Colloidal Properties and Stability of 2D Ti$_3$C$_2$ and Ti$_2$C MXenes in Water

A. Rozmysłowska$^{1,*}$, T. Wojciechowski$^1$, W. Ziemkowska$^1$, L. Chlubny$^2$, A. Olszyna$^1$, S. Poźniak$^1$, K. Tomkiewicz$^1$, A. M. Jastrzębska$^1$

$^1$Warsaw University of Technology, Faculty of Materials Science and Engineering, 02-507 Warsaw, Woloska 141, Poland
$^2$AGH University of Science and Technology, Faculty of Materials Science and Ceramics, 30-059 Krakow, Mickiewicza 30, Poland
$^*${E-mail: anita.rozmyslowska@gmail.com}

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While MXenes have been utilized in many applications, their surface properties in water systems are still unexplored, especially in the aspect of colloidal properties, which highly limits their practical use. In this study, the colloidal properties and stabilities of 2D Ti$_3$C$_2$ and Ti$_2$C MXenes were investigated using time-resolved dynamic light scattering and zeta potential over a wide range of waters (deionized water, tap water and physiological NaCl solution of 0.9%) relevant to natural and engineered systems. Our results indicate that pH has a significant influence on Ti$_3$C$_2$ and Ti$_2$C stabilities from pH 4 to 10. The type of water environment also affects the stability of Ti$_3$C$_2$ and Ti$_2$C due to electrical double layer compression. The aggregation and stabilities of Ti$_3$C$_2$ and Ti$_2$C in the aquatic systems followed colloidal theories, even though Ti$_3$C$_2$ and Ti$_2$C flakes shape is not spherical. The presence of NaCl stabilized more the 2D Ti$_3$C$_2$ than the 2D Ti$_2$C. Dispersions prepared when using tap water were more stable in the case of Ti$_2$C compared to the NaCl solution. The opposite effect was found for Ti$_3$C$_2$. This may be due to the binding capacity of Ca$^{2+}$ ions with hydroxyl and carbonyl functional groups whose amounts vary on the surface of Ti$_3$C$_2$ and Ti$_2$C. In general, our study demonstrates that the 2D flakes of Ti$_3$C$_2$ MXenes are highly stable in NaCl, although they settle more quickly in tap water. The 2D flakes of Ti$_2$C MXenes are more stable in distilled water and less stable in the physiological NaCl solution.

Keywords: 2D Ti$_3$C$_2$, 2D Ti$_2$C, MXenes, dynamic light scattering, zeta potential, stability, safety