Nitrogen Doped Graphene-Supported Fe_3O_4 Nanoparticles for Efficient Oxygen Reduction Reaction

Zhong-Shuai Wu, Yi Sun, Long Chen, Khaled Parvez, Xinliang Feng,* and Klaus Müllen*

Max-Planck-Institut für Polymerforschung, Ackermannweg 10, 55128 Mainz, Germany
feng@mpip-mainz.mpg.de, muellen@mpip-mainz.mpg.de

One of the great challenges for oxygen reduction reaction (ORR) at the fuel cell cathodes is to explore innovative, alternative and high efficient non-precious metal catalysts with low cost, high activity and practical durability in the long-term.[1-3]The currently used platinum based catalysts are the best electrode materials for ORR, which, however, suffer from slow reduction kinetics and high cost. As one of the reasonable alternatives for pure Pt catalysts, nonprecious metal based nitrogen-doped carbon catalysts, in particular, Fe-N/C and Co-N/C catalysts derived from transition-metal/nitrogen containing precursors/complexes, such as porphyrins, phthalocyanides, polypyrrole, and polyaniline, have been revealed to be viable alternative catalysts given their comparable catalytic activity toward ORR. Graphene is expected to be a good carbon support for uniformly anchoring the metal/ metal oxide nanoparticles for energy storage devices,[4-7] in particular, improving the ORR performance in fuel cell.[8]

In this work, we reported a novel class of non-precious metal (Fe_3O_4)/N-doped graphene composite catalysts as high performance cathode catalysts for ORR in alkaline solution (Figure 1). An N-containing conducting polymer of polypyrrole (PPy) was chosen as nitrogen precursor to fabricate nitrogen-doped graphene due to its excellent catalytic activity and high durability. The resulting hybrid catalysts can greatly increase the active site density on the catalyst, therefore, the hybrid catalytsts exhibit high current density, low ring current, low HO_2^- yield, high electron transfer number (~4), and good durability.

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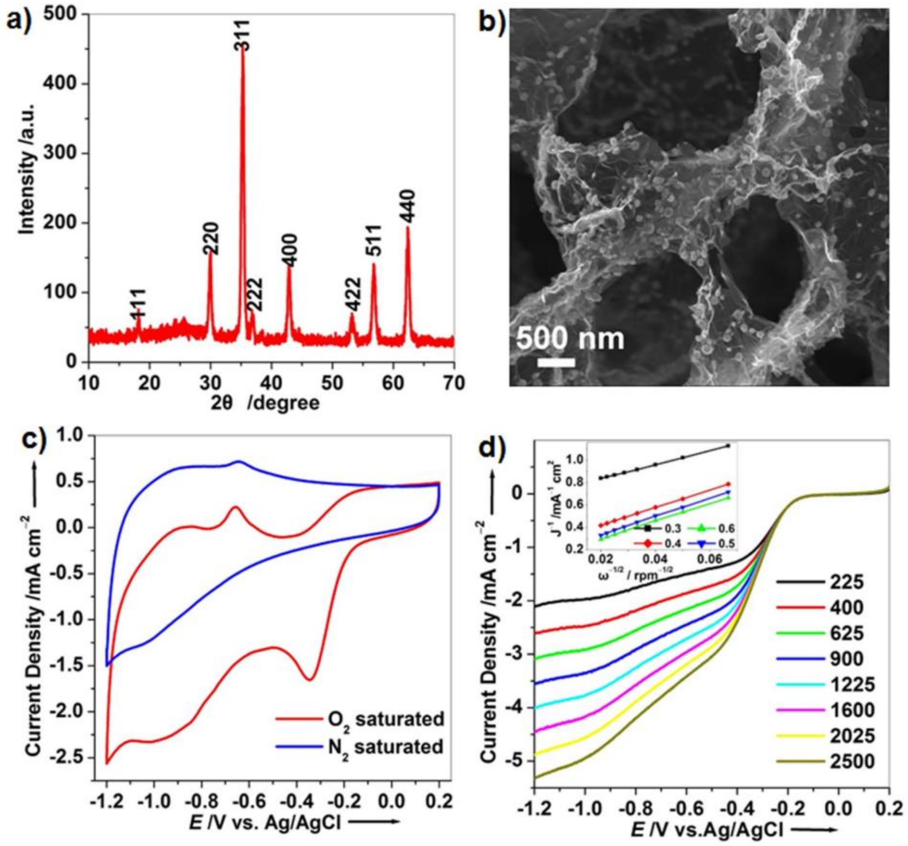

Figure 1. a) XRD pattern and b) SEM image of Fe_3O_4-N-doped graphene. c) Cyclic voltammnetry curves of Fe_3O_4-N-doped graphene in nitrogen- and oxygen-staturated 0.1 M KOH aqueous electrolyte solution. The scan rate is 100 mV s^{-1}. d) linear sweep voltammetry of Fe_3O_4-N-doped graphene in an oxygen-saturated 0.1 M KOH at a scan rate of 10 mV s^{-1} and different rotation rates. Inset is the corresponding K-L plot of current density (J-1) versus $\omega^{-1/2}$.