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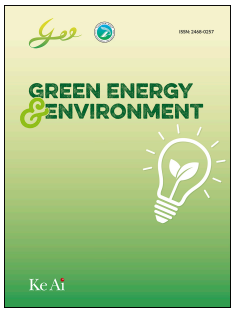

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Heteroatom-doped porous carbon from methyl orange dye wastewater for oxygen reduction

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Abstract: Banana peel-derived porous carbon (BPPC) was prepared from banana peel and used as an adsorbent for methyl orange (MO) wastewater removal. BPPC-MO50 is a N,S-doped BPPC obtained via secondary carbonization. The BPPC-MO50 exhibited a high specific surface area of 1774.3 m^2/g. Heteroatom-doped porous carbon (PC) was successfully synthesized from the BPPC absorbed MO at high temperature and used for oxygen reduction. The BPPC-MO50 displays the highest ORR onset potential among all carbon-based electrocatalysts, i.e., 0.93 V vs reversible hydrogen electrode (RHE). This is the first report to describe porous carbon-activated materials from agriculture and forestry waste that is used for adsorption of dyes from waste water via an enhanced heteroatom (N,S) content. These results may contribute to the sustainable development of dye wastewater treatment by transforming saturated PC into an effective material and has potential applications in fuel cells or as energy sources.

Keywords: banana peel; dye wastewater; porous carbon; heteroatom doping; oxygen reduction reaction.

1. Introduction

Fuel cells offer high efficiency, environmental protection, and unlimited sources of reactants. Therefore, the fuel cell is expected to enter to widespread commercial in the field of transportation.[1-3] Oxygen reduction reaction (ORR) is a crucial reaction in fuel cells. For oxygen reduction reaction in fuel cells, noble Pt-based materials are generally used as active catalysts.[4, 5] However, the commercially large-scale Pt-based materials still suffer from high cost, inferior electron-transfer kinetics and poor durability under operating conditions including dissolution, sintering, and agglomeration, which results in a loss of performance. Thus, finding cheap alternative catalysts is critical.[6, 7]

Heteroatom-doped carbon materials are excellent non-metallic catalysts and have recently attracted significant attention[8]. Versus commercial Pt/C, heteroatom-doped carbon materials offer better electrocatalytic activity for oxygen reduction reactions in both alkaline and acidic media.[9] In particular, pyridinic N offers remarkable ORR active sites.[10] Sugar and urea[11], ammonium persulfate[12], cysteine[13], melamine and phytic acid[14], and sulfocarbamide[15] are generally selected as heteroatom resources. Furthermore, heteroatoms (e.g., N, S, B, P, etc.) with dual and ternary-doped carbon materials are used as electrocatalysts for ORR due to their low cost, good tolerance toward fuel, and strong durability in acid/alkaline environments. The N and S co-doped carbon materials give high catalytic sites and exhibit excellent electrocatalytic activity for ORR, and they can be used for heteroatom doping.[16] All of these features lead researchers towards heteroatom co-doped carbon materials as nonmetal catalysts for ORR.

Sustainable water management including wastewater treatment is a major challenge facing the world.[17] Worldwide dye production from textile industries can reach over 1,500,000 tons annually. During dyeing, about 10–15% of the dye is lost. Among the several methods for dye-containing wastewater treatment, porous carbon (PC) is generally employed as an absorbent due to its strong ability to absorb dyes. [18] After adsorption, the PC (i.e., sludge) can be treated in any of three main ways: (a) burning, (b) disposal in landfills, and (c) regeneration and reuse as absorbent.[19, 20] Regeneration reduces environmental and economic impact. Currently, there are thermal, chemical, microbiological, and vacuum methods of regenerating carbon.[21] However, the absorption capacity of dye on regenerated used