New strategy proposed for defect-free few-layer MXene nanosheets with enhanced physicochemical properties

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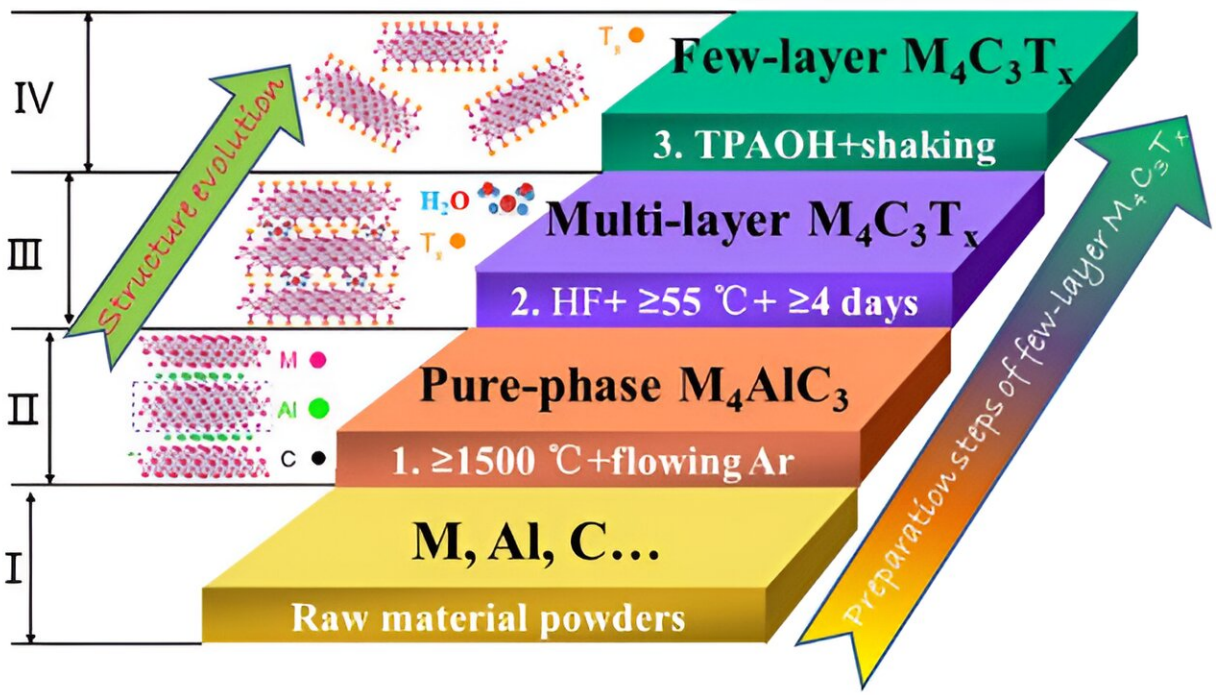


The preparation steps and the corresponding structure evolution of few-layer $M_4C_3T_x$ (M = V, Nb, Ta) MXenes. Credit: Huang Yanan

Researchers from the Hefei Institutes of Physical Science of the Chinese Academy of Sciences have proposed an optimized synthesis strategy to obtain defect-free low-layer $M_4C_3T_x$ (M = V, Nb, Ta) MXene

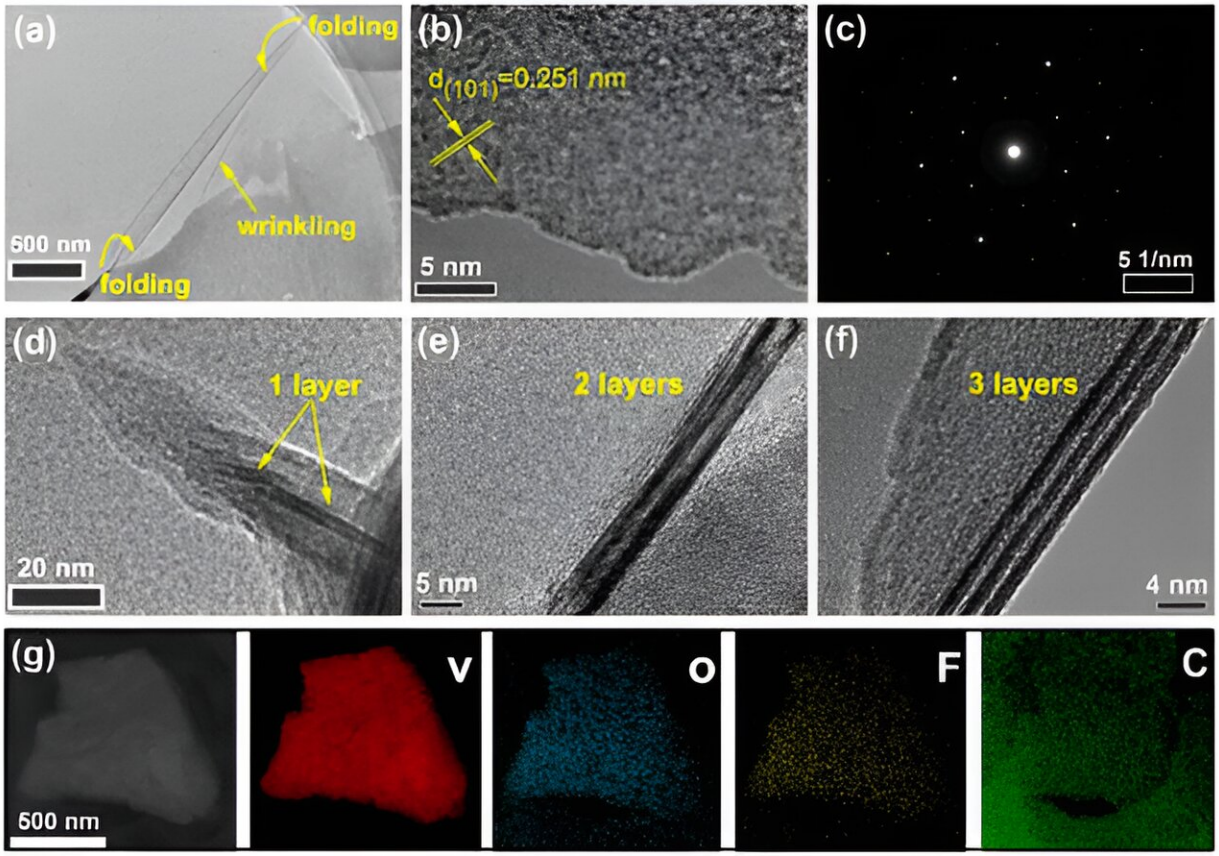
nanosheets. Their results have been published in *Advanced Science*.

MXene materials have enormous potential for applications such as energy storage, energy conversion, and electromagnetic shielding due to their excellent physical and chemical properties. $M_4C_3T_x$ (M = V, Nb, Ta) MXenes have received much attention.

However, obtaining a pure MAX phase precursor, complete etching for multi-layer $M_4C_3T_x$ MXenes, and strict requirements for intercalation agents and exfoliation operations are all difficulties in the synthesis of these few-layer $M_4C_3T_x$ MXenes. As a result, only a few investigations have focused on the study of thin $M_4C_3T_x$ (M = V, Nb, Ta) MXenes.

In this study, the scientists propose a roadmap for the synthesis of defect-free few-layer $M_4C_3T_x$ (M = V, Nb, Ta) nanosheets. It includes high-temperature calcination, HF selective etching, intercalation, and exfoliation. It produces three distinct defect-free few-layer $M_4C_3T_x$ (M = V, Nb, Ta) nanosheets.

Extensive characterization confirms their defect-free structure, significant interlayer spacing (ranging from 1.702 to 1.955 nm), diverse functional groups (-OH, -F, -O), and abundant valence states (M^{5+}, M^{4+}, M^{3+}, M^{2+}, M^0).



The TEM results of defect-free few-layer $V_4C_3T_x$ MXene nanosheets. Credit: Huang Yanan

In addition, they fabricated a free-standing film by vacuum filtration of a few-layer $M_4C_3T_x$ (M = V, Nb, Ta) MXene ink, which exhibited remarkable physicochemical properties such as high conductivity, high stability, and hydrophilicity.

"Our work provides detailed guidelines for the synthesis of other defect-free few-layer MXene nanosheets," said Huang Yanan, a member of the team, "and serves as a catalyst for the extensive exploration of functional applications of $M_4C_3T_x$ (M = V, Nb, Ta) MXene nanosheets in the future."

More information: Yanan Huang et al, Defect-Free Few-Layer $M_4C_3T_x$ (M = V, Nb, Ta) MXene Nanosheets: Synthesis, Characterization, and Physicochemical Properties, *Advanced Science* (2023). DOI: 10.1002/advs.202302882