Supplementary material

The calculation of the total energy consumption for evaporating the mixture of methanol and water:

The physical property data of methanol and water are as follows:

Methanol: Boiling point = 64.8°C, density = 0.791 g/cm^3, relative molecular weight = 32.042 g/mol, the specific heat capacity at constant pressure = 2.51 kJ/(kg·k)(25°C, 101.325 kPa), and the molar enthalpy of evaporation at the boiling point is 35.32 kJ/mol.

Water: boiling point = 100°C, density = 1 g/cm^3, relative molecular weight = 18 g/mol, the specific heat capacity at constant pressure = 4.2 kJ/(kg ·°C)(25°C, 101.325 kPa), and the molar enthalpy of evaporation at the boiling point is 42.73 kJ/mol.

(1) The heat required for heating methanol and water from room temperature to boiling point temperature:

V_{methanol} in this case is 100 ml, therefore,

$$m_{\text{methanol}} = \rho V = 0.791 \times 100 = 79.1\ \text{g}$$

$$n_{\text{methanol}} = m_{\text{methanol}}/M = 79.1/32.042 = 2.496\ \text{mol}$$

And by the same token:

$$m_{\text{water}} = \rho V = 1 \times 40 = 40\ \text{g}$$

$$n_{\text{water}} = m_{\text{water}}/M = 40/18 = 2.22\ \text{mol}$$

Supposing the influence of temperature during heating process on specific heat capacity of methanol and water is ignored, the heat absorbed by methanol and water during heating process can be obtained as follows:

$$E_{(\text{methanol})1} = C_p m \Delta T = 2.51 \times 79.1 \times 10^{-3} \times (64.8 - 25) = 7.9\ \text{kJ}$$

$$E_{(\text{water})1} = C_p m \Delta T = 4.2 \times 40 \times 10^{-3} \times (100 - 25) = 12.6\ \text{kJ}$$

(2) Heat absorbed during methanol and water vaporization:

$$E_{(\text{methanol})2} = 2.469 \times 25.32 = 87.21\ \text{kJ}$$

$$E_{(\text{water})2} = 2.222 \times 42.73 = 94.95\ \text{kJ}$$

(3) Total energy required for the process:

$$E_{\text{total}} = E_{(\text{methanol})1} + E_{(\text{methanol})2} + E_{(\text{water})1} + E_{(\text{water})2} = 7.9 + 87.21 + 12.6 + 94.95 = 202.66\ \text{kJ}$$

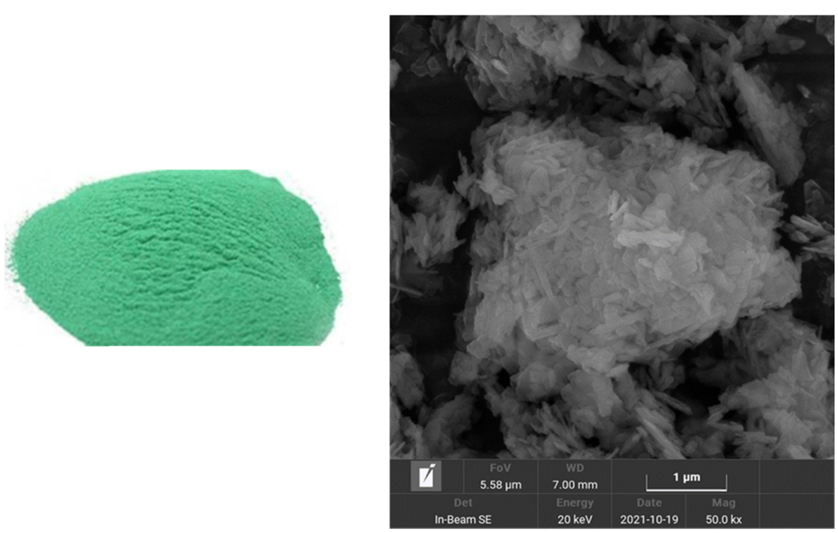

Figure S1: Water-insoluble copper sulfate basic with a hexagonal crystal.

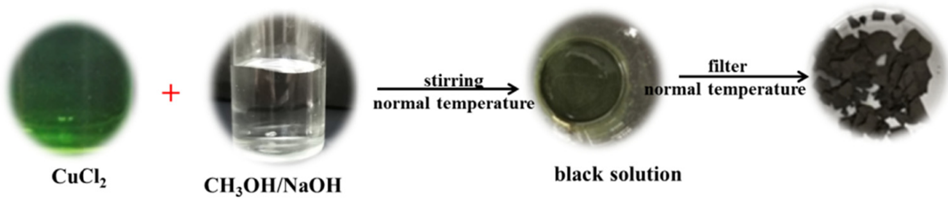

Figure S2: CuO obtained by Dropping $CuCl_2$ into NaOH/CH_3OH.

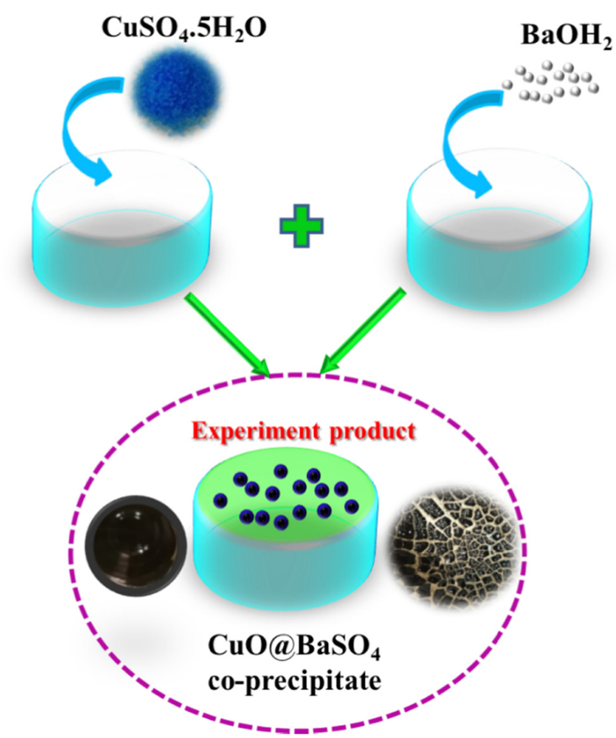

Figure S3: $CuSO_4$ reacts with Ba(OH)$_2$ to obtain CuO @$BaSO_4$ Co-precipitates.

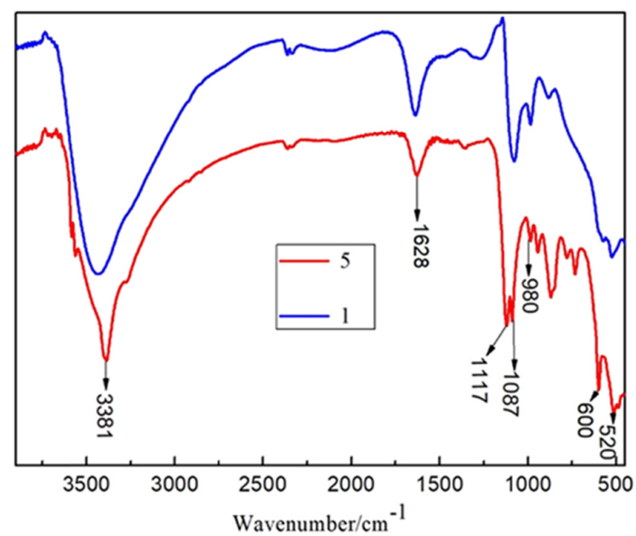

Figure S4: FTIR curves of pure CuO (1) and $Cu(OH)_2$@CuO coprecipitates (5).

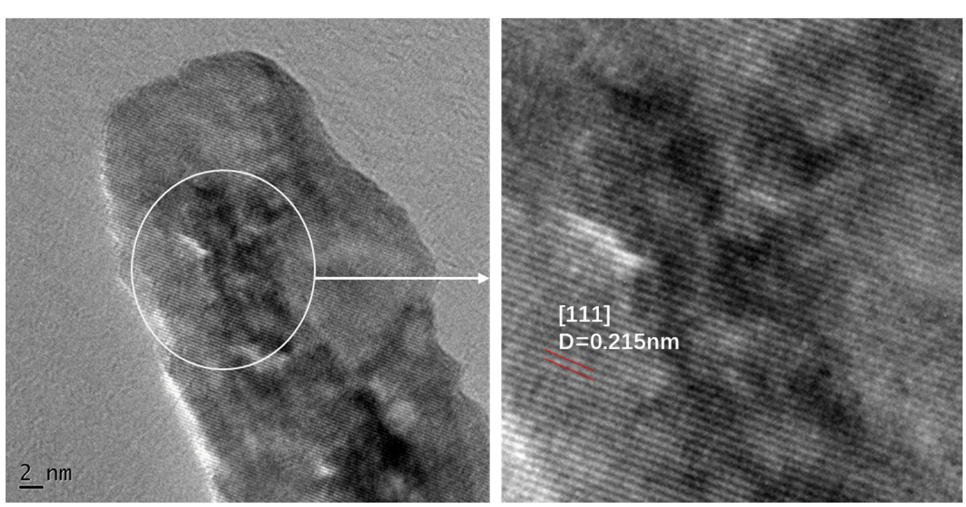

Figure S5: HR-TEM images of nano CuO particles.

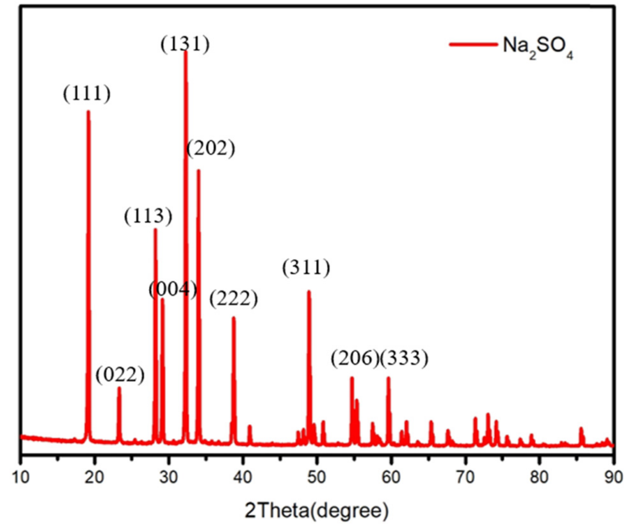

Figure S6: By-product Na_2SO_4.

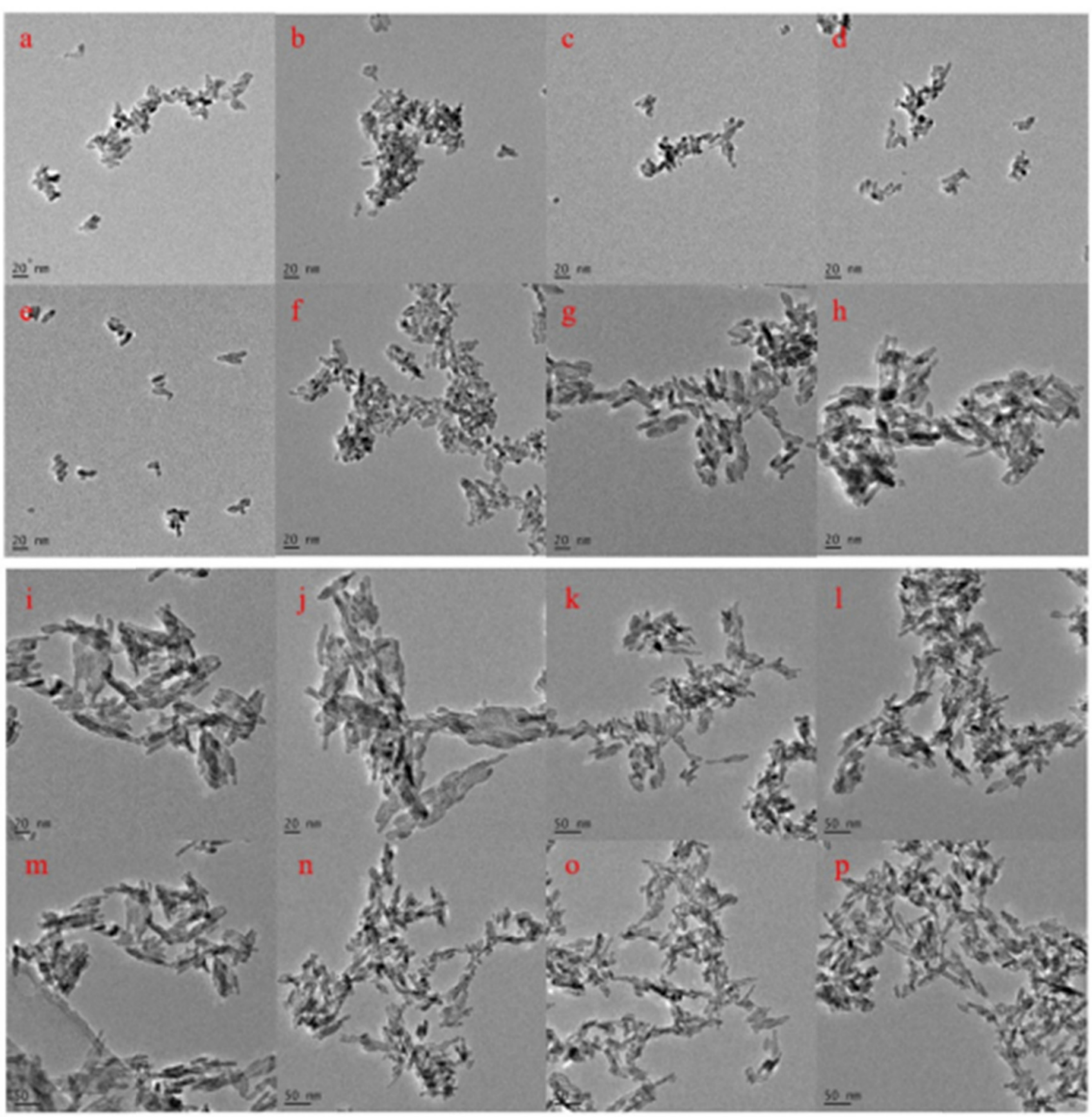

Figure S7: TEM images of the as-prepared nano-CuO (a–p stand for the CH_3OH/water solution circulate 15 rounds).

Table S1: Solution pH in each preparation step

Steps	pH of the supernatant after reaction	pH of the supernatant after adding NaOH
Initial preparation	11.23	13.42
The 1st cycle	11.12	13.49
The 2nd cycle	11.38	13.44
The 3rd cycle	11.21	13.52
The 4th cycle	11.01	13.56
The 5th cycle	11.18	13.51
The 6th cycle	11.24	13.47
The 7th cycle	11.16	13.43
The 8th cycle	11.19	13.50
The 9th cycle	11.22	13.46
The 10th cycle	11.29	13.53
The 11th cycle	11.08	13.45
The 12th cycle	11.23	13.52
The 13th cycle	11.31	13.51
The 14th cycle	11.27	13.48
The 15th cycle	11.18	—