Atomically dispersed platinum species on cerium-based catalyst

Nováková, J.[1], Khalakhan, I.[1], Vorokhta, M.[1], Downing, C.[2,3,4], Nicolosi, V.[2,3,4], Matolinova, I.[1] and Matolin, V.[1]

[1] Department of Surface and Plasma Science, Charles University, Czech Republic, [2] Trinity College Dublin, Dublin, Ireland, [3] CRANN (Centre for Research on Adaptive Nanostructures and Nanodevices), Dublin, Ireland, [4] AMBER (Advanced Materials and BioEngineering Research Centre), Dublin, Ireland

Most of the developed countries are progressively leaning towards utilization of renewable energy. One of the proposed visions, in this regard, is the so-called "hydrogen economy" [1]. It is a concept of low-emission society which harvests most of its energy from renewable sources (e.g. wind and solar) and in case of overproduction, excess amount is used for electrochemical conversion of water into hydrogen. Stored hydrogen would subsequently be used as a fuel for fuel cells, capable of powering most of the devices, ranging from consumer electronics to the electric vehicles. It is obvious that the backbone of hydrogen economy are efficiently working fuel cells and water electrolysers. Unfortunately, both are dependent on noble metals, which are currently the only efficient catalysts of the individual redox reactions, running within the cells. The high price and scarcity of noble metals is considered to be the major factor hindering wider market entry of these technologies.

Catalysts based on well dispersed species of noble metals can lead to efficient use through enhanced reactivity whilst amount of scarce material is decreased. Chosen method of preparation, magnetron sputtering, constitutes a fast and inexpensive way of preparing high-surface-area nanostructure catalyst films that allows to synthesize a large variety of catalytic materials based on a myriad of elements combinations at many different compositions. Herein, we deal with study of cerium oxide based catalyst enriched by platinum supported by carbonaceous material. The selection of appropriate deposition parameters and/or conditions leads to the extremely porous structure formation (Fig. 1) influencing also the crystal size of cerium oxide as well as the platinum dispersion [2]. Direct observation of Pt-CeO_x layer by means of aberration-corrected HAADF-STEM has shown variety of platinum species present on cerium-based catalyst (Fig. 2). Many isolated single atoms (A), subnanometer disordered clusters (B), reconstructed surface atoms of Pt particles (C) and faceted Pt clusters (D) coexist on the surface. All these various types can contribute to the catalytic reactions ongoing within the cells.

[1] N. Armaroli, V. Balzani, ChemSusChem. 4 (2011) 21 - 36.

[2] M. Dubau, J. Lavková, I. Khalakhan, S. Haviar, V. Potin, V. Matolín, I. Matolínová, ACS Appl. Mater. Interfaces, 6 (2014) 1213 - 1218.

The authors acknowledge financial support by the Czech Science Foundation (grant No. 18-06989Y).

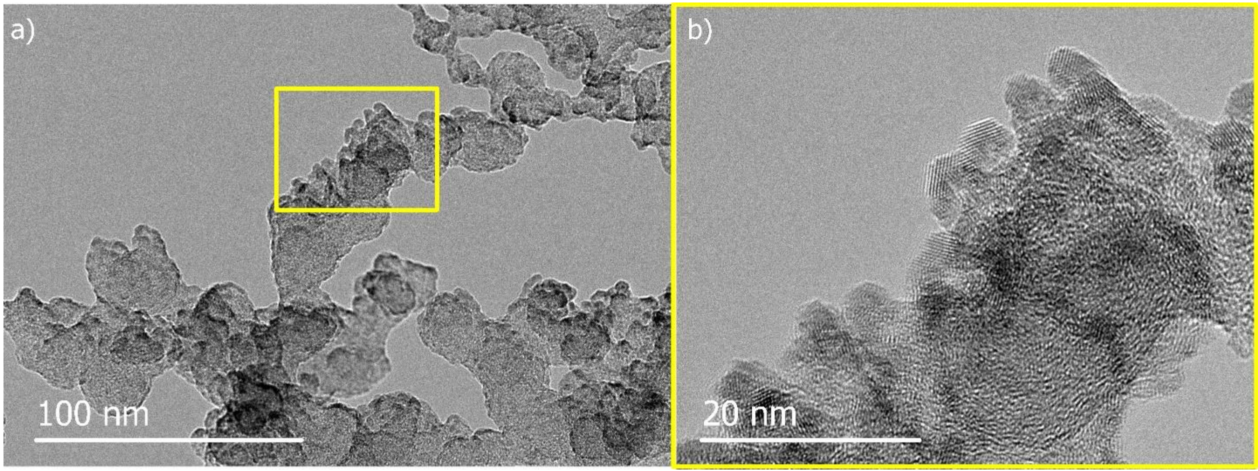

Fig. 1. TEM image of Pt-CeO_x catalyst deposited by magnetron sputtering on candle soot with very high-surface-area a). HRTEM image of well-faceted cerium oxide nanocrystals b) (magnified yellow area).

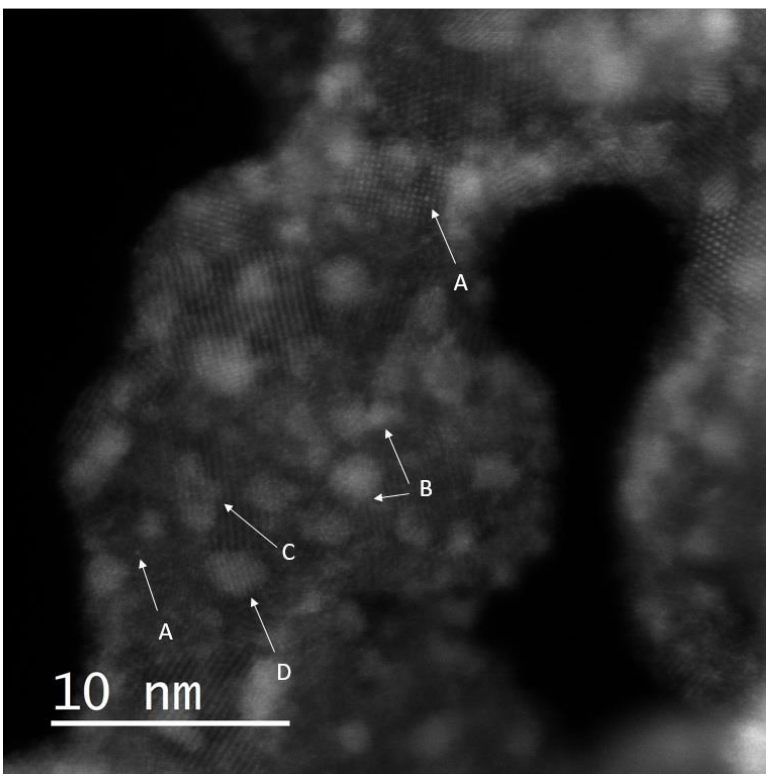

Fig. 2. Aberration-corrected HAADF-STEM image of Pt-CeO_x catalyst deposited on candle soot shows the presence of isolated Pt single atoms (A), subnanometer disordered clusters (B), reconstructed surface atoms of Pt particles (C) and faceted Pt clusters (D) coexisting on the surface.