Electronic Supplementary Material

Ternary Pt/Re/SnO_2/C catalyst for EOR: Electrocatalytic activity and durability enhancement

Elżbieta Drzymała[1] (✉), Grzegorz Gruzeł[1], Joanna Depciuch[1], Miroslawa Pawlyta[2], Mikołaj Donten[3], and Magdalena Parlinska-Wojtan[1]

[1] *Institute of Nuclear Physics Polish Academy of Sciences, PL-31342 Krakow, Poland*
[2] *Institute of Engineering Materials and Biomaterials, Silesian University of Technology, Gliwice 44-100, Poland*
[3] *Faculty of Chemistry, University of Warsaw, Warsaw 02-093, Poland*

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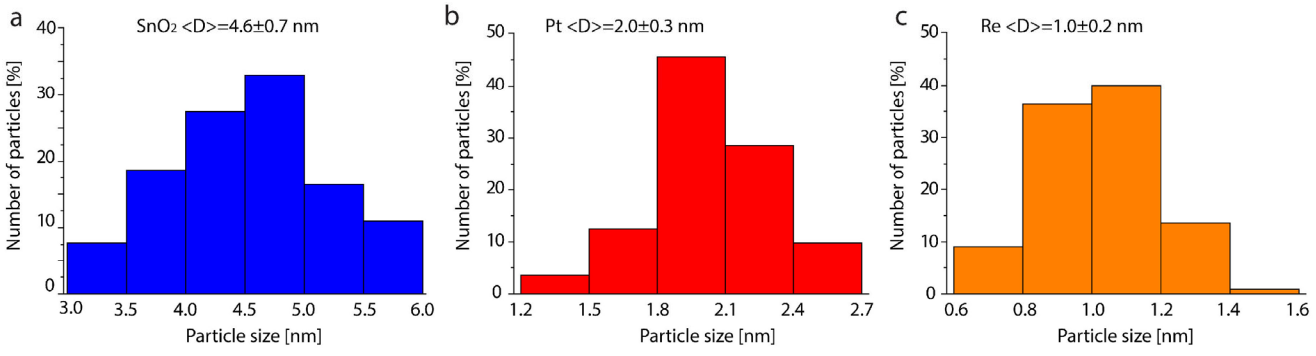

Figure S1 Particle size distribution of a) SnO_2; b) Pt and c) Re nanoparticles assembled into binary and ternary catalysts.

The synthesized catalysts are composed of Pt, Re and SnO_2 nanoparticles. In order to obtain Pt/Re/C, Pt/SnO_2/C and Pt/Re/SnO_2/C combinations we used the same type/size of Pt, Re and SnO_2 nanoparticles, respectively. Figure S1 present the particle size distribution calculated/evaluated based on the HRSTEM images taken from different areas of the TEM grids. For each nanoparticle type, the diameter of 100 NPs was measured.

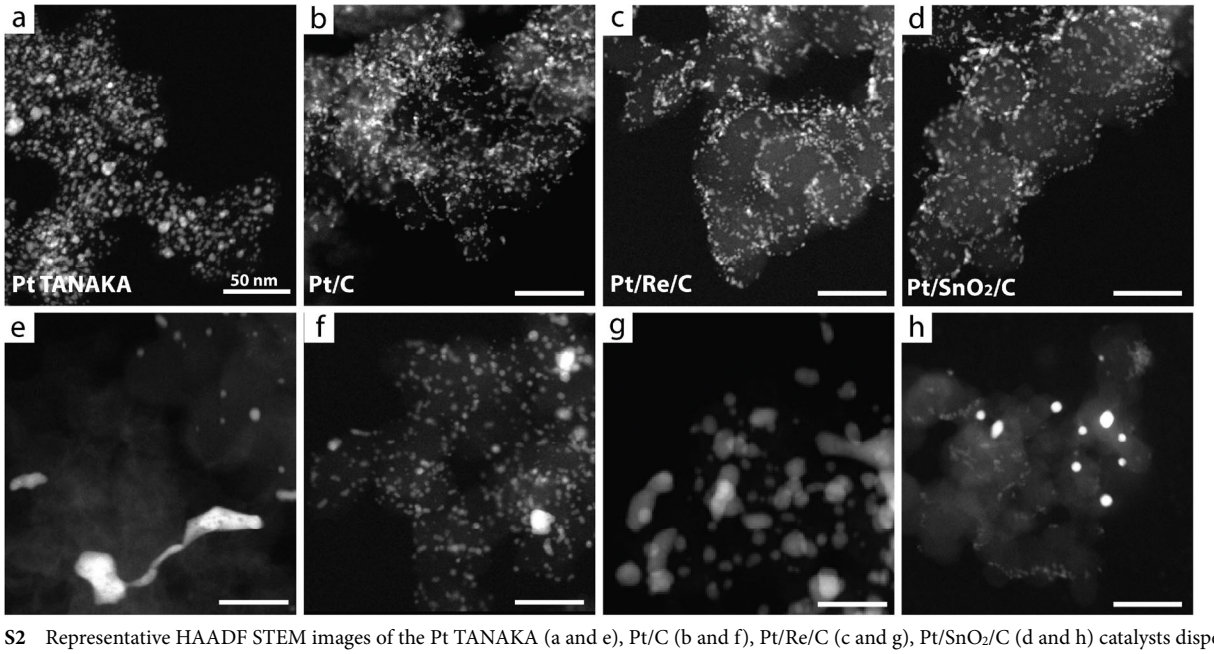

Figure S2 Representative HAADF STEM images of the Pt TANAKA (a and e), Pt/C (b and f), Pt/Re/C (c and g), Pt/SnO_2/C (d and h) catalysts dispersed on carbon Vulcan XC-72R before (a-d) and after (e-h) 10000 potential cycles. The scale bars correspond to 50 nm in every image.

Address correspondence to elzbieta.drzymala@ifj.edu.pl

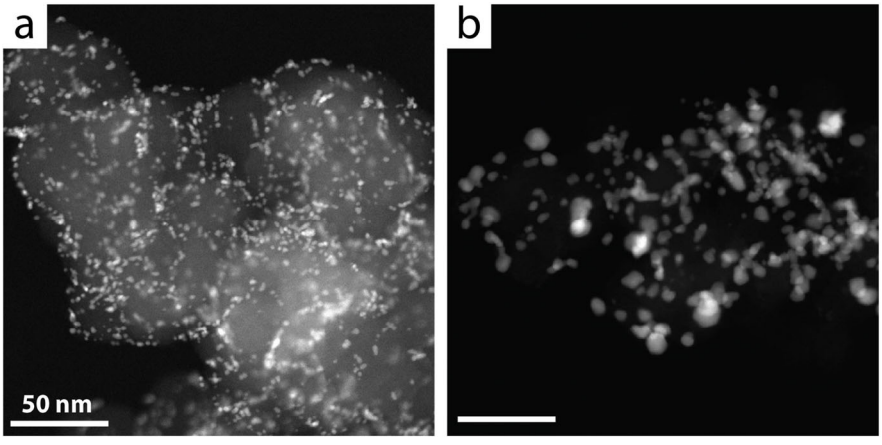

Figure S3 Representative HAADF STEM images of the Pt/Re/SnO_2/C catalyst dispersed on carbon Vulcan XC-72R a) before and b) after 10000 potential cycles.

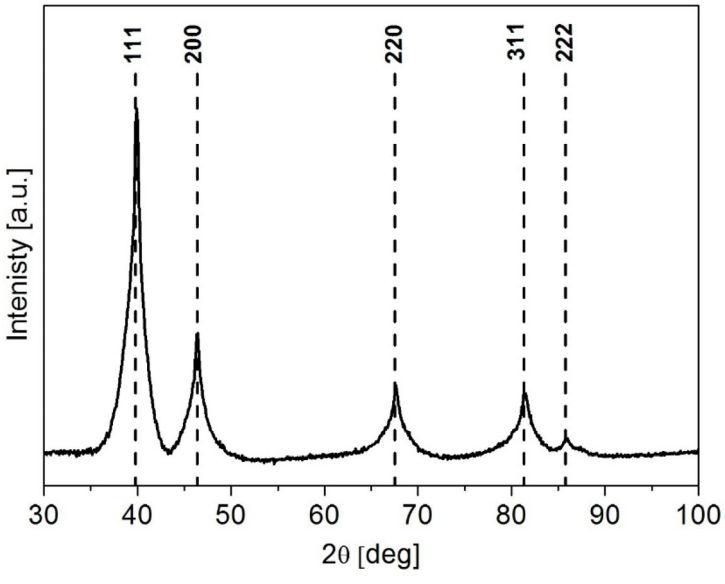

Figure S4 X-ray diffractogram of commercial Pt TANAKA with the corresponding planes. The peaks were normalized to the maximum intensity.

The electrochemical surface area (ECSA) of each catalyst was determined according to the same procedure described below and based on the available protocol [1]. In brief, the region from 0 to 0.35 V vs RHE corresponds to the adsorption-desorption of hydrogen being defined as the electrochemically active surface area (ECSA) and was used to calculate the platinum's active surface by assuming a value of 210 μC cm^{-2}. This red part of the curve is presented in Figure S5(a). The ECSA values were determined by integrating the charge under the hydrogen desorption region. The contribution from the double layer current density was manually removed (blue part of the curve in Figure S5b). The area and mass normalized current densities were obtained by dividing the measured currents by the calculated electrochemical active surface area and platinum mass loading in 10 μl catalyst ink.

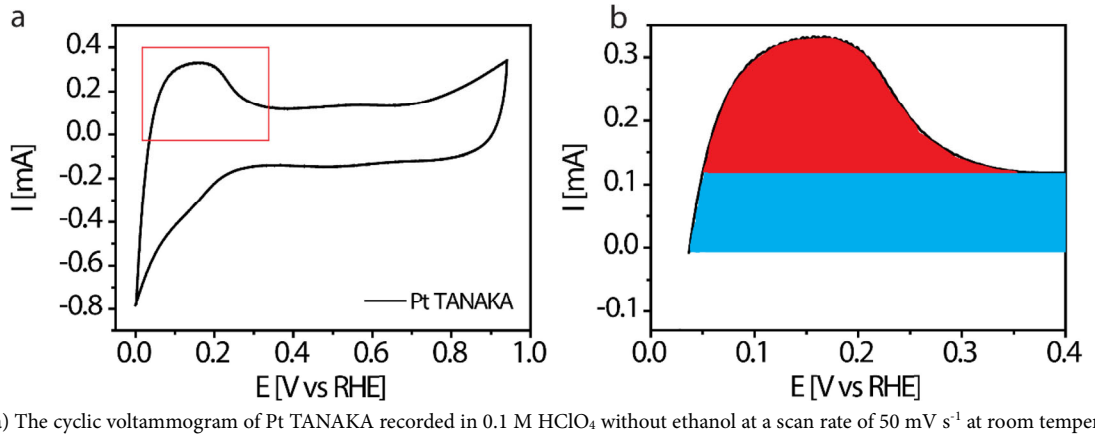

Figure S5 a) The cyclic voltammogram of Pt TANAKA recorded in 0.1 M $HClO_4$ without ethanol at a scan rate of 50 mV s^{-1} at room temperature and b) enlargement of the region marked by the red square in a, which was used to calculate of ECSA: the red area corresponds to the desorption of hydrogen and the blue area corresponds to the capacitive current due to the double layer capacitance.

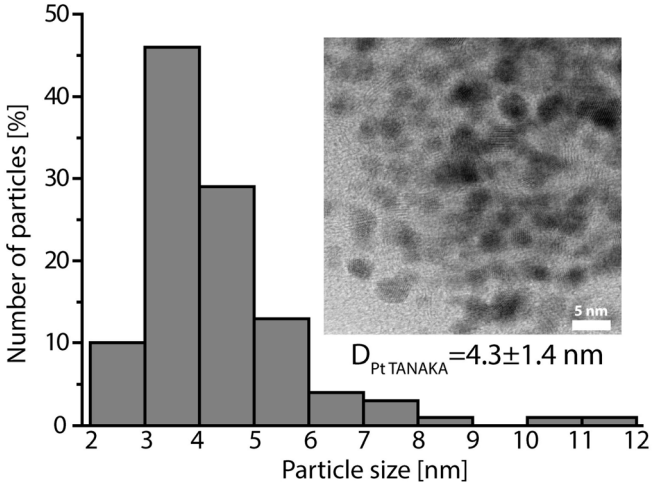

Figure S6 Size distribution of Pt nanoparticles from Pt TANAKA catalyst with the corresponding BF-TEM image.

Table S1 Atomic composition of binary $Pt/SnO_2/C$ and ternary $Pt/Re/SnO_2/C$ catalyst before and after 10000 potential cycles in a 0.1 M $HClO_4$ solution determined by EDS.

Electrocatalysts	EDS (at. %)		
	Pt	Sn	Re
$Pt/SnO_2/C$ before	44	56	-
$Pt/SnO_2/C$ after	92	8	-
$Pt/Re/SnO_2/C$ before	43	57	0
$Pt/Re/SnO_2/C$ after	79	21	0

[1] http://www.bio-logic.net/wp-content/uploads/20101105-application-note-11.pdf