Can carbon dots empower iron-doped carbon electrocatalysts for the oxygen reduction?

ABSTRACT

Oxygen reduction reaction (ORR) electrocatalysts are typically based on noble metals supported on carbon black – mostly platinum. The widespread use of technologies relying on the ORR (*e.g.*, fuel cells and zinc-air batteries) has thus been hindered by both the scarcity and high cost of the precious metals. Seeking alternatives to the use of noble metals through the development of carbon-based electrocatalysts has been the focus of our research group.

In the current study, microwave-assisted methods were employed to synthesize both CD (with citric acid and urea as carbon and nitrogen precursors) and the hybrid CD-CNT (mass ratio of 1:1). The latter was then impregnated with iron (II) chloride and thermally annealed at 800 ºC under an inert flow of N_2, resulting in the material referred to as CD-CNT-Fe. CNT-Fe was obtained by employing the same iron-doping procedure, yet directly on CNT.

The electrocatalysts' properties were extensively characterized, including ultraviolet-visible (UV-Vis), photoluminescence (PL), Raman, Fourier transform infrared (FTIR), and X-Ray photoelectron (XPS) spectroscopies, elemental analysis, N_2 physisorption, transmission (TEM) and scanning (SEM) electron microscopies, thermogravimetric analysis (TGA), and inductively coupled plasma – optical emission spectrometry (ICP-OES). The results confirmed that CDs were indeed obtained through our microwave-assisted synthesis methodology and successfully incorporated into the CD-CNT hybrid material. Except for CD (whose high solubility rendered any experiment unfeasible), the ORR performances of the carbon electrocatalyst in an alkaline medium were evaluated using a conventional three-electrode configuration. Incorporating CD within CNT slightly enhanced the electrocatalytic activity of CNT, as observed when the performance of CD-CNT is compared to that of CNT (Fig. 1a). This positive effect can be explained by the high bulk nitrogen content of CD (21.8 wt.%). Nevertheless, the greatest enhancement of electrocatalytic activity was obtained upon iron doping of CD-CNT. As observed, the resulting material (CD-CNT-Fe) performed better than a benchmark platinum electrocatalyst (Pt/C; 20 wt.% of Pt on carbon black) in what concerns to limiting current density yielded (Fig. 1a), average number of electrons exchanged and hydrogen peroxide (H_2O_2) formation during the ORR (Fig. 1b), and electrocatalytic stability (Fig. 1c). On the contrary, a far worse performance was obtained on CNT-Fe (Fig. 1a), thus highlighting the role of CD during the incorporation of iron on the hybrid CD-CNT electrocatalyst. To the best of our knowledge, this positive effect is reported and discussed for the first time in this communication.

ATTACHMENTS

Fig._Abstract_Carbon.png

TOPICS

- Carbon & electrochemical processes and technologies (Batteries and capacitors, fuel cells, functionalization, electrochemical sensors, etc.)
- Carbon & catalysis (Photocatalysis, CO2 conversion, electrocatalysis, etc.)

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