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OER/ORR bifunctional electrocatalysts based on PtM (M=Ni,Fe,Cu) supported on graphene nanoplatelets

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Three different Pt-M (M = Ni,Fe,Cu) based electrocatalysts were synthetised via simultaneous supercritical carbon dioxide (scCO2) deposition technique of nanoparticles on graphene nanoplatelets (GNPs). These were tested as electrocatalysts for oxygen reduction (ORR) and oxygen evolution (OER) reaction in metal-air batteries and unitized regenerative fuel cells (URFCs). Primary metal (Pt) and secondary metal (Ni, Fe, Cu) were deposited onto GNPs by scCO2 in the same step which resulted in ca. 20 wt.% Pt loading and M loading in the 1.4 - 3.4 wt.% range. Adsorption isotherms of the precursors onto the GNPs were used to determine desired amount of the corresponding precursors [1].
Linear scan voltammetry (LSV) experiments at different rotation rates were performed in alkaline medium (0.1 M KOH) in order to assess the electrocatalytic activity toward ORR and OER. Catalyst with Fe as secondary metal showed the highest diffusion-limited current density, jd, of -4.65 mA cm-2, followed by PtCu/GNPs (-4.37 mA cm-2) and PtNi/GNPs (-3.65 mA cm-2). It is worth noting that commercial Pt/C (40 wt.% Pt) catalyst tested in our previous work reached a jd value of -6.44 mA cm-2, comparable with herein tested catalysts [2]. PtFe/GNPs sample also showed the lowest value of Tafel slope (81 and 66 mV dec-1) and number of exchanged electrons value as high as 3.66, indicating direct 4e- O2 reduction to water. OER investigation revealed that catalyst with Fe as secondary metal also showed superior performance for this reaction as evidenced by the lowest OER onset potential, the highest achieved current densities, and the lowest value of Tafel slope. Moreover, ΔE, the difference between the potential at which OER achieves 10 mA cm-2 current density and half-wave potential of ORR, E1/2, has the lowest value for PtFe/GNPs sample (≈0.89 V). Thus it can be concluded that PtFe/GNPs catalyst exhibits promising ORR/OER performance. Further investigations will be focused on testing its long-term stability and performance in fully assembled URFC or metal-air battery.

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