N-Doped Graphene from PET Bottles Waste as an Effective Carbon Support for PdNi NPs for Borohydride Oxidation Electrocatalysis

A. Balčiūnaitė[1], B. Šljukić[2], N.A. Elessawy[3], M.H. Gouda[3], D.M.F. Santos[2]

1 Department of Catalysis, Center for Physical Sciences and Technology, 10257 Vilnius, Lithuania, email aldona.balciunaite@ftmc.lt
2 Center of Physics and Engineering of Advanced Materials, Instituto Superior Técnico, Universidade de Lisboa, 1049-001 Lisbon, Portugal, email diogosantos@tecnico.ulisboa.pt, biljana.paunkovic@tecnico.ulisboa.pt
3 City of Scientific Research & Technological Applications (SRTA-City), 21934 Alexandria, Egypt, email mgouda@srtacity.sci.eg, nelessawy@srtacity.sci.eg

Fuel cells (FCs) as sustainable power sources have attracted more and more attention from researchers. FCs are intrinsically efficient, non-polluting, silent, and reliable. Alkaline fuel cells are advantageous in several aspects as they enable the use of low-cost non-noble metals as electrocatalysts. Additionally, the problems related to hydrogen transportation and storage can be overcome by using liquid fuels.

The work aims to design efficient and inexpensive nanostructured catalysts for borohydride oxidation. The nitrogen-doped graphene (NG) prepared by the thermal decomposition of PET bottle waste with urea was assessed as catalyst support.

The different palladium-nickel (PdNi) catalysts were prepared by anchoring Ni nanoparticles on NG (Ni@NG) followed by doping with different (5, 10, 15 wt.%) amounts of Pd (noted as PdNi_5@NG, PdNi_10@NG, PdNi_15@NG.

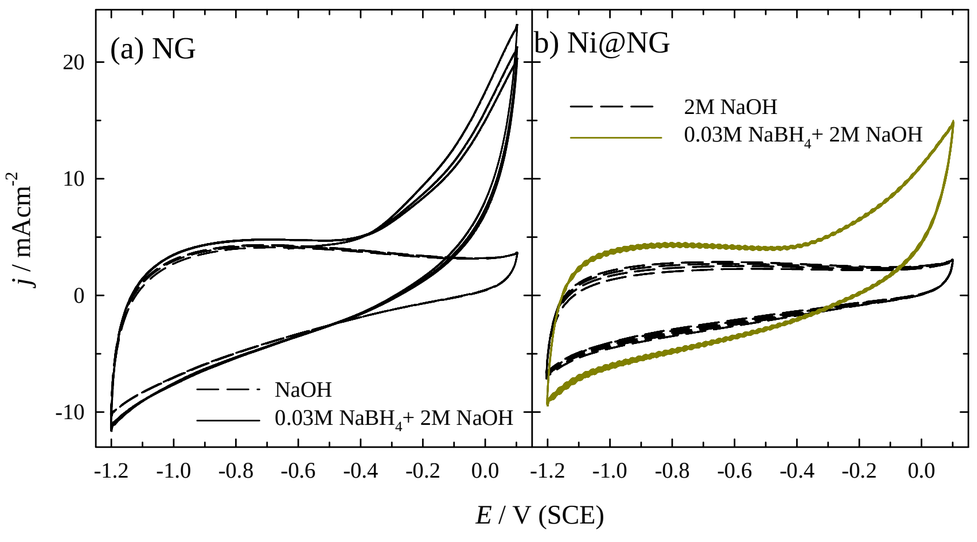

Fig. 1. CVs NG (a) and Ni@NG (b) recorded in 2 M NaOH and 0.03 M $NaBH_4$ + 2 M NaOH at 50 mV s^{-1}.

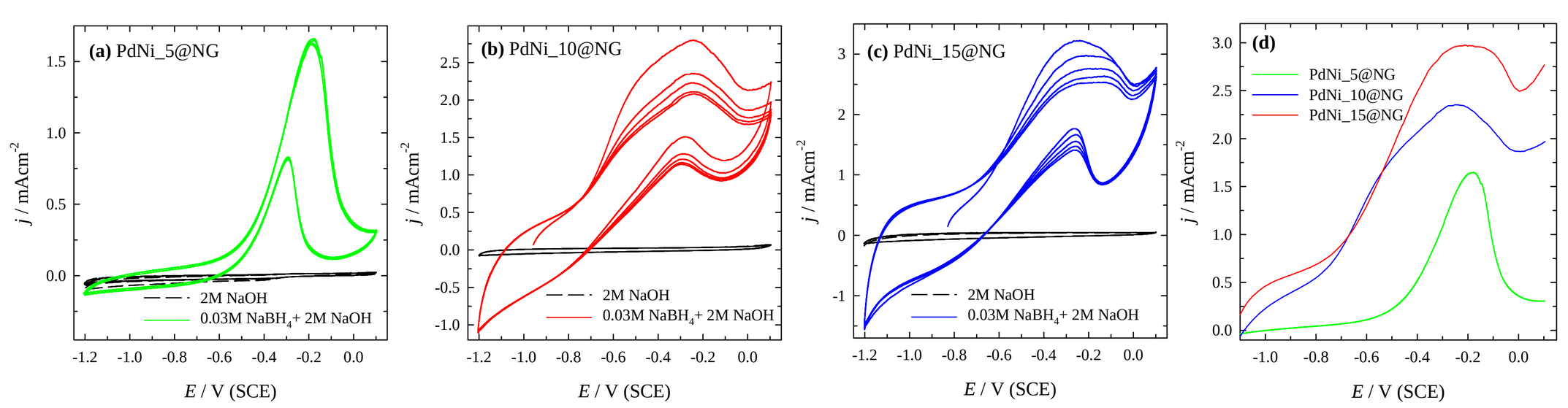

Fig. 2. CVs PdNi_5@NG (a), PdNi_10@NG (b), and PdNi_15@NG (c) recorded in 2 M NaOH and 0.03 M $NaBH_4$ + 2 M NaOH at 50 mV s^{-1}. (d) Positive-potential going scans of PdNi_5@NG, PdNi_10@NG, and PdNi_15@NG.

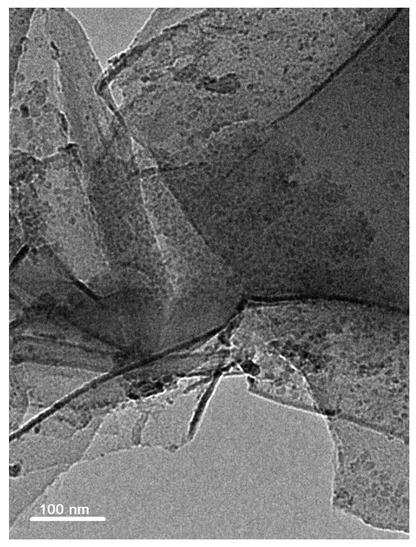

Fig. 5. TEM view of PdNi_15@NG

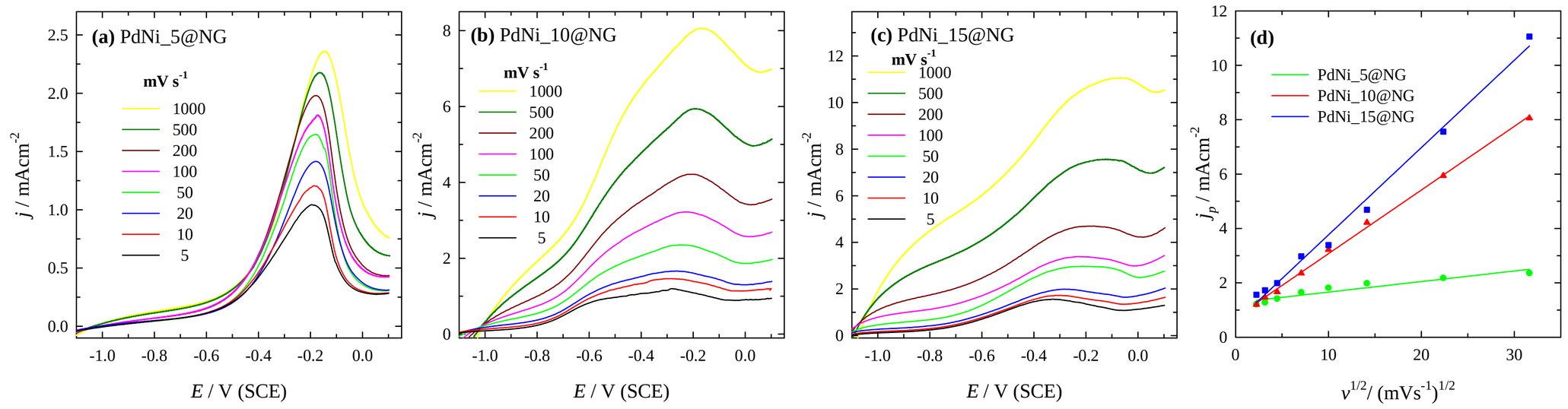

Fig. 3. Positive-going potential scans of PdNi_5@NG (a), PdNi_10@NG (b), and PdNi_15@NG (c) catalysts in 0.03 M $NaBH_4$ + 2 M NaOH at 25 °C at a different electrode potential scan rate. (d) Plots of peak current densities vs potential scan rate.

CONCLUSIONS

The studies showed that the prepared PdNi@NG catalysts have good electrochemical stability in an alkaline $NaBH_4$ solution. The PdNi_15@NG catalyst exhibited the best electrocatalytic activity for the borohydride oxidation reaction. The prepared PdNi@NG catalysts seem to be promising anodic materials for direct borohydride fuel cells.

Table 1. Pore structure parameters of samples.

Catalysts	$a_{S,BET}$ (m^2g^{-1})	Total pore volume (cm^3g^{-1})	Average pore diameter (nm)
NG	57.29	0.053	3.72
Ni@NG	97.31	0.062	2.56
PdNi_5@NG	70.63	0.076	4.31
PdNi_10@NG	39.47	0.089	8.99
PdNi_15@NG	6.05	0.033	21.52

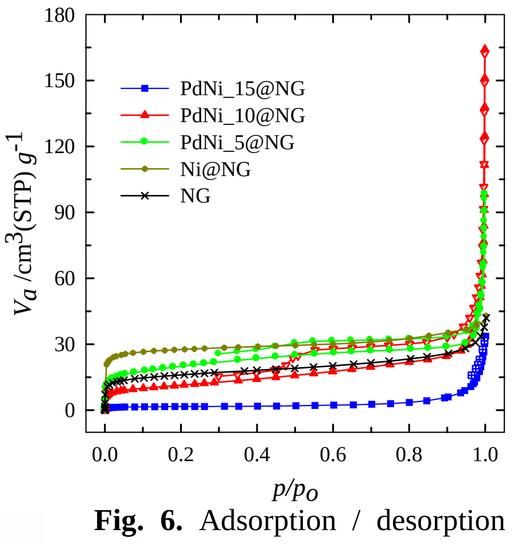

Fig. 6. Adsorption / desorption isotherm of NG, Ni@NG, PdNi_5@NG, PdNi_10@NG, and PdNi_15@NG catalysts.

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