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MXenes show promise against SARS-CoV-2

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The class of novel two-dimensional transition metal carbide nanomaterials known as MXenes show promising antiviral properties against some strains of SARS-CoV-2, according to an international team of researchers [Unal et al., Nano Today 38 (2021) 101136, https://doi.org/10.1016/j.nantod.2021.101136]. These materials could be useful in the development of self-disinfecting surfaces or personal protective equipment (PPE).

The team from Ankara University, Microbiology References Laboratory, Gazi University in Turkey, the Universities of Genoa, Padua, and Trieste in Italy, Sidra Medicine and Hamad Bin Khalifa University in Qatar, University of Pennsylvania, Oregon Health and Sciences University, La Jolla Institute for Immunology, and Drexel University explored the antiviral properties and immune profile of four stable and well-characterized MXenes based on titanium (Ti), tantalum (Ta), molybdenum (Mo), and niobium (Nb).

MXenes, which were first reported a decade ago, comprise layers of transition metals such as Ti, Nb or V bonded with layers of lighter elements like carbon with surface termination groups including O, OH, F and Cl. These surface groups mean that MXenes are hydrophilic and negatively charged, which makes them easy to integrate onto biomedical platforms without additional functionalization. Like some other two-dimensional materials, MXenes have shown antibacterial, antifungal, and, more recently, antiviral properties. So the team led by Yury Gogotsi at Drexel, Lucia Gemma Delogu at Padua, and Açelya Yilmazer at Ankara University wanted to test MXenes against four common variants of SARS-CoV-2 that carry the wild type or mutated spike protein.

“We have previously demonstrated that colloidal titanium carbide (Ti3C2), the most investigated member of the MXene family, is non-toxic but shows promising antibacterial activity,” explains Gogotsi. “Encouraged by its antimicrobial ability, we hypothesized that 2D materials with charged surfaces can show antiviral activity against SARS-CoV-2, so we explored Ti3C2 and several other stable and biocompatible MXenes.”

Two of the MXenes, Ti3C2Tx and Mo2Ti3C2Tx, showed antiviral activity against SARS-CoV-2 in a test cell line and good biocompatibility. However, the results also highlighted the importance of considering different viral genotypes and mutations when designing and testing potentially antiviral materials.

“In order to evaluate the mechanism of MXene-dependent antiviral activity, we performed proteomic, functional annotation analysis and comparison to the already published SARS-CoV-2 protein interaction map, which revealed that MXene treatment exerts specific inhibitory mechanisms,” says Yilmazer.

The researchers’ investigation of the most effective MXene, Ti3C2Tx, indicates that the negatively charged surfaces of the nanomaterial interfere with the viral life cycle by interacting with viral signaling mechanisms (Fig. 1). The nanomaterial also appears to reduce some inflammatory activities, which could be promising in addressing the cytokine storm that COVID-19 can produce (Fig. 2).

“These results contribute towards our understanding of molecular mechanisms involved in COVID-19 and provide insights into some of the relevant pathways and proteins that should be targeted when developing antiviral drugs or nanomaterials,” points out Delogu.

In the near term, MXenes could be used on surfaces or in coatings for face masks or air filters to provide antiviral properties, suggest the researchers, while in the longer term could be explored for antiviral treatments.
“Taking into account a very large variety of MXenes, there is a good reason to assume that other MXenes may have similar or even better properties,” adds Gogotsi. “However, we have shown how critical it is to consider different genotypes of SARS-CoV-2 when assessing the possible use of nanomaterials in the fight against COVID-19 or future pandemics.”

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.