Electronic Supplementary Material (ESI) for RSC Advances.

Supporting Information

1. Schematic of encapsulation assisted chemical vapor synthesis process.

The vertical hot-wall reactor shown in Figure 1 was used for CVS at a fixed heating zone temperature of 1000 °C. Because the vapor pressure of CuCl and the H2 reduction rate are proportional to the temperature, increasing the process temperature has the advantage of increasing the Cu powder production rate. However, due to the limit of the operating temperature of the reactor material, quartz, all process temperatures in this study were performed at 1000 °C with a precision of ±2 °C.

H2 reducing gas was injected directly into the particle formation section at a flow rate of 0.1 SLM. The temperature decreased through the cooling section due to air cooling of the reactor outer wall. Metal chlorides evaporate in the top section while H2 reduction of CuCl vapor occurs in the particle formation section, leading to nucleation, growth, and coagulation of Cu NPs. Complete coalescence of coagulated NPs mainly occurs in the particle formation section, and partial coalescence primarily occurs in the cooling section. The in-flight coating was performed in this cooling section to inhibit partial coalescence in the coating temperature range of 850−950 °C.

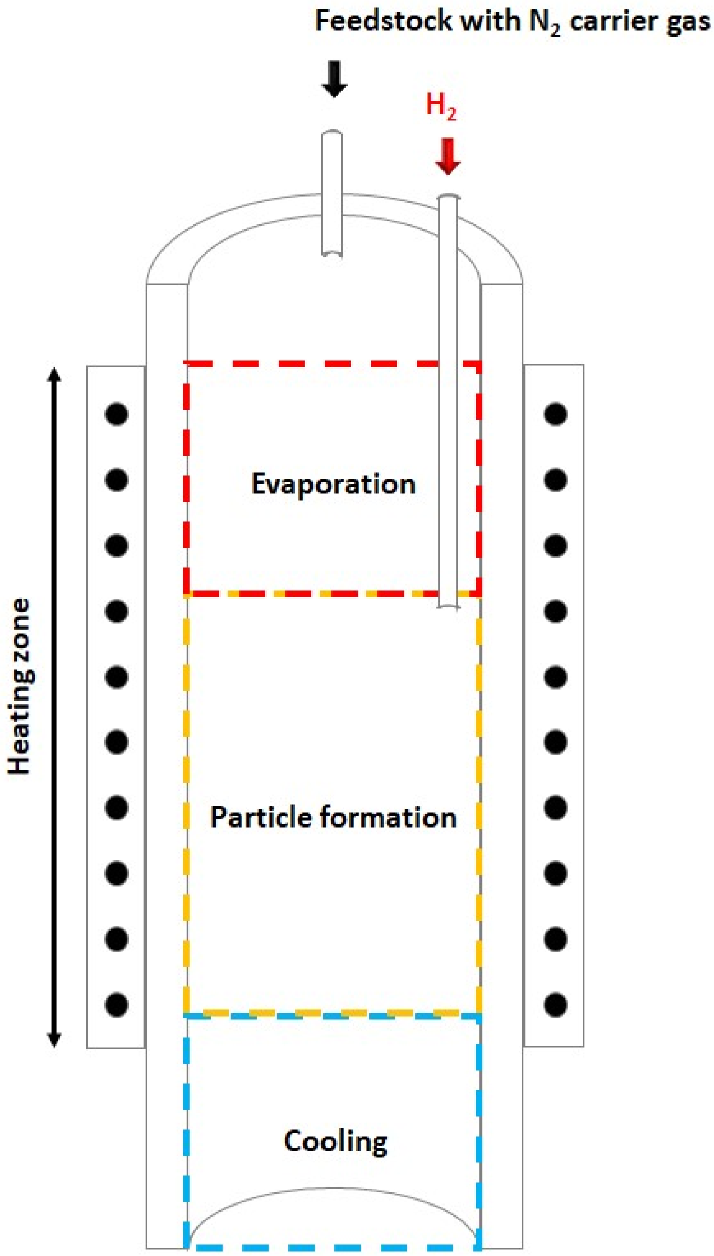

Figure S1 Schematic of encapsulation assisted chemical vapor synthesis process.

2. **count median diameter, geometric standard deviation and aggregation ratio.**

We measured the count median diameter and geometric standard deviation of copper nanoparticles were analyzed according to KS D 2716:2008. After measuring the particle size of more than 500 copper nanoparticles with a scanning electron microscope (FE-SEM (qunta-FEG250, FEI)), the median diameter value was obtained using Equation (1) below.

$$CMD = exp[\frac{\sum_{i=1}^{N} lna_i}{N}] \quad (1)$$

a_i is the diameter of individual particles, and N is the total number of measured particles. The geometric standard deviation was calculated using the following equations (2) and (3).

$$u_n = (a_1 \cdot a_2 ... a_n)^{\frac{1}{N}}] \quad (2)$$

$$GSD = exp(\sqrt{\frac{\sum_{i=1}^{N} (lna_i - lnu_\eta)^2}{N}})] \quad (3)$$

u_η is the geometric mean diameter.

We calculated the aggregation ratio by selecting 500 random particles using the images observed with a scanning electron microscope and counting the number of connected particles among the particles. Since each connected particle is a secondary particle, the number of primary particles constituting the connected particle was calculated as the actual number. For example, one connected particle composed of three primary particles was counted as three particles, and one connected particle composed of four primary particles was counted as four, and the aggregation ratio was calculated.

3. The role of ammonium hydroxide and the mechanism.

In the case of Cu-NPs synthesized with KCl as a coating agent, it is necessary to remove oxidized copper from some surfaces as well as unreacted residual CuCl and KCl used as a coating agent. Therefore, we used NH_4OH to simultaneously remove CuCl, KCl and CuO. Equation (4) shows that NH_4OH removes the copper oxides, CuCl and KCl, but does not directly etch copper.

$$CuO + 4NH_4OH \rightarrow Cu(NH_3)_4(OH)_2 + 3H_2O$$

$$CuCl + 2NH_4OH=(Cu(NH_3)_2)Cl + 2H_2O$$

$$NH_4OH + KCl \rightarrow NH_4Cl + KOH$$

$$2Cu^{2+} + 2e^{-} + H_2O_2 \rightarrow Cu_2O+ \qquad (4)$$