2023-2024 Internship proposal at LMGP Lab.

STUDY OF ELECTROCHEMICAL PROPERTIES OF TWO-DIMENSIONAL TRANSITION METAL CARBIDES (MXENES)

Context

MXenes are two-dimensional transition metal carbides and nitrides with general formula $M_{x+1}C_xT_z$ (M is an early transition metal, X is C or N, and T_z denotes to the surface terminal groups) where carbon or nitrogen atoms are sandwiched between metal layers [1]. They are hydrophilic, stiff and possess high electrical conductivity [2]. In addition, their electronic properties can be controlled by tuning surface chemistry, making MXenes suitable for a wide range of applications. Since the discovery of MXenes, they have demonstrated promising electrochemical properties for energy storage due to a layered structure that enhance electrolyte ion transport and transition metal active redox sites on the surface. In this context, MXenes has been tested as electrodes materials in supercapacitors and batteries.

Project description

The project aims to synthesize MXenes using non-hazardous high temperature molten-salt etching [3] to control their surface terminations and optimize the etching process. In particular, layered $M_{n+1}AX_n$ phase precursors (Ti_3AlC_2, V_2AlC) will be etched in melts of halogen inorganic salts (predominantly $CuCl_2$, $CuBr_2$), which leads to halogen terminal groups on the surface of MXenes (-Cl, -Br, =O). The produced multilayered structures will be subjected to advanced structural characterization, in particular X-Ray diffraction, scanning electron microscopy, and Raman spectroscopy. MXene powder will be used to make electrodes for electrochemical tests. The main objective of the internship is to perform a systematic electrochemical characterization (cyclic voltammetry profiles, charge/discharge curves, etc.) of 2D MXenes with different halogen terminations in aqueous and non-aqueous electrolytes. To perform electrochemical characterization of produced electrode, a potentiostat (Bio Logic) equipped with an impedance channel will be used.

Scientific environment

The candidate will work within the LMGP, Materials and Physical Engineering Laboratory, in the Nanomaterials and Advanced Heterostructure (NanoMAT) Research Team. Located in the heart of an exceptional scientific environment, the LMGP offers the applicant a rewarding place to work.
LMGP Web Site: http://www.lmgp.grenoble-inp.fr/

Profile & requested skills

The desired candidate is a final year engineering school student and/or a Master 2R whose background is mainly focused on materials science, physical and inorganic chemistry or electrochemistry. Excellent communication skills and ability to work as a member of international team as well as good oral and written skills in English language are highly appreciated. We are looking for dynamic, motivated, interested candidates with leading efforts related to experimental work to pursue a thesis.

Contact

To apply, please send a CV and motivation letter to:

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References

[1] Naguib, M., Barsoum, M. W., Gogotsi, Y. Ten Years of Progress in the Synthesis and Development of MXenes. *Adv. Mater.* 2021, 33, 2103393.
[2] VahidMohammadi, A., Rosen, J., Gogotsi Y. The World of Two-Dimensional Carbides and Nitrides (MXenes). *Science*, 2021, 332.
[3] Li, Y., Shao, H., Lin, Z. A general Lewis acidic etching route for preparing MXenes with enhanced electrochemical performance in non-aqueous electrolyte. *Nature Materials*, 2020, 19, 894-899.