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Biomass-derived activated carbon as high-performance non-precious electrocatalyst for oxygen reduction

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Abstract
A new type of Fe and N doped carbon material is synthesized by pyrolyzing ferric chloride doped egg white (EW) and the proposed synthetic route is easy, green, and low-cost. In addition, the as-prepared sample exhibits a feasible magnetism and comparable oxygen reduction reaction (ORR) activity to commercial Pt/C.

As the cathodic ORR plays an important role in the performance of a fuel cell,[1,2] efficient ORR electrocatalysts are highly desirable for practical applications. So far, Pt and its alloys have long been regarded as the most effective catalysts for the ORR in fuel cells.[3,4] However, their large-scale commercial applications have been hindered by high costs.[5] Besides, they still suffer from serious intermediate tolerance, anode crossover, sluggish kinetics, and poor stability in an electrochemical environment.[6–8] For these sakes, extensive research has been expected to solve the problems that involve (i) replacing the noble metal by alloy to reduce the consumption of novel metals and to lower the cost;[9,10] (ii) assuming certain novel carbon materials with particular shapes like carbon nanotubes (CNTs) and graphene to promote the conductivity of the catalyst or the intermediate product trans- fer;[11,12] (iii) the introduction of transition metals (such as Fe, Co)[13,14] as well as metal oxides (such as Fe_3O_4 and CoO)[15,16] to boost the ORR; (iv) doping some N, B, P, and S atoms[17–20] to modify the electrocatalysts to enhance the methanol tolerance. Among these explorations, it is confirmed that nitrogen-doped carbon materials not only exhibit high catalytic activity, long-term stability, and excellent methanol tolerance in alkaline media, but also possess the advantages of low cost and environmental friendliness.

According to the theory of Dai *et al.*,[21] the high catalytic activity by doping N may be attributed to the larger electronegativity of N compared to C atoms. And, N atoms can create positive charge density on the adjacent C atoms, which results in the very favorable adsorption of O_2. Consequently, intense research on the ways to modify the carbon materials with nitrogen atom has been greatly inspired. To our knowledge, the source of nitrogen is always derived from expensive organic monomer containing nitrogen element[22] or NH_3.[12] However, these

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