Electrocatalytic remediation of contaminated water: will going nano be the technology enabler?

Jelena Radjenovic[1,2]
Luis Baptista-Pires[1,3], Natalia Sergienko[1,3], Giannis Florjan-Norra[1,3], Nick Duinslaeger[1,3]

[1] Catalan Institute for Water Research (ICRA), c/Emili Grahit, 101, 17003 Girona, Spain.
[2] Catalan Institution for Research and Advanced Studies (ICREA), Passeig Lluís Companys 23, 08010 Barcelona, Spain.
[3] University of Girona, Girona, Spain.

jradjenovic@icra.cat

According to the joint report of UNICEF and World Health Organization (WHO), 2.2 billion people around the world do not have safely managed drinking water services, 4.2 billion people do not have safely managed sanitation services, and 3 billion lack basic handwashing facilities [1]. Seawater desalination in coastal areas and wastewater recycling in coastal and inland regions are the most promising approaches to satisfying water demand in cities [2]. However, these options are not economically and technically feasible in towns and smaller communities, and their water future is entirely relying on the development of new, small-scale water treatment technologies that will allow them to safely treat and reuse the available water (e.g., contaminated groundwater, generated wastewater, rainwater). Among the available technologies, electrochemical systems have the most potential to be used for small-scale and decentralized treatment of (waste)water, as they do not use chemical reagents, do not form a residual waste stream, operate at ambient temperature and pressure, are robust, versatile and have a small footprint. Yet, there are two key, long-standing challenges that need to be addressed: 1) high energy consumption and cost, and 2) formation of toxic halogenated byproducts in the presence of halides.

Three-dimensional (3D) reactor design is characterized by the high electrode surface area to reactor volume ratio and significantly improved reactor efficiency, with a larger effective surface area available for electrolytic degradation of contaminants and reduced mass transfer limitations. Nanotechnology can provide solutions to enhance the current efficiency of electrochemical water treatment systems, as carbon- and metal-based nanostructures offer unique electronic and mechanical properties that make them very attractive as electrode materials. They can be tailored to obtain a large specific surface area, flexible structure, excellent mobility of charge carriers and good electrical and thermal conductivities. In the scope of our ERC Starting Grant project ELECTRON4WATER, we have developed porous flow-through Mn-oxide based electrodes for selective and reversible oxidation of sulfide from wastewater to sulfur [3]. We have also developed a tailored graphene sponge electrode for one-pass electrochemical filter capable of eliminating persistent organic and microbial contaminants from water, without forming halogenated byproducts [4]. As nanotechnology continues to generate better materials and improve their functions, its fusion with electrocatalysis will undoubtedly accelerate the development of high-performing, reliable, cost-effective, and environmentally friendly water treatment technologies.

References

[1] U.W.H. Organization, Progress on household drinking water, sanitation and hygiene 2000-2017: Special focus on inequalities, in, 2019.
[2] D. Sedlak, Water 4.0: The past, present, and future of the world's most vital resource, 2014.
[3] N. Sergienko, J. Radjenovic, Manganese oxide-based porous electrodes for rapid and selective (electro)catalytic removal and recovery of sulfide from wastewater, Applied Catalysis B: Environmental, 267 (2020) 118608.
[4] L. Baptista-Pires, G. Florjan-Norra, J. Radjenovic, 3D graphene sponge for one-pass flow-through electrochemical elimination of persistent pollutants ACS Nano, submitted (2020).