

In 2014 Toyota introduced the first FCV-type car (Fuel Cell Vehicle). Powered by H₂, FCVs are considered complementary to today's battery-electric cars and they will help expand the range of zero-emission transportation options. After Toyota, more companies are announcing their own models of FCVs, for instance Daimler with cooperation with Ford and Nissan (coming in 2017) or Korean Hyundai. This is indeed a great achievement in the car industry, yet taking into account the high price of Toyota Mirai (ca. 57500 USD) the popularity of such cars might be limited. A large part of this high cost comes from the price of Pt utilized as a catalyst in the fuel cells. The electricity for FCVs is produced by the fuel cell stack where it is generated following an electro-chemical reaction between H₂ (stored in a high-pressure tank) and O₂ from the air. While direct utilization of H₂ in an internal combustion engine has an efficiency of only 10–20 % the ideal thermodynamic efficiency of a H₂–O₂ fuel cell reaches about 83 %. Among all of the possible fuel cells, the proton exchange membrane fuel cell (PEMFC) is actively studied for use in vehicles and portable electronics due to its simplicity, low working temperature and quick start-up. Like a battery, PEMFCs consist of an anode, a cathode and an electrolyte (e.g. Nafion). In the PEMFC, the oxygen reduction reaction (ORR), localized at the cathode, requires higher over-potentials in order to initiate the reaction as compared with the hydrogen oxidation reaction (HOR) occurring at the anode, and therefore denotes the limiting step. Pt is an excellent catalyst for the HOR, however it reveals a sluggish performance for the ORR. Therefore, most of the Pt in today's fuel cells is used in the cathode, in order to catalyze the ORR. The reaction rate of HOR on Pt is extremely fast so that the Pt loading at the anode can be reduced to less than 0.05 mg/cm². On the other hand, at the cathode, the sluggish reaction kinetics of ORR even on the best Pt-based catalyst requires much higher Pt loading (ca. 0.4 mg/cm²). Since the ORR is ~5 orders of magnitude slower than the HOR, 10 times more Pt is needed in the cathode than in the anode. As a result, efforts towards synthesizing non-precious metal catalysts are focused on developing Pt-free ORR catalysts (as opposed to HOR catalysts). Today, Pt-based catalysts are exclusively used in the fabrication of PEMFC; however, they contribute by ca. 30 % to the overall costs resulting in high FCVs prices. Besides fuel cells, the ORR in acid and alkaline environments is a pivotal reaction for other emerging energy technologies and device such as metal-air batteries or oxygen depolarization cathodes in brine and HCl acid electrolyzers. Developing active, non-precious metal oxygen reduction reaction catalyst materials to replace Pt-based catalysts is an urgent necessity. While the potential non-noble metal electro-catalysts for electrochemical reduction of O₂ comprise a rich, diverse family of organic, inorganic and composite materials, the **metal–nitrogen–carbon (Me–N_x/C**, where Me usually stands for Fe or less often Co) materials are by far the most promising and active members of this group. They demonstrate activity and stability close to that of commercially available Pt/C catalysts. The project focuses on synthesis of new, **self-supporting, bimetallic (Fe/Me)–N–C** structures derived from **porous, heteroaromatic polymeric networks**. As porous polymeric networks new type of nitrogen- and sulfur-co-doped organic gels obtained from **sol-gel copolycondensation of heteroaromatic aldehydes** will be utilized. The fundamental synthesis–structure–performance (ORR catalytic activity in acidic and basic solutions) correlations will be pursued in order to create/select the most promising non-noble metal ORR catalysts.