

## Unique Behaviour of Shaped Palladium Nanoparticles in Electrochemical Hydrogen Adsorption and Absorption

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**Keywords:** Palladium, Nanoparticles, Hydrogen, Adsorption, Absorption, Hydrogen Evolution

Palladium (Pd) is an excellent hydrogen (H) host and find application in hydrogen storage systems and anodes in rechargeable nickel–metal hydride [Ni-M(H)] batteries. The charge and discharge kinetics of Ni-M(H) batteries are limited by the slow H diffusion in solids and pulverization of host materials. This kinetic limitation can be overcome through the use of nanoparticles (NPs) that can be quickly charged and discharged, due to their dimensions leading to high surface-to-volume ratio. Pd is capable of both adsorbing and absorbing H, and in the case of bulk materials, the amount of adsorbed H ( $H_{ads}$ ) is tiny as compared to the amount of  $H_{abs}$ . H adsorption and absorption can be accomplished under gas-phase and electrochemical conditions, but the respective mechanisms are different owing to the nature of the H precursor.

In the present communication, Pd-NPs with controlled size and shape distributions (nano-spheres, nano-cubes and nano-octahedrons) are synthesized using a method based on chemical reduction of  $K_2PdCl_4$  in ultrapure water with polyvinylpyrrolidone as surfactant and with ascorbic / citric acid as reducing and surface agents. The Pd-H interactions are examined using electrochemical techniques. The potential range in which H electro-adsorption, electro-absorption, and evolution reaction occur is examined in an acidic medium using cyclic voltammetry (CV). The three processes give rise to unique features in CV profiles and are observed in distinct potential ranges (Figure 1). This behavior is not observed for bulk Pd materials and arises due to the nanoscopic nature of the Pd materials. In the case of octahedral Pd-NPs the H loading is as high as  $0.9^1$ . On the basis of thermodynamic analysis of H adsorption and absorption as well as through the application of the surface stress model in the analysis of H absorption mechanism, it is proposed that the octahedral Pd-NPs develop a core-shell-skin structure<sup>2</sup>.

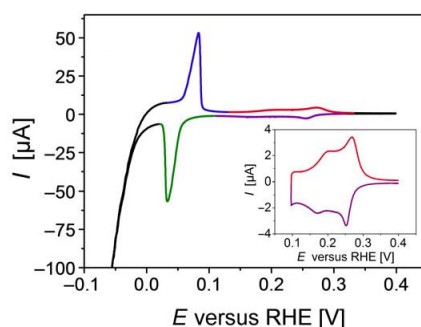


Figure 1: CV profile for octahedral Pd-NPs acquired in 0.5 M aqueous  $H_2SO_4$  solution at  $T = 296 K$  and  $\nu = 1.0 mVs^{-1}$  in the range of  $-0.05$  to  $0.40 V$ . The purple and red transients refer to UPD H (shown in detail in the inset), the green and blue transients refer to H adsorption and  $H_{abs}$  desorption, and the black transient refers to HER.

### Acknowledgements

A.Z. acknowledges financial support toward her postdoctoral studies from the County Council of Poitou-Charentes, France. G.J. acknowledges support from the Natural Sciences and Engineering Research Council of Canada.

### REFERENCES

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# European Fuel Cell Car Workshop

March,  
1<sup>st</sup> - 3<sup>rd</sup>  
2017,  
Orléans,  
France

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