MODIFICATION OF $Ti_3C_2T_X$ MXENE NANOSHEETS WITH POLYDOPAMINE FOR ANTIBODY IMMOBILIZATION

Kristina Sobol[1], Viktorija Liustrovaite[1], Benediktas Brasiunas[1], Anton Popov[1], Igor Iatsunskyi[2], Oleksiy Gogotsi[3], Almira Ramanaviciene[1]

[1]Vilnius University, Faculty of Chemistry and Geosciences, Institute of Chemistry, NanoTechnas – Center of Nanotechnology and Materials Science, Institute of Chemistry, Naugarduko St. 24, LT-03225, Vilnius, Lithuania
[2]Adam Mickiewicz University, NanoBioMedical Centre, Poznan, Poland
[3]Nano Carbon Tech LLC, Poznan, Poland
kristina.sobol@chgf.vu.lt

MXenes are a novel family of two-dimensional (2D) inorganic nanomaterials, first discovered in 2011. The MXene family consists of transition metal carbides, nitrides, and carbonitrides with the general formula $M_{n+1}X_nT_x$, where M is an early transition metal, X is carbon and/or nitrogen, and T_X stands for surface terminations [1]. Owing to their unique properties, including large surface area, excellent conductivity, and abundant surface functional groups, MXenes are well-known as highly biocompatible nanomaterials with a wide range of biomedical applications. However, the practical use of pristine MXenes is often limited by their sensitivity to oxidation in aqueous and oxygen-rich environments, as well as the instability of their surface functional groups [2-3]. To address these limitations in developing immunosensors, we modified $Ti_3C_2T_X$ MXene nanosheets with polydopamine (PDA) via the self-polymerization of dopamine, thereby creating a versatile platform for antibody immobilization. Herein, electrochemical and optical analysis methods were assessed to confirm the successful immobilization of antibodies on PDA-coated MXenes. For electrochemical analysis, the preparation and drop-casting of $Ti_3C_2T_X$ MXene nanosheets onto screen-printed carbon electrodes were optimized. Subsequently, the PDA-coated MXenes were modified with antibodies against the SARS-CoV-2 spike protein. Electrochemical impedance spectroscopy was used to characterize the surface of the modified electrodes, enabling a simple and rapid evaluation of antibody immobilization. For optical analysis, $Ti_3C_2T_X$–PDA complexes were modified with horseradish peroxidase-conjugated secondary antibodies (Ab-HRP). Successful Ab-HRP immobilization on $Ti_3C_2T_X$–PDA was verified through an enzymatic reaction of HRP with tetramethylbenzidine in the presence of H_2O_2, which produced a distinct blue color, enabling direct visual assessment of antibody binding.

The obtained results demonstrate that PDA-coated MXenes are a promising platform for antibody immobilization and can be effectively evaluated using both optical and electrochemical methods.

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