

Séminaire de Chimie Autour des Nanosciences

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POUROUS HOLLOW PtNi NANOSTRUCTURES: SYNTHESIS, OXYGEN REDUCTION REACTION ELECTROCATALYSIS AND APPLICATION AT LOW-TEMPERATURE FUEL CELL CATHODE

The ever-increasing energy consumption from developed and developing countries endangers our future supply of energy and releases greenhouse gases in the atmosphere. As a response, more efficient and diversified power generation systems are required, in particular based on renewables. In this context, electrochemical storage and conversion systems such as electrolyzers and fuel cells will be major actors. They can store electrical energy into chemical energy via water electrolysis (for example into the H-H bond of the H₂ molecule), and convert back this chemical energy into electrical energy via fuel cells when needed. However, a major challenge in these systems remains to find highly active and stable materials, which sustainably catalyse the electrochemical reactions.

In this contribution, we report our most recent findings on the synthesis, ORR activity and stability of porous hollow PtNi/C nanoparticles developed at LEPMI. We firstly shed fundamental light on their mechanism of formation, then focus on their electrocatalytic activity for the ORR and their stability in simulated PEMFC operating conditions. The best porous hollow PtNi/C nanocatalyst (Ni content 15 at. %) features 6-fold and 10-fold enhancement in mass and specific activity for the ORR relative to standard solid Pt/C nanocrystallites of the same size, respectively. Furthermore, the catalytic enhancement is 4-fold and 3-fold in mass and specific activity, respectively over solid PtNi/C nanocrystallites with similar chemical composition, Pt lattice contraction and crystallite size [1, 2].

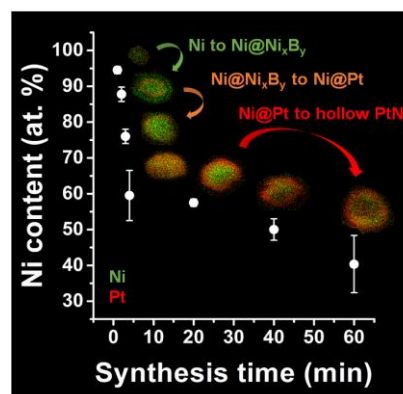


Figure 1. Time-sequenced STEM/X-EDS images illustrating the formation and growth mechanism of hollow PtNi/C nanoparticles.

After 5,000 potential cycles between 0.60 and 1.00 V vs. RHE at T = 80°C, combined physical, chemical and electrochemical results show that losses in ORR activity are related to weakening of strain and ligand effects associated with the dissolution of Ni atoms [3]. However, the initial catalytic advantage of hollow over solid PtNi/C nanoparticles is maintained during the accelerated stress test. Investigations on various PtNi nanostructures indicate that implementing structural disorder in ORR nanocatalysts is a new direction to look at to improve sustainably the ORR kinetics [4].

[1] L. Dubau, et al. Tuning the performance and the stability of porous hollow PtNi/C nanostructures for the oxygen reduction reaction. *ACS Catalysis*, 5(9), 5333-5341 (2015).

[2] T. Asset, et al., Structure – oxygen reduction reaction activity relationships in porous hollow PtNi/C nanoparticles”, *ChemElectroChem*, 3, 1591-1600 (2016).

[3] L. Dubau, et al., Atomic-scale restructuring of hollow PtNi/C electrocatalysts during accelerated stress tests, *Catal. Today*, 262, 146-154 (2016).

[4] R. Chattot, et al., Beyond strain and ligand effects: Microstrain-induced enhancement of the oxygen reduction reaction kinetics on various PtNi/C nanostructures”, *ACS Catalysis*, 7, 398-408 (2017).

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