as on the formation of stable PANI/MXene composites. The obtained materials provide a basis for further research toward their potential application in advanced functional and electrochemical systems.

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