Catalytic performance of Pt-decorated nitrogen-doped Mn_2O_3-NiO for oxygen reduction and evolution

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The oxygen reduction reaction (ORR) and oxygen evolution reaction (OER) represent pivotal electrochemical processes with wide-ranging implications in energy conversion and storage technologies. However, both reactions are inherently sluggish, necessitating efficient catalysts to accelerate kinetics and enhance overall performance. Transition metal-based catalysts, including platinum, palladium, and non-noble metals such as iron, cobalt, manganese, and nickel, have gained significant attention for their catalytic activity and durability. Furthermore, using nanostructured catalysts, heteroatom-doped carbon materials, and metal oxides has broadened the spectrum of catalyst options, improving efficiency and cost-effectiveness.

In this work, we synthesized nitrogen-doped Mn_2O_3-NiO with a binary metal oxide (BMO) to N ratio of 2:1 by mixing BMO and melamine, followed by annealing in an inert environment. Subsequently, the synthesized material was decorated with Pt nanoparticles using the microwave-assisted polyol method, as described in the authors' previous work [1].

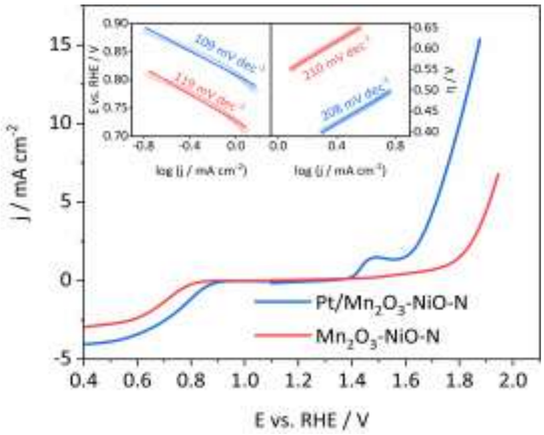

Figure 1. Polarisation curves for two tested materials in ORR and OER potential regions with the corresponding Tafel plots in the inset.

The catalytic activity of synthesized catalysts toward oxygen reduction and oxygen evolution was investigated in 0.1 M KOH; obtained polarization curves are depicted in Figure 1. Pt-decorated material showed notably better performance in comparison with non-decorated N-doped BMO in the ORR potential region, with 3.4 e^- exchanged in the elementary step of the reaction, a higher value of diffusion-limited current density reached at 1800 rpm, and a lower value of Tafel slope of 109 mV dec^{-1}. This was expected, given that Pt is well known as one of the best ORR catalysts. However, Pt-decorated catalyst also showed better performance in the OER potential region with lower onset potential, overpotential to reach benchmark current density of 10 mA cm^{-2} of just under 0.6 V, and lower value of Tafel slope of 208 mV dec^{-1}. Moreover, a relatively low value of ΔE ($\approx$ 1 V) as a measure of bifunctional performance was calculated for this material. The acquired value of ΔE is comparable with the value of 0.95 V calculated for the commercial Pt/C tested under the same experimental conditions [2]. Nevertheless, it is important to highlight that commercial Pt/C contains 40 wt.% Pt, whereas the material synthesized herein comprises only 20 wt.% Pt, rendering it significantly more cost-effective to produce.

Considering the preliminary findings, subsequent experiments will prioritize enhancing performance by making slight adjustments to the synthesis procedure and evaluating the synthesized materials' long-term stability.

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