

Supporting Information for

Structure – Oxygen Reduction Reaction Activity Relationships in Porous Hollow PtNi/C Nanoparticles

Tristan Asset ^{a, b, c}, Raphael Chattot ^{b, c}, Jaysen Nelayah ^d, Nathalie Job ^a, Laetitia Dubau ^{b, c, *} and Frederic Maillard ^{b, c, *}

^a University of Liège, Department of Chemical Engineering– Nanomaterials, Catalysis, Electrochemistry, B6a, Sart-Tilman, B-4000 Liège, Belgium.

^b University of Grenoble Alpes, LEPMI, F-38000 Grenoble, France

^c CNRS, LEPMI, F-38000 Grenoble, France

^d Laboratoire Matériaux et Phénomènes Quantiques (MPQ), UMR 7162 CNRS & Université Paris-Diderot, Bâtiment Condorcet, 4 rue Elsa Morante, F-75205 Paris Cedex 13, France

*To whom correspondence should be addressed. E-mail: (L.D.) laetitia.dubau@lepmi.grenoble-inp.fr; (F.M.) frederic.maillard@lepmi.grenoble-inp.fr

This Supporting Information file includes:

Figures S1 to S5

Table S1

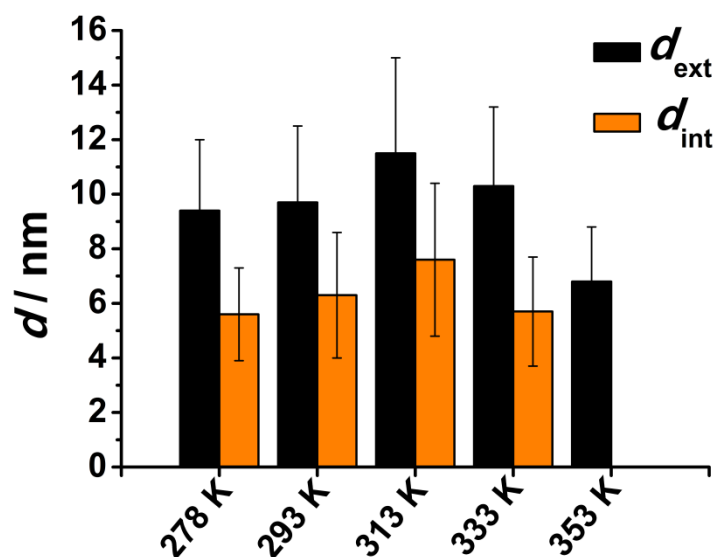


Figure S1. Mean external (d_{ext}) and internal (d_{int}) diameters for the hollow PtNi/C electrocatalysts synthesized at different temperatures (see particle size distributions in Figure 2).

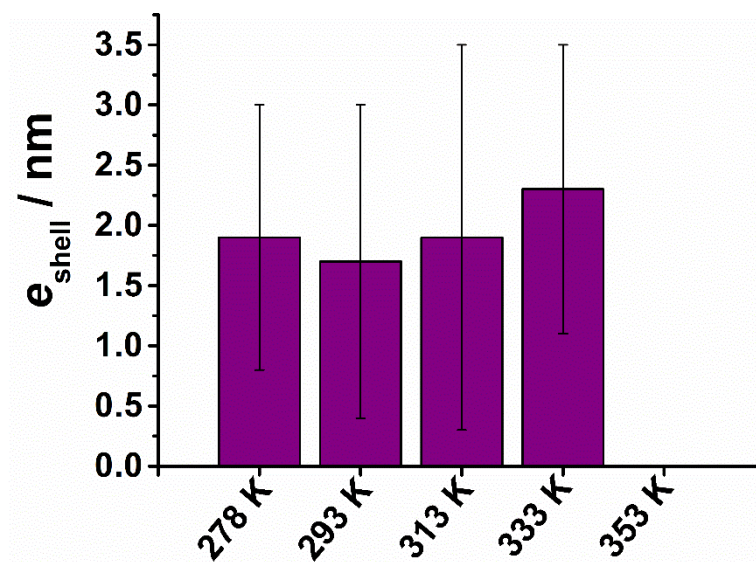


Figure S2. Mean shell thickness (e_{shell}) of the hollow PtNi/C electrocatalysts synthesized at different temperatures (see particle size distributions in Figure 2).

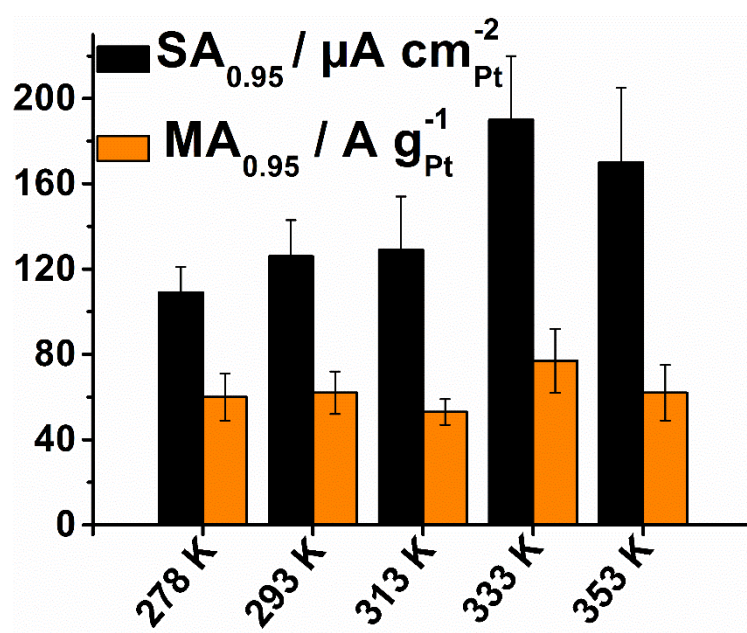


Figure S3. ORR activity measured at $E = 0.95$ V vs. RHE for the porous hollow PtNi/C nanoparticles synthesized at various temperatures.

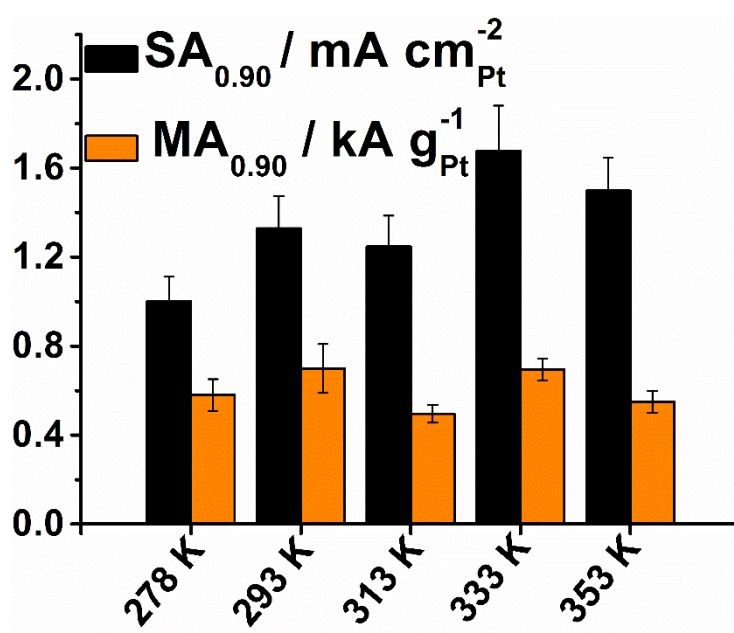


Figure S4. ORR activity measured at $E = 0.90$ V vs. RHE for the porous hollow PtNi/C nanoparticles synthesized at various temperatures.

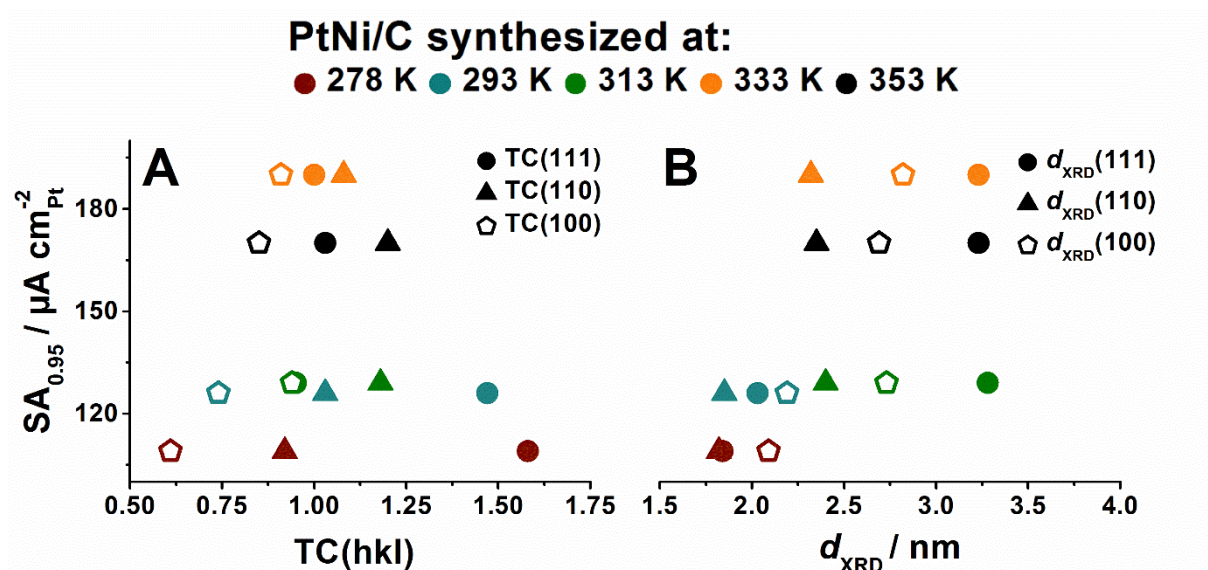


Figure S5. Structure – catalytic activity relationships for the porous hollow PtNi/C nanoparticles synthesized at various temperatures. The ORR specific activity measured at $E = 0.95 \text{ V}$ vs. RHE and corrected from Ohmic losses and diffusion in solution is plotted vs. (A) the texture coefficient (TC(hkl)) for the (111) (TC(111)), the (100) (TC(100)) and the (110) crystallographic orientations (TC(110)) vs. a commercial Pt/C catalyst and (B) the crystallite size of the porous hollow PtNi/C electrocatalysts (d_{XRD}) determined from the X-ray diffraction peaks from the (111) ($d_{XRD}(111)$), the (100) ($d_{XRD}(100)$) and the (110) ($d_{XRD}(110)$) planes using Scherrer's law. For the sake of clarity, the error bars of the specific activity for the ORR were removed from the figure. Please refer to Table 3 for more information.

Table S1. ORR activity measured at $E = 0.90$ V vs. RHE for the porous hollow PtNi/C synthesized at various temperatures.

	Specific activity^[a] ($\mu\text{A cm}^{-2}_{\text{Pt}}$)	Mass activity^[a] ($\text{A g}^{-1}_{\text{Pt}}$)
Pt/C	209 ± 32	166 ± 30
Solid PtNi/C	575 ± 157	216 ± 40
Hollow PtNi/C - RT	1444 ± 108	594 ± 95
Hollow PtNi/C – 278 K	$1,000 \pm 111$	580 ± 72
Hollow PtNi/C – 293 K	$1,328 \pm 146$	699 ± 110
Hollow PtNi/C – 313 K	$1,247 \pm 139$	496 ± 40
Hollow PtNi/C – 333 K	$1,677 \pm 204$	695 ± 89
Hollow PtNi/C – 353 K	$1,498 \pm 148$	550 ± 50

^[a] The ORR curves were recorded in O_2 -saturated 0.1 M HClO_4 at $T = 298 \pm 1$ K using a potential sweep rate $\nu = 0.005$ V s^{-1} and $\omega = 1600$ rpm. The specific activity ($\mu\text{A cm}^{-2}_{\text{Pt}}$) and the mass activity ($\text{A g}^{-1}_{\text{Pt}}$) for the ORR were corrected from the Ohmic losses and from diffusion in solution. Pt loading: $20 \mu\text{g cm}^{-2}$. Each data point is the average of at least three independent experiments.