Supplementary Information

Preparation of Different Phase Structure Nano Sized FePO4/C Cathode Material by Ultrasonic-assisting and Their Electrochemical Performance

Chunmei Tang[1], Wei Ma[1], Jichuan Huo[1,*] and Shuxin Liu[2,*]

[1] College of Materials and Chemistry, Southwest University of Science and Technology, Mianyang, Sichuan, 621010, China.

[2] School of Chemistry and Chemical Engineering, Mianyang Techers' college, Mianyang, Sichuan, 621000, China.

*Corresponding author:Jichuan Huo, Shuxin Liu

E-mail address: huojichuan@163.com (Jichuan Huo), liushuxin88@126.com

1. Carbon black in different samples

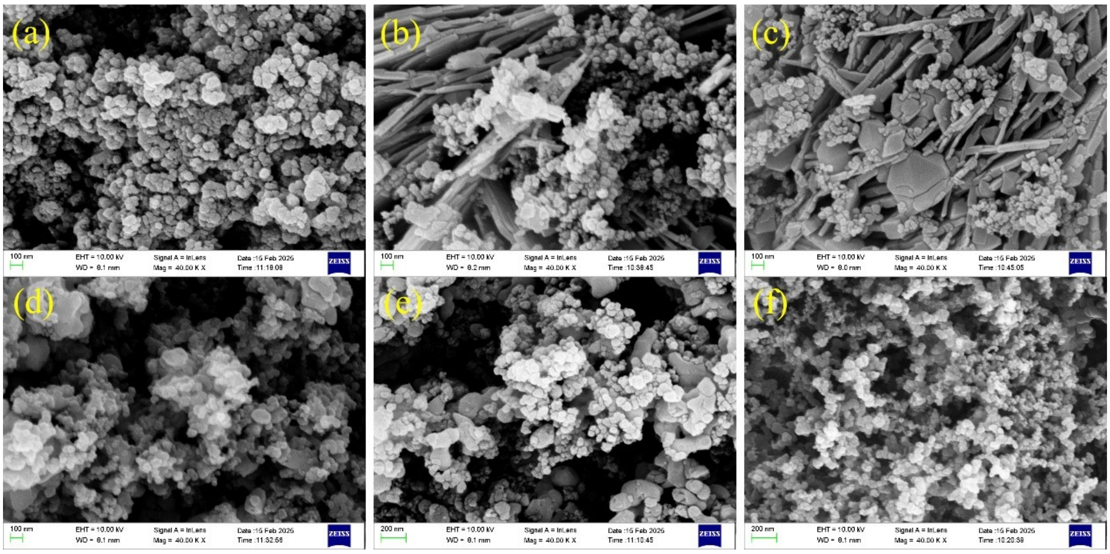

Fig. S1 SEM of a-FPH /C(a), m-FPH /C(b), om-FPH /C(c), a-FP/C(d), h-FP/C(e), and carbon black(f).

In order to further show the shape of carbon black in the cathode material prepared under different conditions, the SEM of the samples was characterized. In figure S1(b) and S1(c), because $FePO_4$ particles are flaking, different from the shape of carbon black particles (S1(f)), it can be clearly seen that carbon black particles are spheroidal with a particle size of about 100nm. In other samples, because $FePO_4$ particles are also spheroidal, they are difficult to distinguish from carbon black. However, it can still be found that some particles of about 100nm are distributed among the particles, and we believe that some of these particles should be carbon black particles.

2. The effect of the synthesis temperature on the capacitance properties of the materials

The aging temperature or calcination temperature has an important effect on the phase composition and microstructure of the cathode materials, that is, the phase composition and microstructure of cathode materials are different at different treatment temperatures. In older to explain the effect of the synthesis temperature on the capacitance properties of the material, the charge and discharge specific capacity of the materials at different synthesis temperature were tested.

First of all, it can be found by combining Fig. 4a in the article, the sample aged at 50 ^{o}C for 2 h is amorphous structures, when the aging temperature is 70 ^{o}C, a few monoclinic structure appear. When the aging temperature is 90 ^{o}C, the sample is mainly composed of monoclinic structure and amorphous structures. When the temperature rises further, the orthogonal structure appears, and increase as the temperature rises. Combined with the main conclusions of this work, the amorphous structure has the best electrochemical activity, followed by the orthogonal structure, and the monoclinic structure has poor electrochemical chemistry. This is why the material aged at 50 ^{o}C and 70 ^{o}C for 2 h has the best electrochemical performance, and the material aged at 90 ^{o}C for 2 h has the lowest electrochemical performance. Moreover, the discharge specific capacity of material aged at 110 ^{o}C for 2 h is higher than aged at 130 ^{o}C for 2 h, this may be due to the fact that at higher temperatures, although more orthogonal structures are generated, at the same time, the degree of disorder of amorphous structures becomes lower, resulting in lower electrochemical performance.

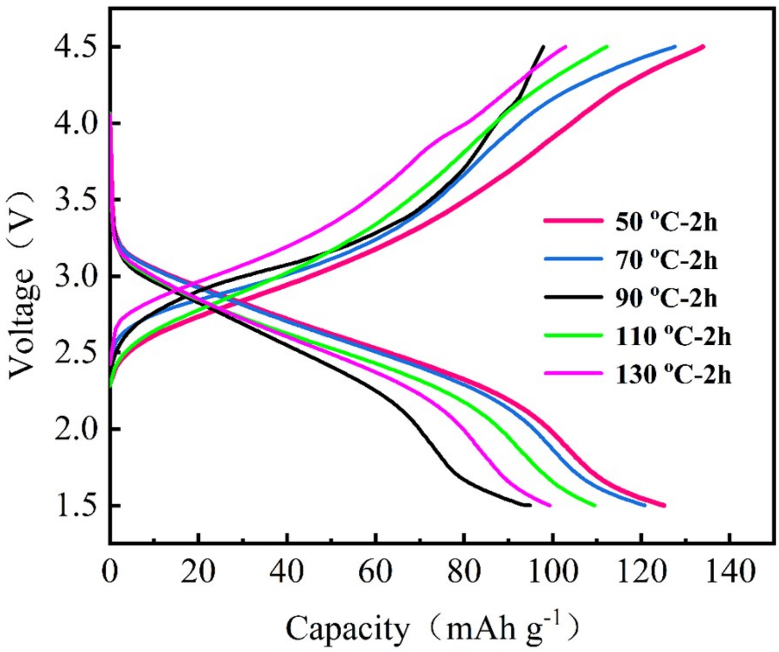

Fig. S2 The charge and discharge specific capacity of the materials at different synthesis temperature

3. Compared with previous studies

Table S1 Comparison of the results in this work with those previously reported for the $FePO_4/C$ cathode materials.

Samples	Technique	Discharge specific capacity	cycling stability	Reference
Amorphous Core-shell structure of multiwalled carbon-$FePO_4$	Multiwalled carbon nanotubes as the core material together with the growth control of $FePO_4$ produced the core-shell structure of MWCNTs@$FePO_4$ with a delicately controlled shell thicknesses	120 mAh g^{-1} at 50 mA g^{-1}(about 0.28 C)	Capacity retention rate is 96% at 50 mA g^{-1}(about 0.28 C) after 50 cycles	[1]
Orthorhombic heterosite $FePO_4$@C	Carbon-coated $FePO_4$@C (FP@C) composite obtained by chemical delithiation of a commercial carbon-coated LFP@C pre-cursor	100 mAh g^{-1} at 0.1C	/	[2]
Amorphous $FePO_4$	Hydrothermal method	171.2 mAh g^{-1} at 20 mA g^{-1}(about 0.1C) after 5 cycles	/	[3]
Orthogonal $Fe_{2.7}Mn_{0.2}Ni_{0.1}PO_4$@C	Water-based ion exchange method is proposed for the synthesis of Ni-doped, Mn-doped, and Ni, Mn co-doped $FePO_4$@C	154.4 mAh g^{-1} at 0.1C	Capacity retention rate is 70.7 % at 1C after 300 cycles	[4]
Amorphous $FePO_4/C$	Glass-transformation-free amorphous phase $FePO_4/C$ was prepared by chemically induced precipitation	140 mAh g^{-1} at 0.1C	Capacity retention rate is 83% at 1C after 200 cycles	[5]
Amorphous $FePO_4/C$	Ultrasonic-assisted precipitation and calcined at 400 ^{o}C for 2h	149.8 mAh g^{-1} at 0.1C	Capacity retention rate is 94.06% at 0.1C after 50 cycles	This work

Reference

1 S.-Y. Duan, J.-Y. Piao, T.-Q. Zhang, Y.-G. Sun, X.-C. Liu, A.-M. Cao and L.-J. Wan, *NPG Asia Mater*, 2017, **9**, e414–e414.

2 B. Pandit, B. Fraisse, L. Stievano, L. Monconduit and M. T. Sougrati, *Electrochimica Acta*, 2022, **409**, 139997.

3 W. Wang, S. Wang, H. Jiao, P. Zhan and S. Jiao, *Phys. Chem. Chem. Phys.*, 2015, **17**, 4551–4557.

4 Y. Wang, M. Deng, X. Zhang, J. Zhang, Y. Sui, K. Sun, K. Rao and L. Wu, *Journal of Colloid and Interface Science*, 2024, **661**, 23–32.

5 Z. Wang, J. Liu, X. Zhang, Y. Wang, D. Wang, W. Shi, H. Li, P. Zhang, J. Man and L. Liu, *Journal of Non-Crystalline Solids*, 2024, **634**, 122983.