

Supporting Information

A novel method for synthesizing one or two-dimensional metal oxide (hydroxide) nanomaterials using deep eutectic solvents

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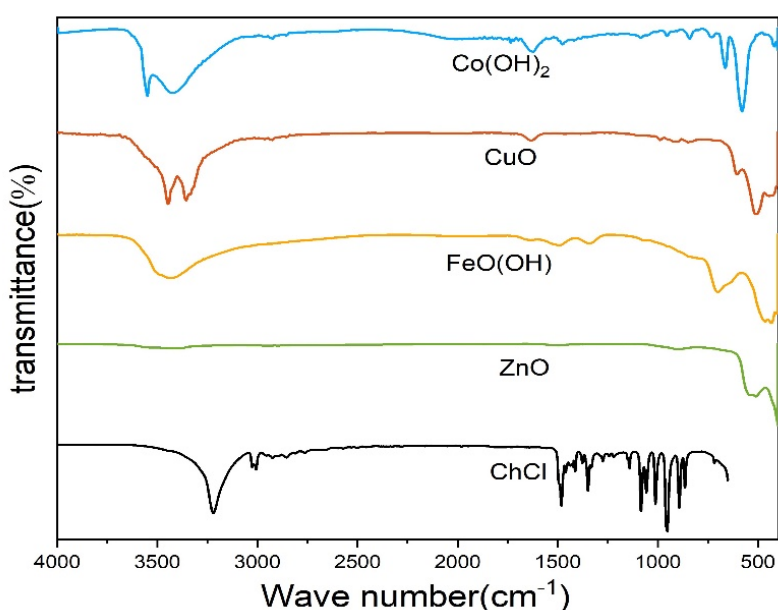


Fig. 1S FT-IR spectra of FeO(OH), Co(OH)₂, ZnO, CuO and ChCl.

The FTIR technique is usually used to recognize the specific functionalities existing in the sample by measuring their vibration energies in the form of transmission bands. We use infrared spectrum to determine whether there is CHCl molecules on the surface of the samples. Figure 1S show FTIR spectra of FeO(OH), Co(OH)₂, ZnO, CuO, and ChCl. For Co(OH)₂, the absorption peaks at 3459.14 and 1622.84 cm⁻¹ correspond to the stretching vibration and bending vibration of O-H in Co(OH)₂, respectively; The absorption peak at wave number less than 1000 cm⁻¹ corresponds to the stretching vibration of Co-O and bending vibration of Co-OH in Co(OH)₂. For CuO, the absorption peaks of 3446.07, 1633.85 and less than 850 cm⁻¹ correspond to the stretching vibration and bending vibration of Cu-O in CuO. In the absorption curves of FeOOH, the absorption peak at 3431.75 cm⁻¹ corresponds to the stretching vibration of O-H, while the absorption peak at 1491.84 and 1342.41 cm⁻¹ corresponds to the bending vibration of Fe-OH, the absorption peak at 432.79 cm⁻¹ corresponds to Fe-O, and 701.32 cm⁻¹ is the characteristic absorption peak of FeO(OH). In the absorption curves of ZnO, the absorption peak at 509.72 cm⁻¹ corresponds to the characteristic absorption peak of ZnO. Vibration peaks at 3220 cm⁻¹, 1480 cm⁻¹, 1340 cm⁻¹, 1082 cm⁻¹, 953 cm⁻¹

and 887 cm^{-1} are observed for ChCl. No peak belonging to the ChCl functional group is detected in the spectra of the nanoparticles, indicating that a high purity product was obtained.

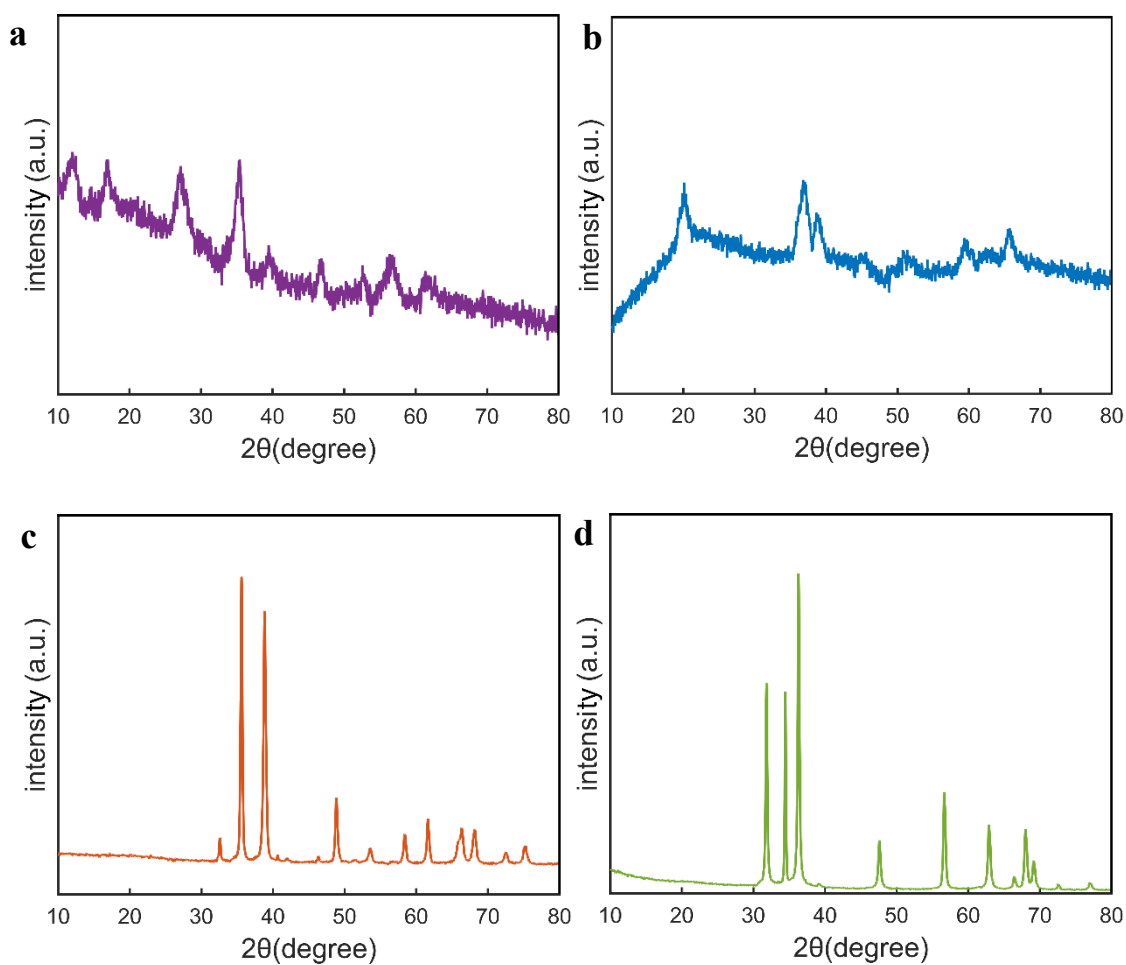


Fig. 2S XRD patterns: (a) FeO(OH), (b) CoO(OH), (c) ZnO, (d) CuO.

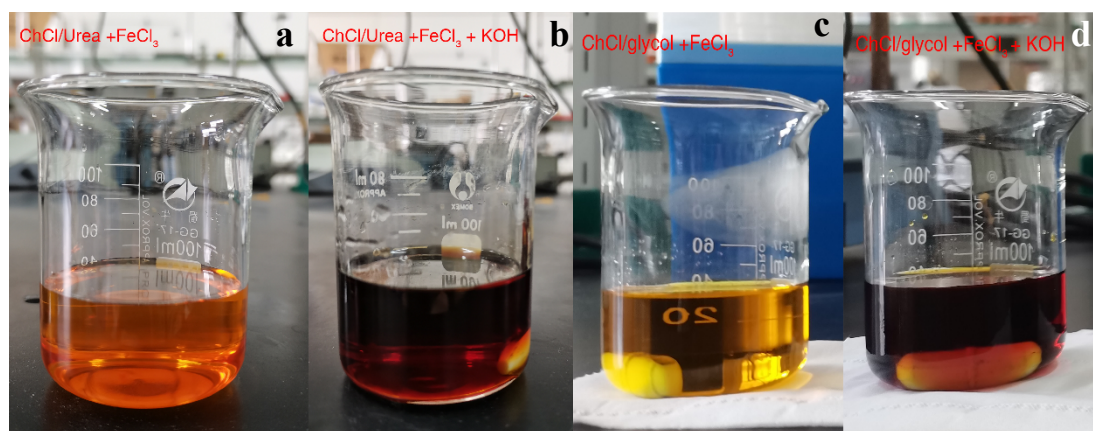


Fig. 3S The digital photos: (a) FeCl₃ solution in ChCl/urea DES, (b) KOH was added into FeCl₃ solution of ChCl/urea DES, (c) FeCl₃ solution in ChCl/ glycerol DES, (d) KOH was added into FeCl₃ solution of ChCl/ glycerol DES.

$\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ was added into ChCl/urea DES. The digital photos of Fig. 3S-a showed that FeCl_3 could dissolve into the ChCl/urea DES and form the transparent solution. Because KOH solid does not dissolve into ChCl/urea DES, KOH was directly added into the FeCl_3 solution in ChCl/urea DES under magnetic stirring. Surprisingly, Fig. 3S-b evidenced that there was no precipitation except the darker color of the solution. We also did the same experiments except using ChCl/glycerol instead of ChCl/urea DES as solvent (KOH solid also does not dissolve into ChCl/glycerol DES). Fig. 3S-c showed that $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ could dissolve into the ChCl/glycerol DES and form the transparent solution. Fig. 3S-d showed that there were also no precipitation. The above experiment results evidenced that KOH did not react with FeCl_3 solution in a DES based on ChCl/urea or ChCl/glycerol.

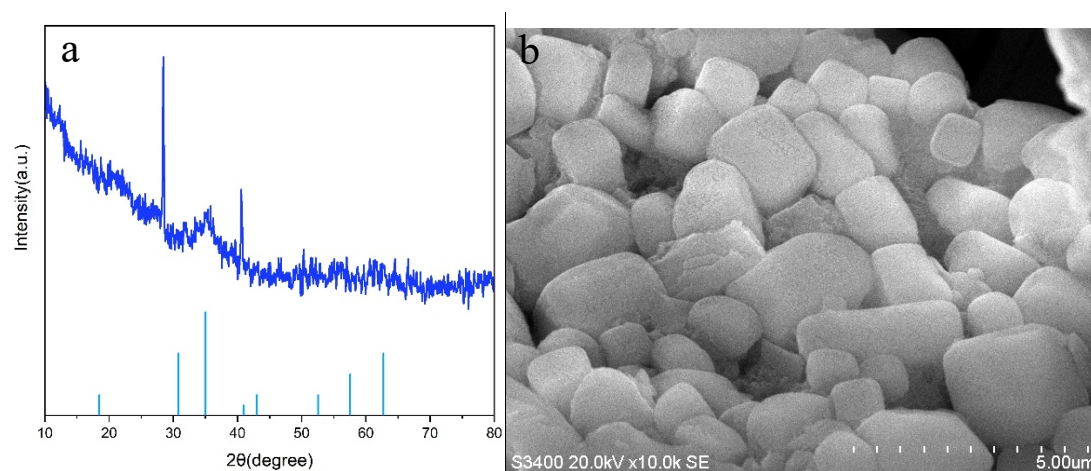


Fig. 4S (a) XRD pattern of the sample, (b) SEM image of the sample.

A basic solution of KOH was added to an aqueous solution of $\text{FeCl}_3 \cdot \text{H}_2\text{O}$ in the presence of ChCl. The procedure is as follows: 0.183 mol $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ and 0.366 mol ChCl are added into 182 mL water under stirring. The transparent yellow solution formed. Then, 60 mL $0.1 \text{ mol} \cdot \text{L}^{-1}$ KOH solution was slowly dropped into the mixed solution of FeCl_3 and ChCl at 90°C under stirring. After the reaction, the temperature was maintained for 30 min to allow the product to age. Precipitates were washed several times with deionized water and dried. The sample were characterized by XRD and SEM. XRD pattern in Fig. 4S-a showed that all peaks were well indexed to cubic $\text{Fe}(\text{OH})_3$ (JCPDS 22-0346). SEM image in Fig. 4S-b indicated that the morphology of the sample was cube with 2-3 μm . It was significantly different from the tetragonal $\text{FeO}(\text{OH})$ with rod-bundle prepared by our method.