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Oxygen reduction reaction at binary and ternary nanocatalysts based on Pt, Ni, Cu, Co and Au

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Improving design and/or reducing noble metal content in electrocatalysts for fuel cellelectrodes while maintaining and/or increasing proton exchange membrane fuel cell (PEMFC)performance in terms of durability and power density are crucial challenges for PEMFC massmarket applications. A possible way consists in combining noble metals (Pt, Pd, Au ...)and non-noble metals for preparing binary and ternary nanocatalysts. The formation of platinum alloys with transition metals such as Ni, Co, Fe, Cr represents a promising way for improving the activity of Pt-based catalysts [1-3].Pt based alloys have indeed often demonstrated higher electrocatalytic activity towards ORR than pure platinum.However, while non-noblemetals are interesting from a cost reduction point of view, their presence may involve lower stability of the catalyst than that of pure platinum due to their dissolution [4.5], which leads to a loss of performances in PEMFC. Au addition was proposed toimprove durability of the nanocatalysts [6-9].On the other hand, the atomic structure andmorphology [10] also play very important roles in the electrocatalytic efficiency for ORR.

In this context, the present study aims at systematically comparing the catalytic activity and the selectivity towards the ORR of binary and ternary catalysts based on Pt, Ni, Co, Cu and Au in order to determine the best atomic ratio for this reaction, in terms of kinetics current density and of number of exchanged electrons per oxygen molecule reduced. For this purpose, monometallic (Pt/C), binary (Pt_xNi_{10-x}/C, Pt_xCo_{10-x}/C, Pt_xCu_{10-x}/C) and ternary ($Pt_xAu_yNi_z$/C, $Pt_xAu_yCu_z$/C, $Pt_xAu_yCu_z$/C) nanocatalysts supported on carbon Vulcan XC-72 have been first synthesized by a wet chemical method and comprehensively characterized. The morphologies, compositions and structures of the particles were characterized by physical methods (transmission electron microscopy, X-ray diffraction and atomic absorption), whereas metal loadings on the carbon support was determined by thermogravimetric analysis. Electrochemical active surface areas and surface compositions were estimated by cyclic voltammetry. Electrocatalytic activity, selectivity and durability of catalysts were studied by the rotating discand rotating ring disc electrodes.

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