Weaving polymers for efficient oxygen electrocatalysis

Depletion of fossil fuels, impact of their burning on the environment followed by climate change are key driving forces for development of sustainable energy conversion methods, water treatment or production of chemicals. Oxygen as a main component of earth atmosphere is one of the most abundant and easy accessible chemicals. Electrochemical reactions of oxygen: oxygen electroreduction or oxygen evolution (water electrooxidation) are core steps of such devices as fuel cells, metal-oxygen batteries or water electrolysers. Oxygen generated electrochemically from water can be employed for water treatment. Hydrogen peroxide generation by electrochemical reduction of oxygen or water electrooxidation are good candidates to replace outdated, energy consuming and environmentally harmful technology.

Although electrochemical oxygen processes are already applied in real life, their reaction speed is the largest disadvantage. In order to accelerate these processes, noble metal catalyst are applied. This makes devices based on electrochemical oxygen reactions expensive. Recently researchers are focused on catalysts based on cheaper metals as cobalt or nickel. However, they are not as stable as noble metal catalyst. Moreover, their application requires development of recycling technology, because of their limited availability and toxicity.

Application of non-metallic catalyst to electrochemical oxygen reactions is an alternative and our project fits into this very recent trend. Porous organic polymers emerged recently as prospective non-metallic catalyst. Among them are completely overlooked extremely stable non-metallic hypercrosslinked polymers. Their synthesis is relatively easy and their porosity and number of catalytic sites can be controlled. Their impact on environment is minor, because they are mainly composed of carbon and hydrogen with some amounts of nitrogen, sulphur and phosphorus.

This project is focused on oxygen reduction and oxygen evolution at electrodes modified with a family of hypercrosslinked polymers weaved from monomers selected in a way to provide tuned porosities for oxygen transport and catalytic reaction sites. This will not only help to find most efficient non metallic hypercrosslinked polymer catalyst, but also to understand relation between porous polymer structure and its catalytic activity. If catalyst based on porous organic polymers will turn out to be as efficient and stable as noble metal catalysts it may bring revolutionary change in technologies based on oxygen electrochemical processes.