N, B and P co-doped graphene as metal-free catalysts for the oxygen reduction in alkaline media

Miguel A. Molina-García
Neil V. Rees

Centre for Fuel Cells and their Fuels Research, School of Chemical Engineering, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK.

MAM367@bham.ac.uk

Doping graphene with heteroatoms such as N, B or P can tailor the properties of the 2D structure of graphene[1] and increase the catalytic activity towards the oxygen reduction reaction (ORR) with respect to pristine graphene.[2] Here we present a new systematic study in which we compare the performance of B-N and P-N dual-doped graphene and their single-doped N-free counterparts.

The doping-precursor agents are melamine, boric acid and orto-phosphoric acid for N, B and P, respectively. These are mixed with a certain amount of commercial GO and subjected to a thermal treatment at 900 °C during 2 hours with an incremental step of 5 °C min^{-1} from room temperature.

In the Raman analysis (Fig. 1) the ratio between the I_D peak, linked to defective sites in the structure, and the I_G peak, related to the degree of graphitization,[3] is lower when B and P are co-doped with N, with respect to B-Gr and P-Gr, respectively. Regarding the catalytic activity (Fig. 2), doping graphene with one single element does not improve the performance with respect to thermally reduced GO without doping. Nevertheless, when graphene is co-doped with two elements (BN-Gr and PN-Gr) there is a significant improvement with respect to the catalysts in which these elements are not combined with N. This effect is considerably more noticeable in the case of PN-Gr.

The better performance of the dual co-doped graphene catalysts is attributed to a synergistic effect between the two different elements incorporated into the active 2D graphene structure.[4]

Figures

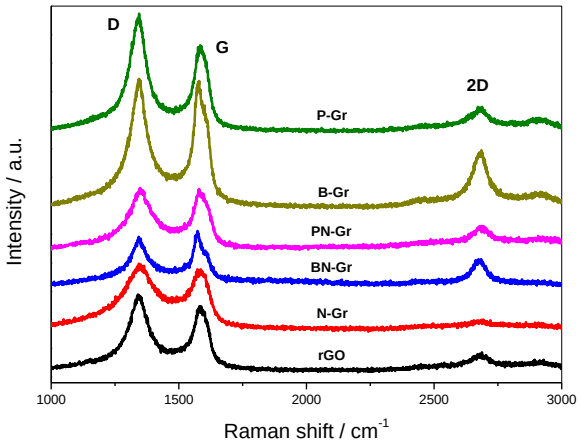

Figure 1: Raman spectra at an excitation wavelength of 532 nm.

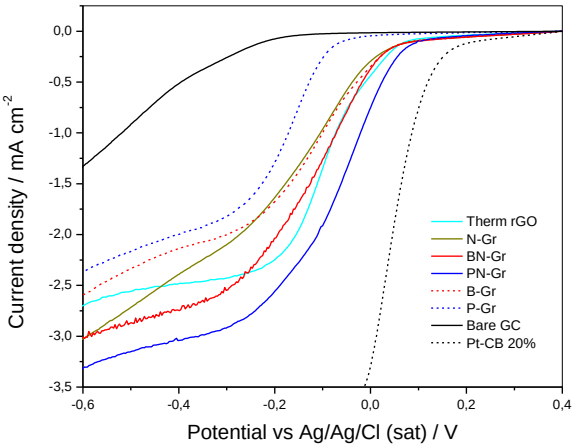

Figure 2: LSV at 1600 rpm in O_2 saturated 0.1 M KOH solution.

References

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