Preparation and functionalization of   
two-dimensional transition metal carbides

Błażej Scheibe1,2\*, Josef Kaślik2, Claudia Aparicio2, Juri Ugolotti2, Marcin Jarek1,, Mikołaj Lewandowski1, Barbara Peplińska1, Magdalena Scheibe2, Jacek Jenczyk1, Mateusz Kempiński1,3, Varun Natu4, Michele Barsoum4, Michal Otyepka2, Stefan Jurga1

# 1 Nanobiomedical Centre, Adam Mickiewicz University in Poznań, Wszechnicy Piastowskiej 3, 61-614 Poznań, Poland

2 Regional Centre of Advanced Technologies and Materials, Czech Advanced Technology and Research Institute, Palacký University, Ślechtitelů 241/27, 779 00 Olomouc, Czech Republic

3 Faculty of Physics, Adam Mickiewicz University in Poznań, Uniwersytetu Poznańskiego 2, 61-614 Poznań, Poland

4 Department of Materials Science and Engineering, Drexel University, 3141 Chestnut Street, PA 19104 Philadelphia, USA

\*corresponding author: bscheibe@amu.edu.pl

The MXenes are an expanding family of two-dimensional transition metal carbides, which graphene-like structure is featured by hydrophilic transition metal oxide/hydroxide surface and conductive transition metal carbide core. MXenes due to ease of their processability are obtained and stored as a water colloidal dispersions. However, MXenes are environmentally unstable and decompose to transition metal oxides and carbide derived carbon upon time, while being stored in room temperature, in water solutions and with an access to oxygen. The time of decomposition is dependent on transition metal component. Up to date, there are several methods allowing to prolong MXenes’ shelf-life, namely, the addition of stability enhancers and antioxidants such as LiCl and citric acid, respectively. However, additives have to be removed via additional purification steps, influencing MXenes dispersability. Another technique is capping of MXene’s hydroxyl groups with polyphosphates or via silane grafting. In both cases, MXenes’ conductivity is diminished. Moreover, in the latter, MXenes become hydrophobic and less active electrochemically. Therefore, the other solution to the problem is required. In our research, we used a multistep functionalization approach based on the surface groups exchange process. This simply technique typically applied to alcohol compounds in organic chemistry, actually worked on the MXene’s surface moieties. Due to exchanging bad leaving MXene’s –OH groups toward good leaving groups and modifying them further, we both stabilized MXenes and greatly expanded their chemistry, beyond current state-of-the-art.