

Supporting Information for

A template-free route to $\text{Fe}_3\text{O}_4\text{-Co}_3\text{O}_4$ yolk-shell nanostructure as a noble-metal free electrocatalyst for ORR in alkaline media

Yixing Ye, Long Kuai and Baoyou Geng*

College of Chemistry and Materials Science, the Key Laboratory of Functional Molecular Solids, Ministry of Education, Anhui Laboratory of Molecular-Based Materials, Anhui Normal University, Wuhu 241000, P. R. China

Corresponding author's E-mail: bygeng@mail.ahnu.edu.cn

S1 Additional Figures and Figure Captions

Figure S1

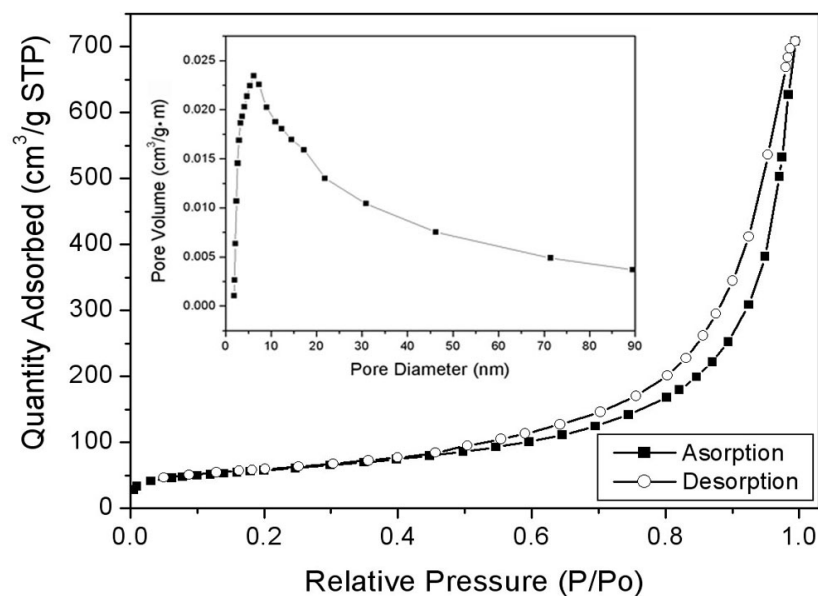


Figure S1: The nitrogen adsorption-desorption isotherm and pore size distribution curve (inset) of the as-prepared $\text{Fe}_3\text{O}_4\text{-Co}_3\text{O}_4$ yolk-shell nanostructures.

Figure S2

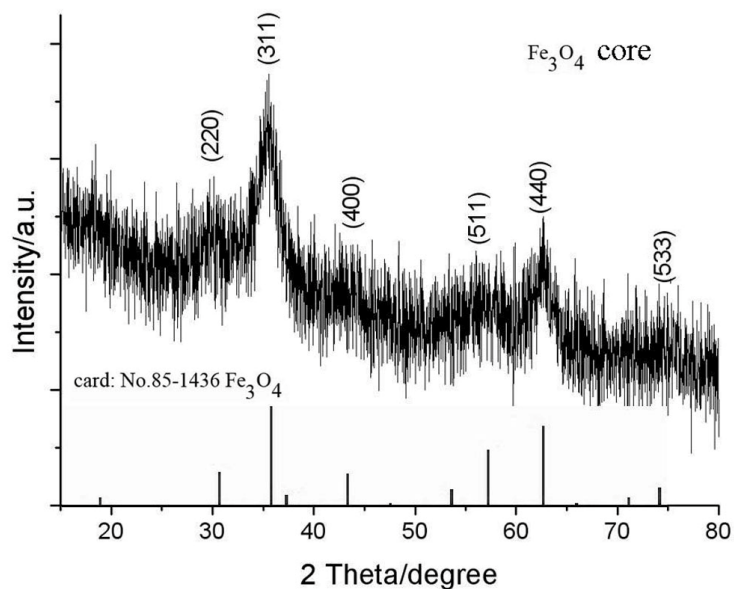


Figure S2: The XRD pattern of the products obtained after reaction for 4h.

Explanation of Figure S2

The cores were obtained by carrying out the experiment for 4h, and we can clearly find that the cores are mainly consisted by Fe₃O₄. The as-obtained XRD pattern is shown in Figure S2 which is in good agreement with the standard Joint Committee on Powder Diffraction Standards (JCPDS) cards No. 85-1436.

Figure S3

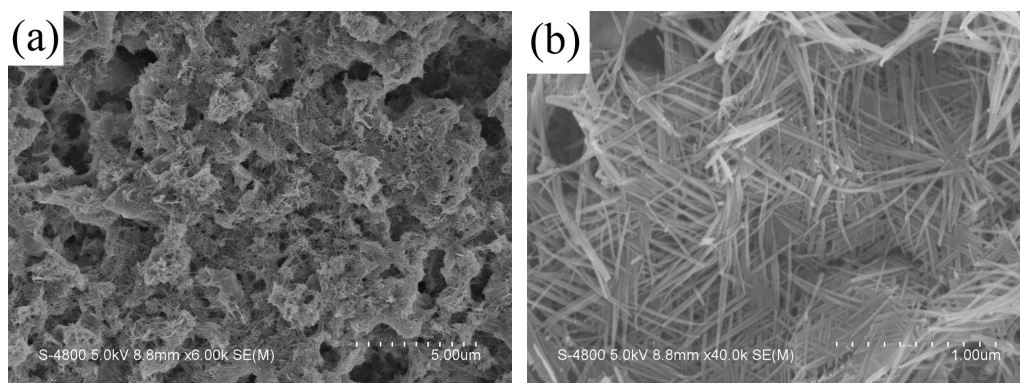


Figure S3: Low (a) and high (b) SEM images of the products obtained without Na_3Cit .

Figure S4

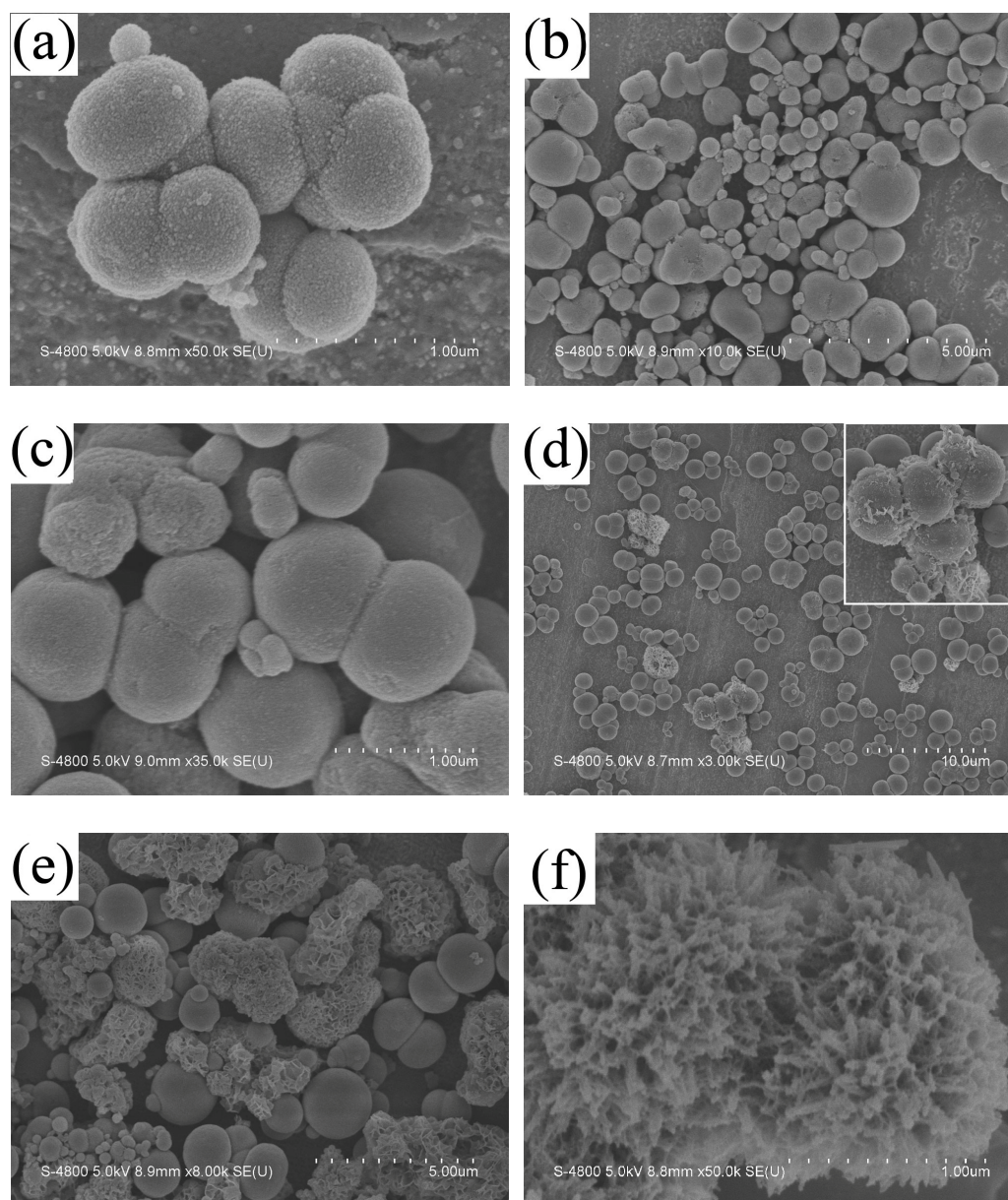


Figure S4: SEM images of the products obtained with Fe/Co molar ratio of 1:0 (a), 5:2 (b), 4:3 (c), 1:1 (d), 3:4 (e) and 0:1 (f).

Figure S5

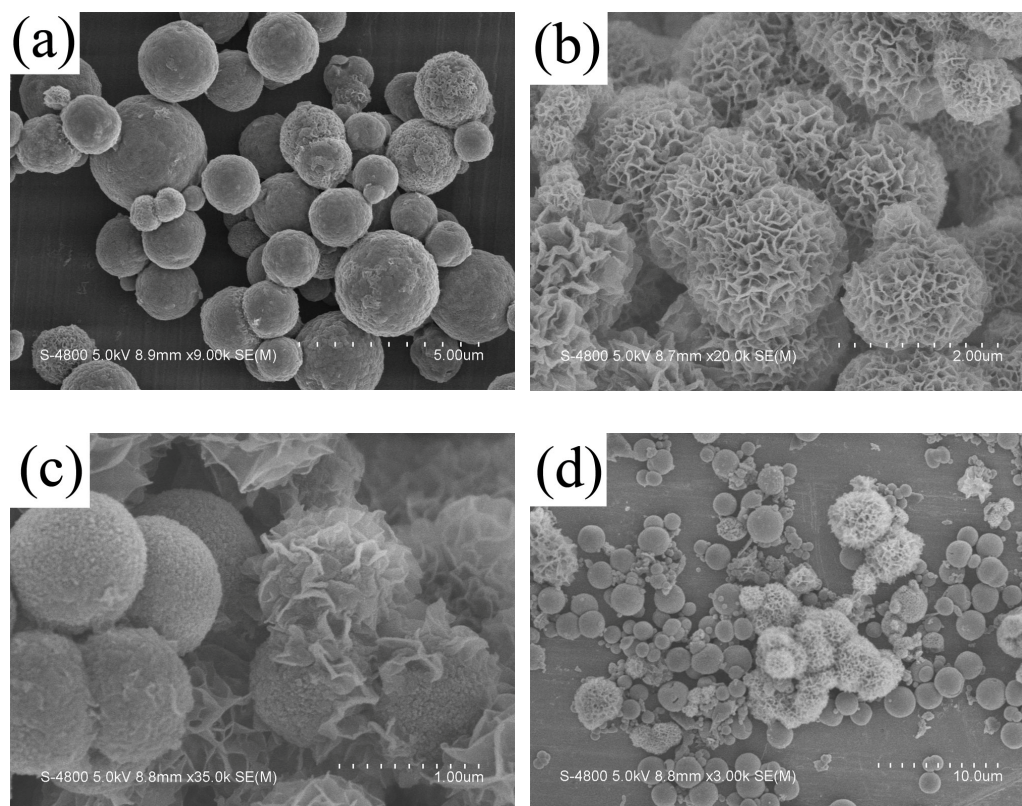


Figure S5: SEM images of the products obtained with the temperature of 100 °C (a), 130 °C (b), 160 °C (c) and 180 °C (d).

Figure S6

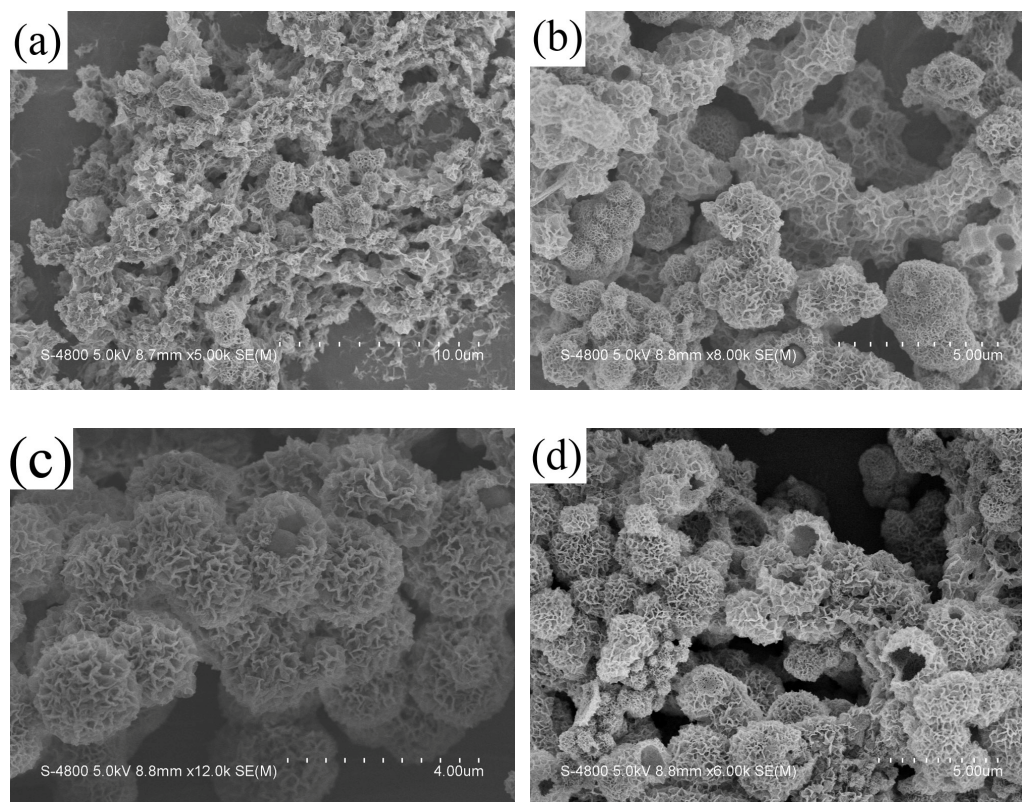


Figure S6: SEM images of the products obtained with volume ratio of water, ethanol and butanol of 0:100:0 (a), 20:100:0 (b), 20:100:1 (c) and 20:100:10 (d).

Explanation of Figure S6

The effects of the typical solvent ratio are shown in Figure S8. If there is only ethanol, we can not find shaped products in Figure S7a. Scattered and anomalous particles fill the screen. Along with the adding of water, although anomalous impurities are still in existence, more shaped outcomes appear (Figure S7b). Finally, the dramatic adding of butanol makes the successful prepare of the perfect products in Figure S7c. In order to get the best ratio, more butanol was added, shown in Figure S7d, more broken yolk-shells exist, and the impurities increased.

Figure S7

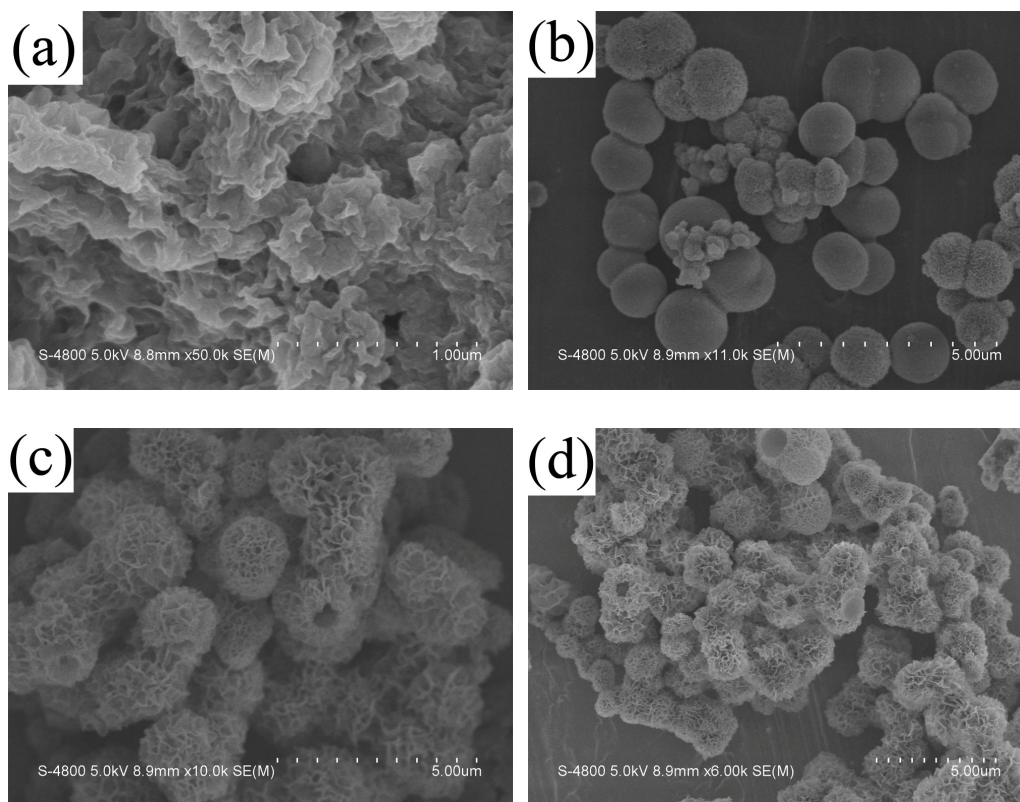


Figure S7: SEM images of the products obtained with the reaction time of 2 h (a), 4 h (b), 6 h (c) and 10 h (d).

Figure S8

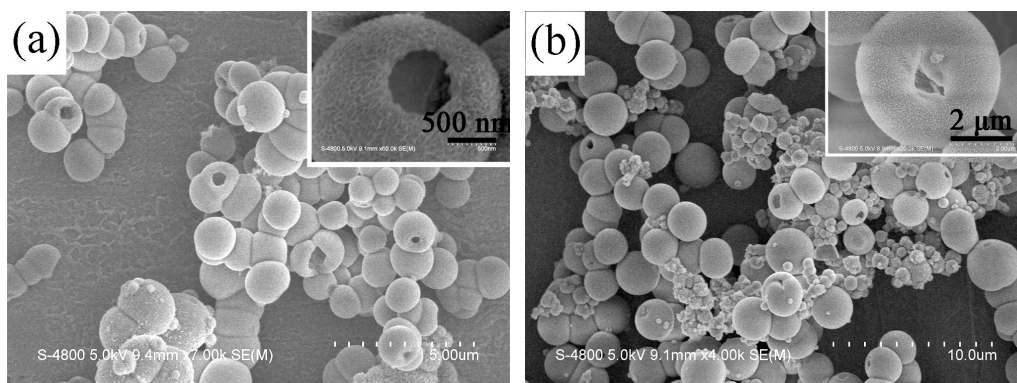


Figure S8: The SEM images of the products obtained by using $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$, $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ (a) and $\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$, $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ (b) as raw materials.

Figure S9

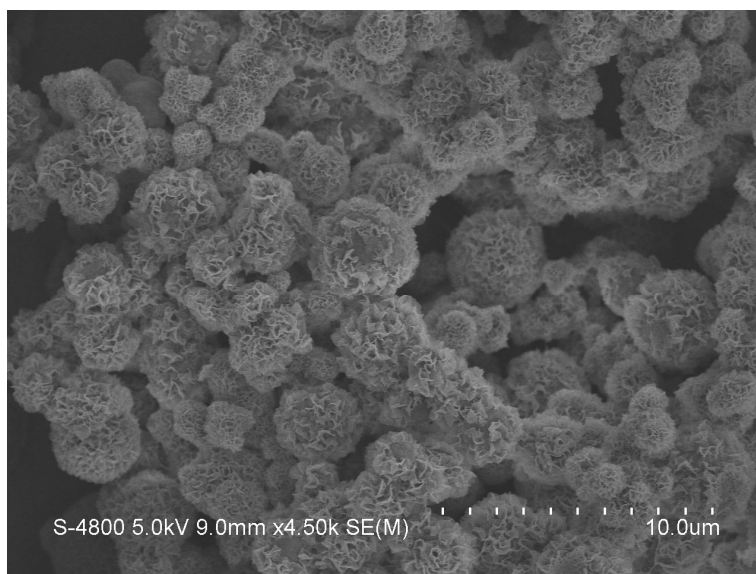


Figure S9: SEM image of $\text{Fe}_3\text{O}_4\text{-Co}_3\text{O}_4$ core-shell nanostructure obtained at 4.5 h.