MXene-based materials for the application in point-of-use water filters

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The ultrathin 2D nanomaterials restrict the size of materials in one or more dimensions, which distinguishes them from their bulk counterparts Resulting unique properties and therefore versatile functionalities are obtained in many areas [1]. MXenes are one of the new and still not fully explored families of 2D nanomaterials which are characterized by a few-atoms-thick layered structure. These are transition metal carbides and/or nitrides. The name MXene relates to their parental MAX phases, with the chemical formula of $M_{n+1}AX_n$ in which M is an early transition metal, A reflects an element from A group of the periodic table, X stands for carbide and/or nitride, while n = 1, 2 or 3. The A element may be removed *via* further acid etching and therefore $M_{n+1}X_n$ MXene is created [2].

Recently, the antibacterial properties of MXenes have been investigated intensively. In particular, titanium carbide (Ti_3C_2) was tested in terms of its possible application in water treatment technologies [3]. The efficiency of these systems is however limited, especially in the case of harsh sanitation conditions. An efficient point-of-use water treatment system must not only eliminate microbial contamination at a relatively high flow velocity, but it also should require minimal maintenance and be able to keep a long life cycle. In our work, we have shown that polypropylene fabric modified with Ti_3C_2 MXene and noble metal nanoparticles is a promising candidate for such applications. With improved flow velocity, an oxidized $Ti_3C_2/Al_2O_3/Ag/Cu$ nanocomposite-based filtration material was able to efficiently remove potentially pathogenic bacteria (*E. coli* and *S. aureus*) from contaminated water. Such effect was not observed in the case of the pristine MXene. In addition, we observed the self-disinfecting potential of nanocomposite-based material, which was the most important result of our work. After 24 h of storage at room temperature, oxidized $Ti_3C_2/Al_2O_3/Ag/Cu$ nanocomposite-based bed was able to eliminate almost 100% of bacteria cells accumulated in its structure. The secondary release of the nanocomposite, which could potentially limit its utilization, was also not observed. Our findings are important in understanding MXenes bioactivity towards bacteria, development of nanocomposite systems, and their application in various water treatment technologies.

References:

[1] N. B. Singh, S. K. Shukla, *Elsevier*, 73-100 (2020).
[2] M. Naguib, M. Kurtoglu, V. Presser, J. Lu, J. Niu, M. Heon, L. Hultman, Y. Gogotsi, M. Barsoum, *Adv. Mater.* **23**, 4248-4253 (2011).
[3] K. Rasool, R. P. Pandey, P. A. Rasheed, S. Buczek, Y. Gogotsi, K. A. Mahmoud, *Mater. Today* **30**, 80-102 (2019).

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