

## Electrochemical Hydrogen Storage of Activated Carbon Modified by Pd-based Nanoparticles

by Brian Adams

Safe and efficient storage of hydrogen is one key challenge involved in the adaption to a hydrogen-based economy. Hydrogen storage on carbon materials has become a major interest. Carbon is a light-weight and inexpensive material that can be prepared in fine or porous textures with high surface areas. Activated carbons at low temperatures

and/or high pressures can achieve high capacities by the physical adsorption of hydrogen molecules. However, it is difficult to achieve high hydrogen storage capacities on carbon materials at ambient conditions. To increase the capacity at room temperature, metal catalysts have been used. It is known that Pd and its alloys can electro-sorb large quantities of hydrogen.<sup>1,2</sup> Our previous studies have shown that PdCd nanostructures display increased hydrogen solubility compared to pure Pd.<sup>3,4</sup> In this work, electrochemical techniques were applied to investigate the effect of Pd and PdCd nanoparticles dispersed on activated carbon for hydrogen sorption.

Commercially-available activated carbon, Norit PAC 200 from Norit Americas Inc. was used in this study and is referred to as AC. Pd and PdCd nanoparticles were dispersed onto the surface of this carbon material using a room temperature impregnation method with sodium borohydride as the reducing agent. Typical transmission electron microscope (TEM) images of the AC, Pd/AC, and PdCd/AC samples are presented in Fig.1a, 1b, and 1c. The total mass loading of these metal nanoparticles was 5 wt.% and the composition of PdCd nanoparticles was Pd<sub>0.85</sub>Cd<sub>0.15</sub> as indirectly confirmed by

(continued on next page)

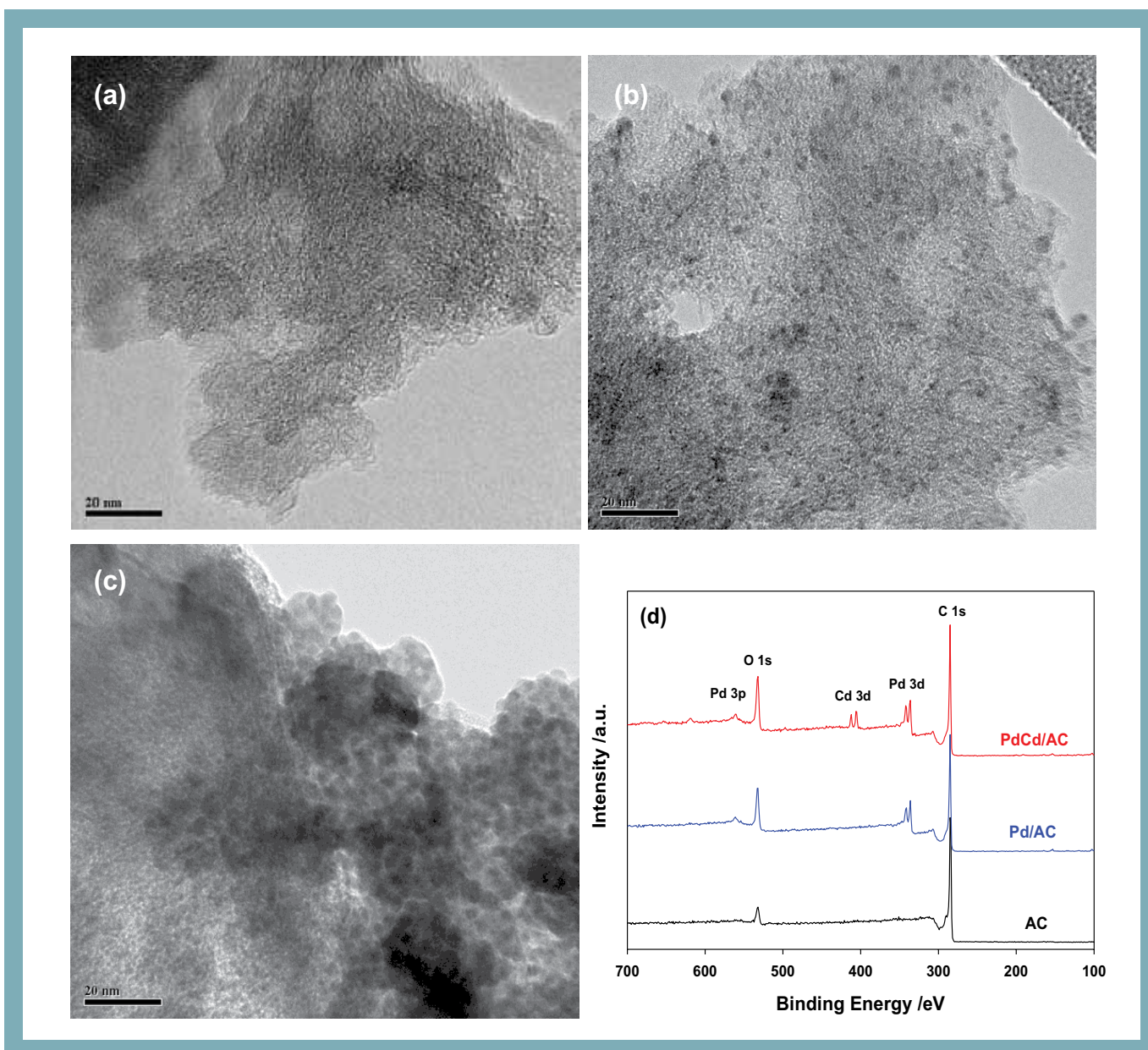


Fig. 1. TEM images of the prepared AC (a), Pd/AC (b), and PdCd/AC (c) samples, as well as the XPS survey scan for each of the samples (d).

inductively coupled plasma and directly confirmed by X-ray photoelectron spectroscopy (XPS). Displayed in Fig. 1d are the XPS survey scans for each of the samples.

Voltammetric experiments were performed using a VoltaLab PGZ402 potentiostat. A three-electrode cell system was used with a Pt coil as the counter electrode and an Ag/AgCl reference electrode in 0.5 M H<sub>2</sub>SO<sub>4</sub>. The working electrodes were prepared by coating a glassy carbon electrode with the activated carbon and prepared nanoparticle dispersed samples. The coating load for each working electrode was approximately 407 μg/cm<sup>2</sup>. Argon was continuously bubbled into the solution during the experiments. Cyclic voltammograms at various anodic limits are displayed in Fig. 2a, 2b, and 2c at a scan rate of 5 mV/s. No hydrogen adsorption or desorption occurred on

the AC within this investigated potential region. In contrast, strong hydrogen sorption was observed on the Pd/AC and PdCd/AC. At potentials more negative than -275 mV, hydrogen evolution took place, with the PdCd particles being more active for hydrogen evolution.

To completely saturate the films with hydrogen, the potential was held at -275 mV for 1 minute and then swept from -275 mV to 200 mV to desorb all of hydrogen (Fig. 2d). By integrating the area under these curves it was found that the Pd/AC and PdCd/AC samples had hydrogen desorption charges of 14.19 and 44.27 mC/cm<sup>2</sup>, respectively. This work has demonstrated that when PdCd nanoparticles are dispersed on the activated carbon, the material has a high capacity for the electro-sorption of hydrogen, promising for hydrogen storage.

## Acknowledgments

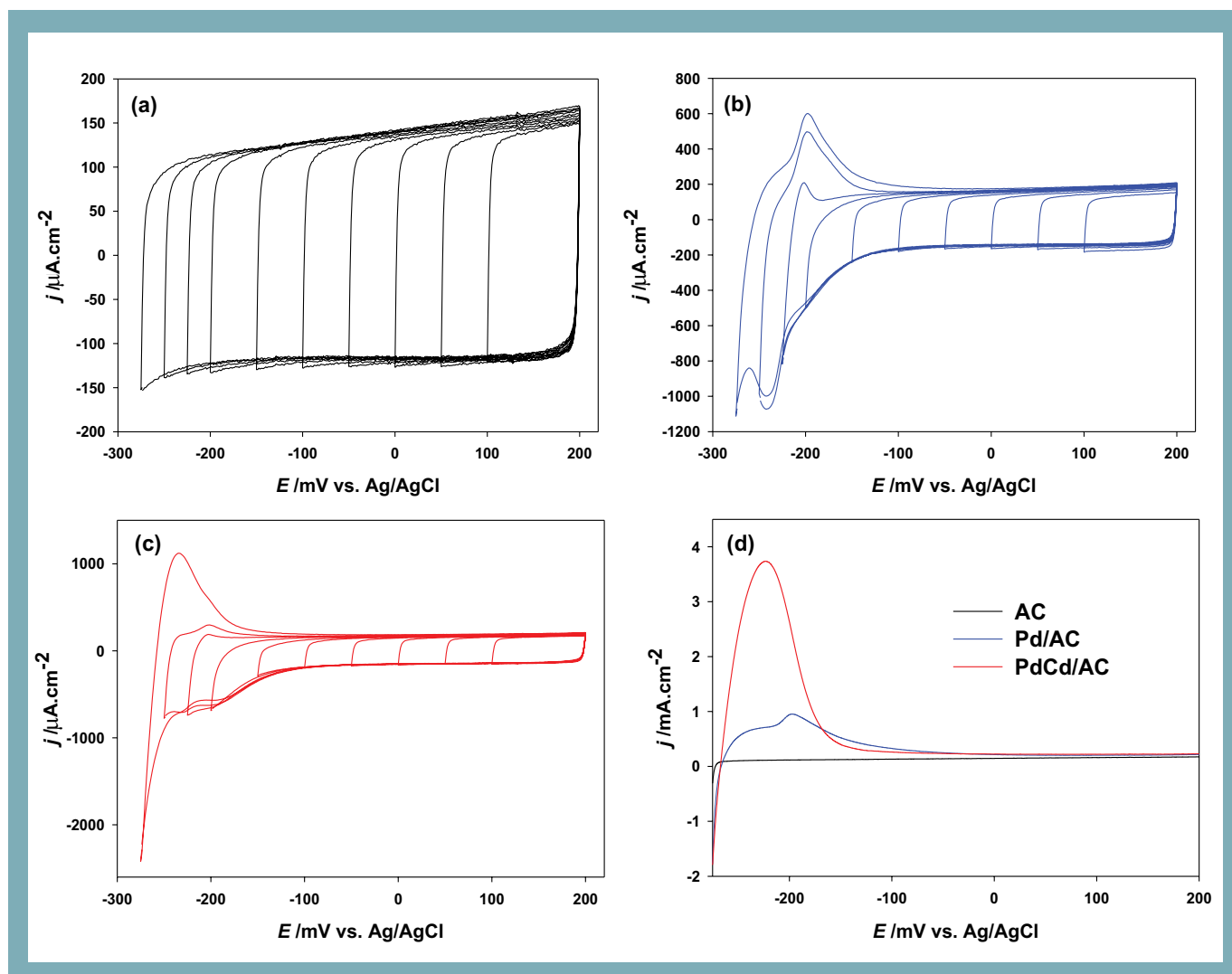
The author thanks ECS for the Colin Garfield Fink 2010 Summer Fellowship and Prof. Aicheng Chen at Lakehead University for his guidance with this work. ■

## About the Author

**BRIAN ADAMS** is a second-year MSc student at Lakehead University under the supervision of Prof. Aicheng Chen. Adams may be reached at badams1@lakeheadu.ca.

## References

1. H. Duncan and A. Lasia, *Electrochim. Acta*, **53**, 6845 (2008).
2. M. Łukaszewski and A. Czerwiński, *J. Solid State Electrochem.*, **12**, 1589 (2008).
3. B. D. Adams, G. Wu, S. Nigro, and A. Chen, *J. Am. Chem. Soc.*, **131**, 6930 (2009).
4. B. D. Adams, C. K. Ostrom, and A. Chen, *Langmuir*, **26**, 7632 (2010).



**Fig. 2.** Cyclic voltammograms for the AC (a), Pd/AC (b), and PdCd/AC (c) working electrodes recorded with various potential regions at a scan rate of 5 mV/s. The anodic sweeps from -275 mV to 200 mV are displayed in (d) after holding the potential at -275 mV for 1 minute to saturate the thin films with hydrogen.