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W. He[1*], X. D. Zhang[1], S. J. Liu[1], Y. Z. Yue[1,2]

[1]Key Laboratory of glass & ceramic materials, Shandong Polytechnic University, Jinan, 250353, China
[2]Section of Chemistry, Aalborg University, DK-9000 Aalborg, Denmark

Amorphous iron phosphate-active carbon nanocomposite microspheres with mesoporous structure are synthesized by co-precipitation method using yeast cells as a structural template, electric carbon source and cementation agent. The X-ray diffraction (XRD) pattern indicates that the synthesized sample is of amorphous nature. The mesoporous structure of the resultant samples was characterized by Brunauer-Emmett-Teller(BET), N_2 adsorption-desorption isotherms (NADI) and Barrett–Joyner–Halenda (BJH) models, and was found to have a specific surface area of 107 m^2/g and a pore size distribution of 7–12 nm. Transmission electron microscopy (TEM) measurements confirm the mesoporous microsphere structure of the resulting samples. Both the composition of the mesoporous microsphere composites and the chemical bonds between iron phosphate and active carbon are studied by Fourier transform infrared spectroscopy (FT-IR). The mechanism of biomineralization was clarified in terms of chemical bonds and surface charges. An air electrode fabricated using this mesoporous microsphere composites exhibited remarkable electrocatalytic activity for oxygen reduction reaction (ORR). Compared to the electrolytic manganese dioxide (EMD) air electrode employed commercially, a 89% higher catalytic reduction current was achieved. The mesoporous structure and nanocomposite structure play important roles both in significantly reducing electrochemical polarization and in improving the mass transport of the air diffusion electrode. This simple and efficient approach could be used as a general way to prepare advanced mesoporous materials in mild condition. The mesoporous microsphere composite is considered to be promising for application in positive electrode materials of lithium batteries, fuel cell, and metal–air battery fields. Additionally, this low cost, simple and environmentally-friendly method can be easily scaled up for industrial production of advanced mesoporous materials.