Supporting Information

Ligand-Assisted Solid-State Transformation of Nanoparticles

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Synthesis of β-FeOOH ellipsoids.[1] The synthesis of β-FeOOH ellipsoids is based on a previously reported method with minor revisions. 0.2 M $FeCl_3 \cdot 6H_2O$ and 10 g CTAC were dissolved in 100 ml water. Then, the solution was transferred into a 250 mL narrow-necked bottle and was heated at 87 °C for 24 hours. The final product was washed with water 3 times and collected by centrifugation. At last, the precipitate was dispersed in 25 mL of water.

Synthesis of β-FeOOH nanorods.[2] 0.1M $FeCl_3 \cdot 6H_2O$ was dissolved in 400 mL distilled water. Then the solution was heated at 60 °C for 4 days. In the initial stage of the heating process, the temperature rises at a rate of 0.2 °C·min^{-1} until it rises to 60 °C. The product was removed by centrifugation and washed with water twice and then dispersed in 25 mL water for future use.

Synthesis of Prussian blue nanocubes.[3] The synthesis followed a previously reported method. 113.14 mg potassium ferricyanide and 3 g of PVP (Mw.40,000) were added to a 40 mL 0.1 M HCl solution. After stirring at room temperature for 30 min, the system was heated at 80°C for 20 hours. The blue product was then collected by centrifugation and dispersed in 25 mL water for future use.

Synthesis of $Co(OH)_2$ nanoplates.[4] $Co(OH)_2$ nanoplates were synthesized based on a previous report with some modifications. Typically, 0.48 g of $CoCl_2$ was dissolved in 0.2 g of PVP (Mw=55,000) and 72 mL of H_2O, followed by adding 0.56 g of hexamethylenetetramine and 8 mL of ethanol. The mixture was heated at 95 ºC for 2 h. The products were collected by centrifugation, washed with H_2O and redispersed in 40 mL of H_2O.

Synthesis of $Ni(OH)_2$ nanoplates.[5] To synthesize the 50 nm $Ni(OH)_2$ nanoplates, an aqueous solution of 10 mol·mL^{-1} $Ni(NO_3)_2$ and 20 mol·mL^{-1} $NH_3 \cdot H_2O$ was heated in an oven at 90°C for 2 hours. And then the solution was washed with water several times and dispersed in 25 mL water for the next step.

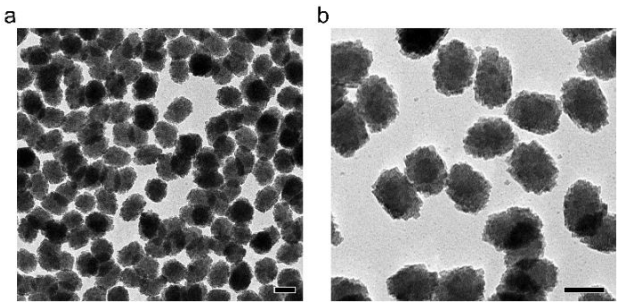

Figure S1. TEM images of the original β-FeOOH ellipsoids. Scale bars: 100 nm.

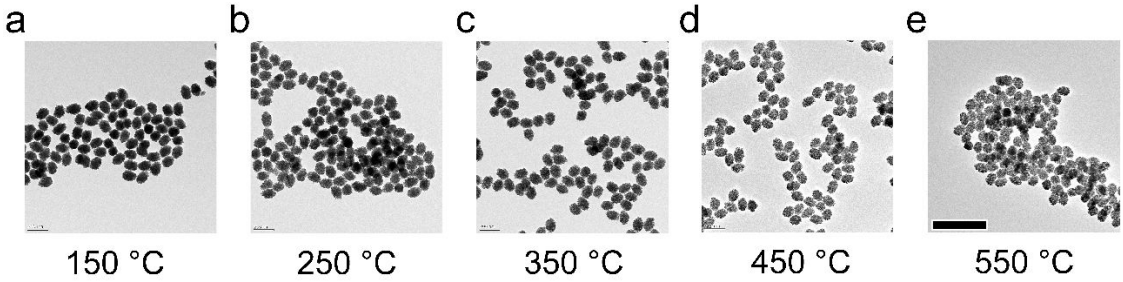

Figure S2. TEM images of the PAA-modified β-FeOOH ellipsoids calcined at various temperatures for 2h. Scale bar: 500 nm.

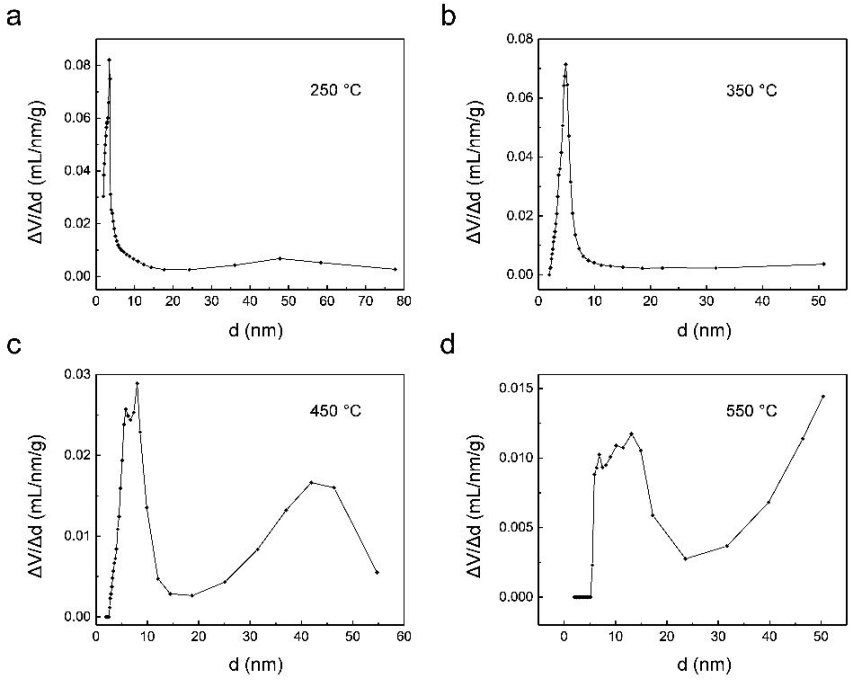

Figure S3. Pore size distribution curves of PAA-modified β-FeOOH ellipsoids calcined at various temperatures for 2h.

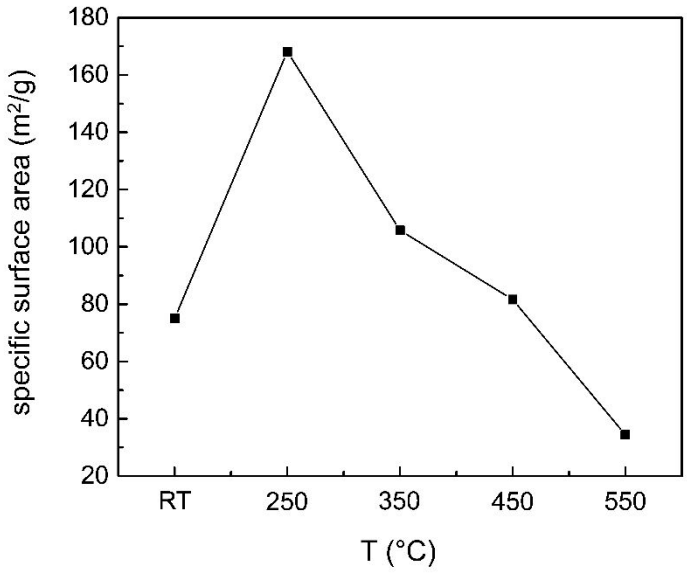

Figure S4. Specific surface area of the original β-FeOOH ellipsoids and the samples calcined in air at various temperatures for 2h.

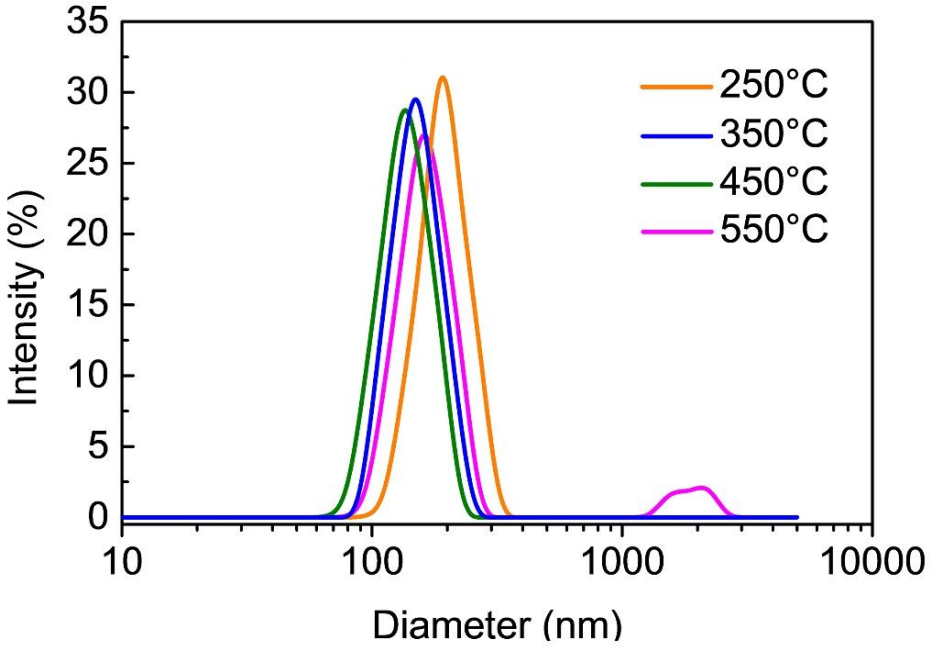

Figure S5. The size distributions of PAA-modified ellipsoids calcined for 2h at 250 °C, 350 °C, 450 °C and 550 °C.

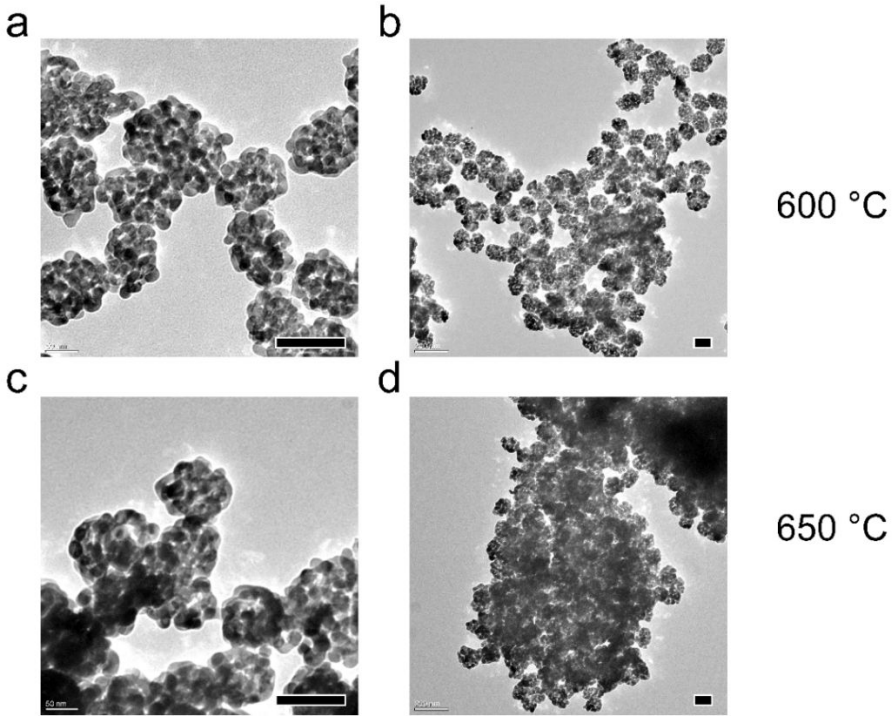

Figure S6. Morphologies of the β-FeOOH ellipsoids calcined at 600 °C (**a** and **b**) and 650 °C (**c** and **d**) for 2h. Scale bars: 100 nm.

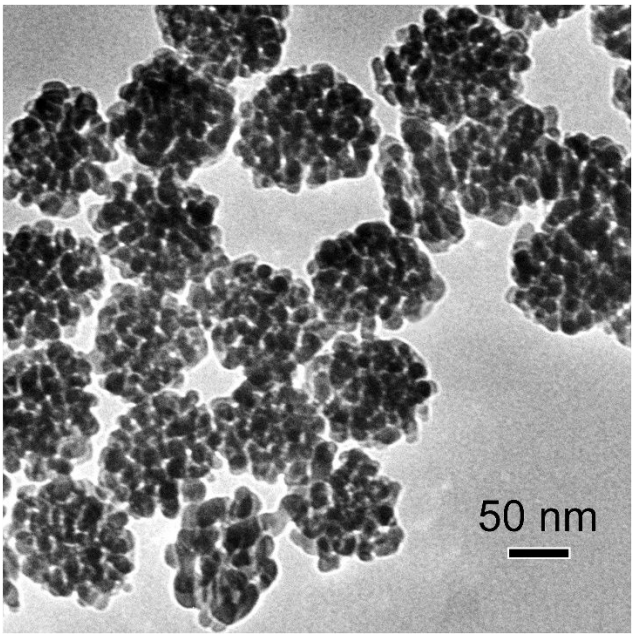

Figure S7. TEM image of the Fe_2O_3 ellipsoids with a secondary PAA modification calcined in air at 550 °C for 2h.

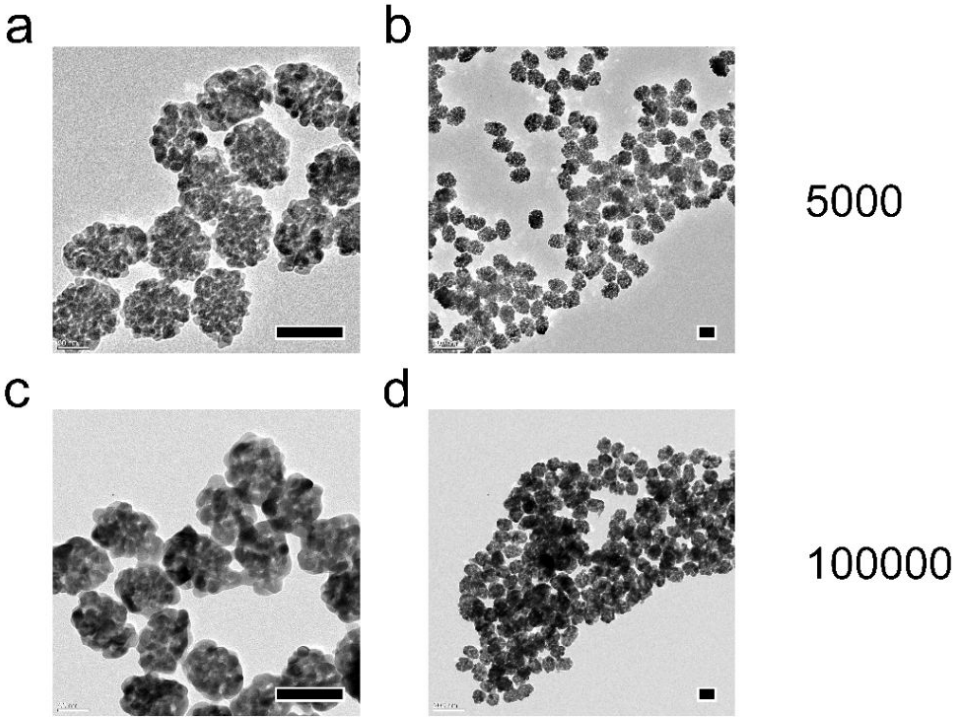

Figure S8. PAA with a molecular weight of 5000 (**a** and **b**) and 100,000 (**c** and **d**) were used to modify the FeOOH ellipsoids. Then these nanoparticles were calcined at 600 °C for 2h. Scale bars: 100 nm.

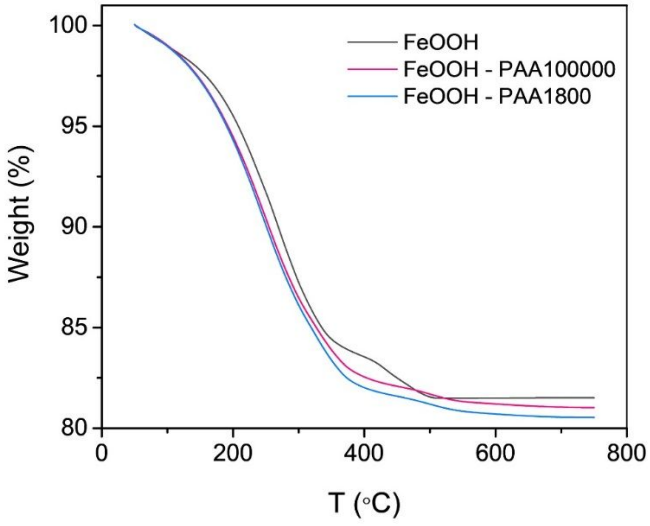

Figure S9. TGA measurements of FeOOH ellipsoids and FeOOH ellipsoids modified by PAA with molecular weight of 1800 and 100000.

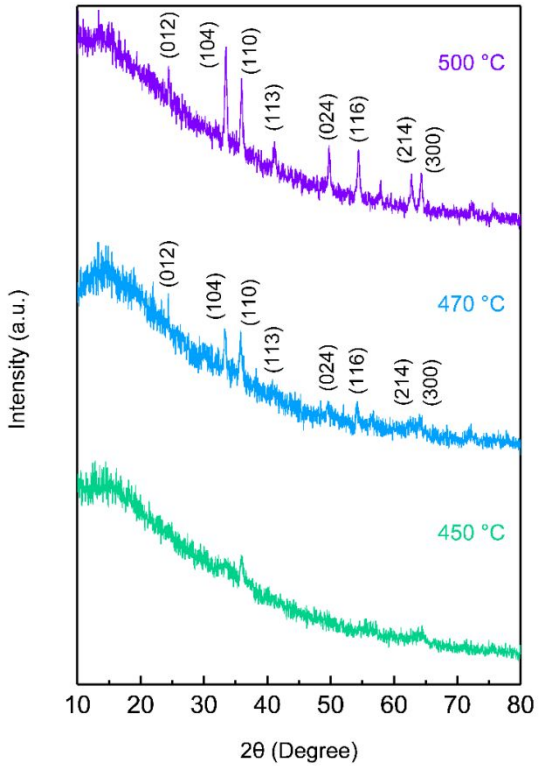

Figure S10. XRD patterns of PAA-modified β-FeOOH ellipsoids calcined at 450 °C, 470 °C, and 500 °C.

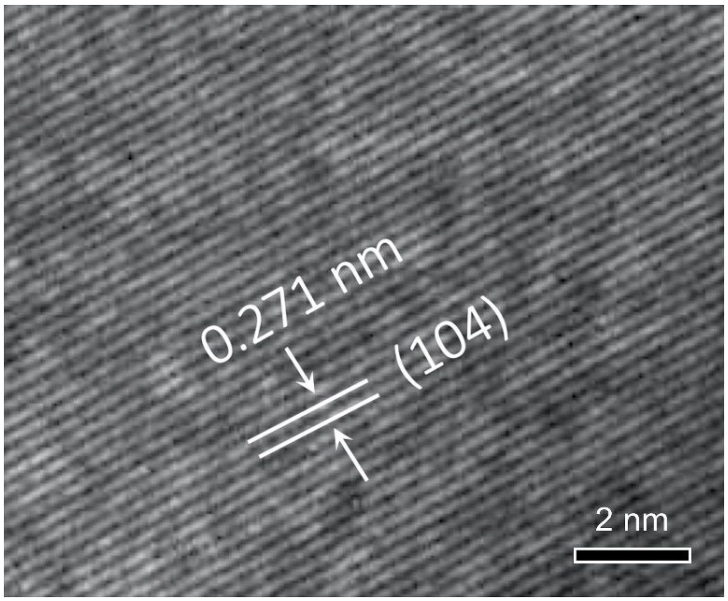

Figure S11. HRTEM image of Fe_2O_3 ellipsoids.

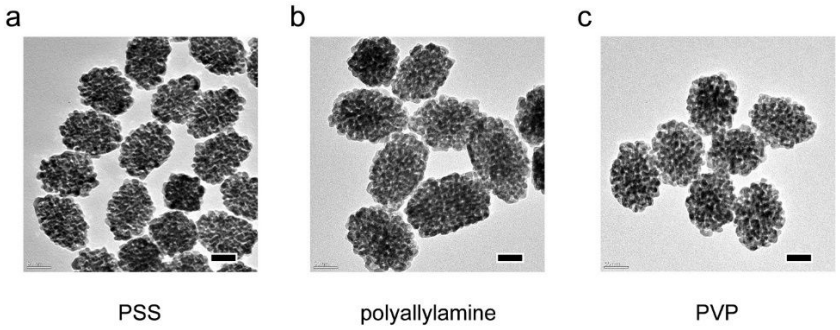

Figure S12. β-FeOOH ellipsoids were modified by PSS (**a**), polyallylamine (**b**) and PVP (**c**) and then calcined at 350 °C for 2h. Scale bars: 50 nm.

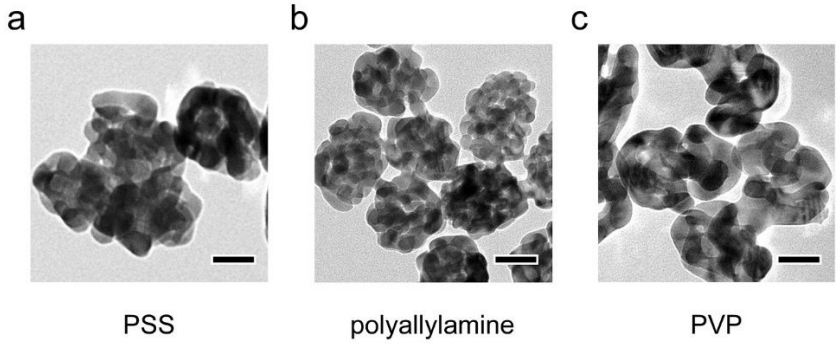

Figure S13. β-FeOOH ellipsoids were modified by PSS (**a**), polyallylamine (**b**) and PVP (**c**) and then calcined at 550 °C for 2h. Scale bars: 50 nm.

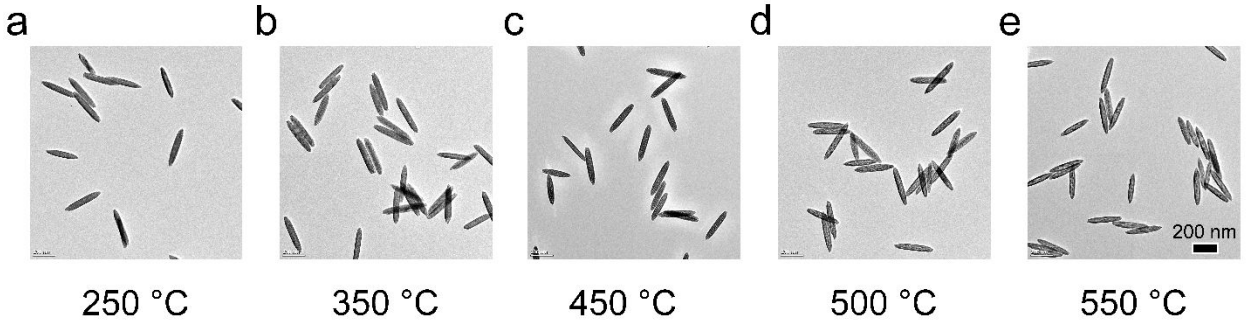

Figure S14. The morphology evolution of the β-FeOOH rods after calcination for two hours at a gradient temperature from 250 °C to 550 °C with an interval of 100 °C.

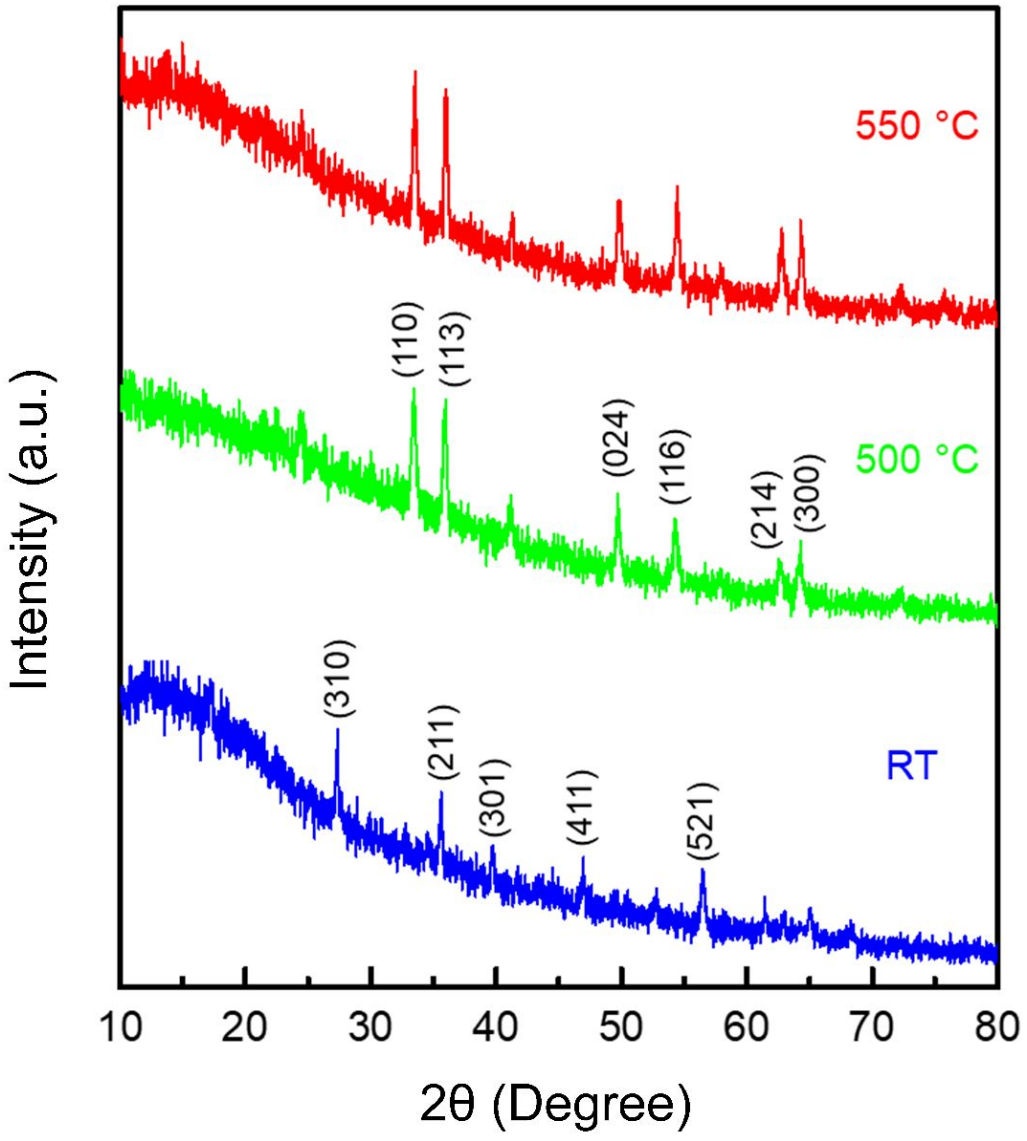

Figure S15. XRD patterns of PAA-modified β-FeOOH rods and the samples calcined at 500 °C and 550 °C.

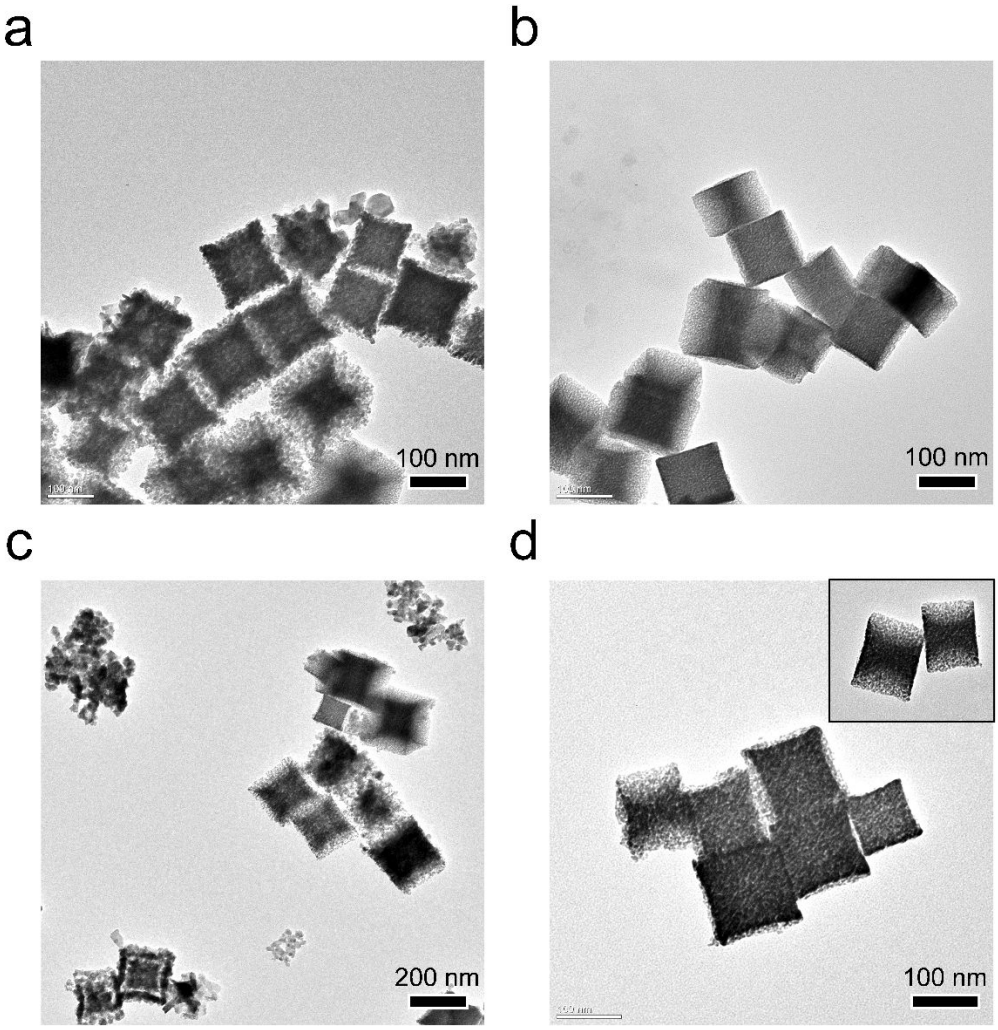

Figure S16. a and **c** are TEM images of original PB nanocubes calcined at 250 °C and 350 °C, respectively. PB nanocubes capped with PAA were also heated at 250 °C (**b**) and 350 °C (**d**).

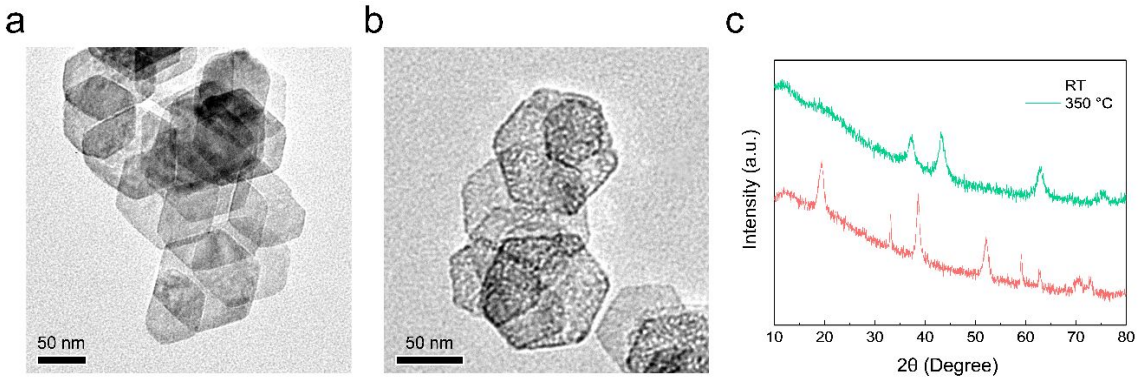

Figure S17. Morphology of PAA-modified $Ni(OH)_2$ nanoplates before (**a**) and after (**b**) calcination at 350 °C for 2h. **c**, XRD patterns of PAA-modified $Ni(OH)_2$ nanoplates annealed at 350 °C.

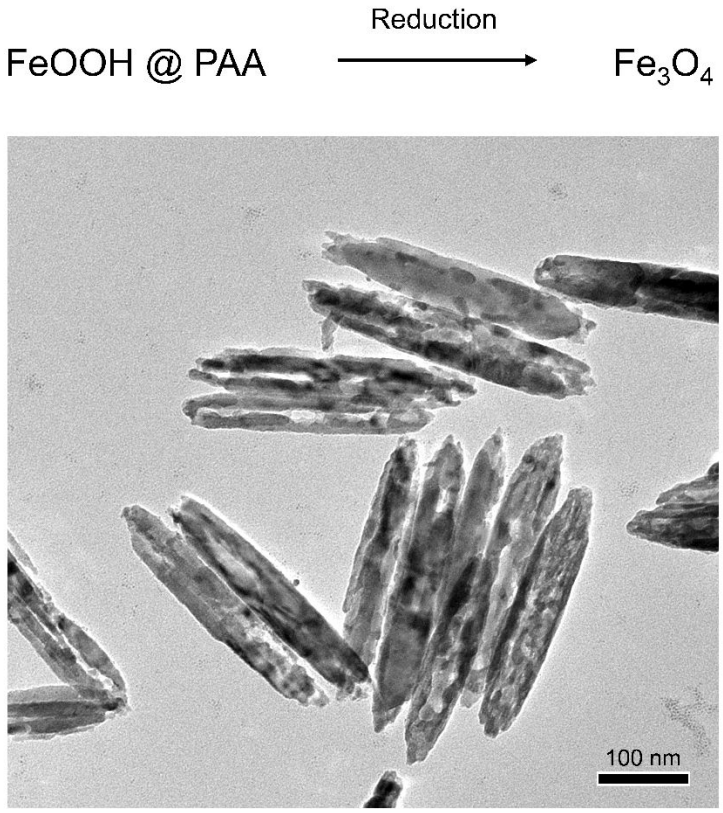

Figure S18. Direct reduction of PAA-modified FeOOH rods in forming gas at 330 °C for 2h.

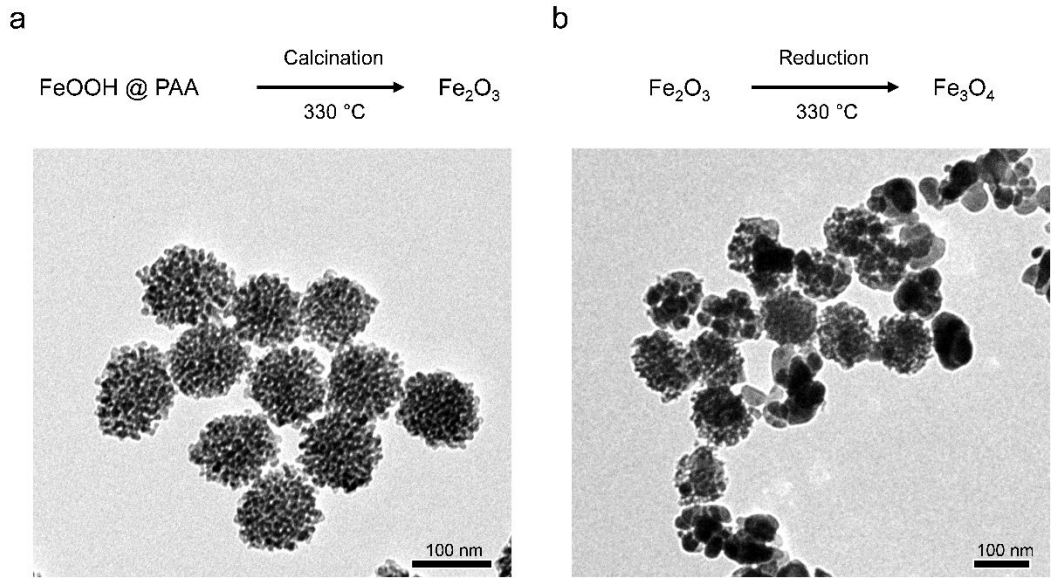

Figure S19. PAA-modified FeOOH ellipsoids were heated in air at 330 °C for 2h. Then the obtained nanoparticles (**a**) were reduced in forming gas directly without a secondary PAA modification (**b**).

References:

1. Wang, M.; He, L.; Xu, W.; Wang, X.; Yin, Y. *Angew Chem Int Ed Engl* **2015,** 54, (24), 7077-81.
2. Maeda, Y.; Hachisu, S. *Colloids and Surfaces* **1983,** 6, (1), 1-16.
3. Hu, M.; Furukawa, S.; Ohtani, R.; Sukegawa, H.; Nemoto, Y.; Reboul, J.; Kitagawa, S.; Yamauchi, Y. *Angew Chem Int Ed Engl* **2012,** 51, (4), 984-8.
4. Liu, Z.; Ma, R.; Osada, M.; Takada, K.; Sasaki, T. *J Am Chem Soc* **2005,** 127, (40), 13869-74.
5. Durand-Keklikian, L.; Haq, I.; Matijević, E. *Colloids and Surfaces A: Physicochemical and Engineering Aspects* **1994,** 92, (3), 267-275.