Platinum group metal-free electrocatalysts derived from wastes for fuel cells and electrolyzers

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Hydrogen as energy vector will be crucial to foster the Green Revolution. The green hydrogen produced will be then used in the fuel cells to generate clean electricity. Proton exchange membrane water electrolyzers (PEM-WE) are the most powerful device to generate green and pressurized hydrogen when coupled with renewable energies. Unfortunately, PEM-WE utilizes high loading of precious and scarce metals such as Iridium at the anode and platinum at the cathode.

Proton exchange membrane fuel cells (PEM-FCs) have reached unprecedented performance in terms of power output and durability and are the most performing low temperature fuel cells. However, as for PEM-WEs, PEM-FCs utilize platinum based electrocatalysts on both electrodes. To further push both technologies towards wide commercialization, a drastic reduction of cost is desired. Great effort has been devoted to decrease the amount of precious metals used as electrocatalyst on both anodic and cathodic reactions or actually replace it completely when possible. It is the utilization of platinum and critical raw materials the biggest issue of these technologies that is actually slowing down the large-scale commercialization. The operations in alkaline media favor the utilization of electrocatalysts that do not contain platinum group metals (PGM-free). This consideration is valid for both fuel cells and electrolyzers. Therefore, in the past 10-15 years a great effort has been invested in developing this class of materials. Among the different classes of electrocatalysts, M-N-C type known also as single atom electrocatalysts are based on a carbonaceous backbone where earth abundant transition metals (e.g. Mn, Fe, Co, Ni, Cu) coordinated with nitrogen are integrated in the graphene-like structure.

A carbonaceous structure is then necessary to synthesize these M-N-C electrocatalysts. Therefore, the synthesis approach for fabricating these materials using green and sustainable methods should be considered and thought differently. Following the core of the circular economy, where a waste become a resource for another process, waste biomasses and plastics were upgraded to valuable carbonaceous materials.

These carbonaceous materials were then used as a building block for the synthesis of electrocatalysts for the cathodic reactions of fuel cells and electrolyzers. This presentation will show few successful examples of valorization of waste biomass and plastics and their transformation into high surface area carbon materials. Further functionalization to synthesize electrocatalysts for the reactions of oxygen reduction reaction (ORR) and hydrogen evolution reaction (HER) are then presented.