Element replacement in Mo_2Ga_2C via molten salt synthesis

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The molten salt synthesis of MAX-phases has been known for over ten years [1]. Using Lewis-acids like $ZnCl_2$ or $CuCl_2$ offers a way to synthesize MXenes without HF. The procedure is known for more than just titanium-based MAX-phases like Ti_3AlC_2. Using $ZnCl_2$, the synthesis is limited to Al-containing MAX-phases [2]. By using Lewis-acids with a higher redox-potential, the method can be extended for other A elements like gallium or silicon [3]. Other metals like tantalus or niobium could also be delaminated. By molten salt synthesis, the A metal could also be replaced by the metal of the Lewis acid. Herein, we report the partial replacement of gallium by copper using Mo_2Ga_2C, CuCl and $CuCl_2$.
The reaction between Mo_2Ga_2C and $CuCl/CuCl_2$ ends in the formation of Mo_2C according to 1.1

$$Mo_2Ga_2C + 3\ CuCl_2 \rightarrow Mo_2C + 3\ Cu + 2\ GaCl_3 \qquad 1.1$$

Adding RbCl allows for a lower reaction temperature, due to the formation of an eutectic system. During variation of the reaction temperature, the formation of a new MAX-phase could be observed via XRD. EDX measurement identified this phase as $Mo_2Ga_{1-x}Cu_xC$, where x is 2/3. Excess copper could be easily removed by treating the sample with concentrated HCl under reflux.

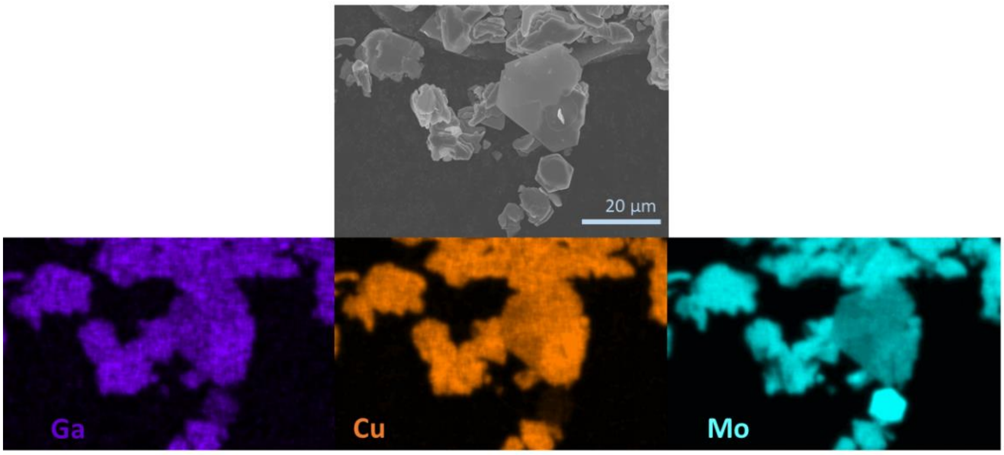

Fig. 1 EDX mapping of $Mo_2Ga_{1-x}Cu_xC$

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[2] M. Li, J. Lu, K. Luo et al., “Element Replacement Approach by Reaction with Lewis Acidic Molten Salts to Synthesize Nanolaminated MAX Phases and MXenes,” *JACS*, vol. 141, no. 11, pp. 4730–4737, 2019.

[3] Y. Li, H. Shao, Z. Lin et al., “A general Lewis acidic etching route for preparing MXenes with enhanced electrochemical performance in non-aqueous electrolyte,” *Nat. Mater.*, vol. 19, no. 8, pp. 894–899, 2020.