

## *Supplementary File*

# **Liquid-Cell TEM Study of Nanobubble Growth Kinetics and Dynamics in Ethanol**

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## 1. Materials and methods

### 1.1. Materials

poly-(methyl vinyl ether-co-maleic anhydride) (PVM/MA),  $\text{Co}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ , acetone, and ethanol were purchased from Sinopharm Chemical Reagent Co., Ltd (Shanghai, China).  $\text{CO}_2$  with a 99.9% purity was purchased from Rihong Air Products Co. Ltd. (Xiamen, China). Unless otherwise specified, no processing was done on any of the chemicals before they were used.

### 1.2. Solution-enhanced dispersion (SEDS) process

*PVM/MA-coated  $\text{Co}(\text{NO}_3)_2$  nanoparticles:* a typical SEDS (experimental apparatus from Waters, S.N. 3937782, Milford, USA) approach was used to synthesize the precursor PVM/MA-coated  $\text{Co}(\text{NO}_3)_2$  constructs as nanoreactors. The pressure and temperature of the high-pressure vessel were kept at 120 bar, and 35 °C, and the supercritical fluid - $\text{CO}_2$  and precursor flow rates in absolute ethanol solution were kept at 35  $\text{g} \cdot \text{min}^{-1}$  and 0.5  $\text{mL} \cdot \text{min}^{-1}$ , respectively. The acetone solution mixed in with the precursor during SEDS processing tends to be broken up by the high-velocity supercritical fluid - $\text{CO}_2$  flow and atomized into particles of small size at high pressure.

## 2. In situ TEM experiments

The transmission electron microscopy (TEM, ThermoFisher Talos F200X, Massachusetts, USA) were employed to examine the morphology in liquid cell. The liquid cell assembly process is as follows: The as-synthesized PVM/MA-coated  $\text{Co}(\text{NO}_3)_2$  nanomaterial was placed in ethanol under ultrasonic dispersion for 30 minutes (1  $\text{mg mL}^{-1}$ ). Then about 50 nL of supernatant was selected and injected into a  $\text{SiN}_x$  liquid cell. The assembled liquid cell is then loaded into a TEM single holder. Real-time TEM data were recorded using a Ceta CCD camera. During the experiment, the focus is carefully adjusted before TEM image and video capture.

## 3. Movie Statement

Movie S1: Nanobubble growth trajectories with significant size differences. The movie is played at 0.5 times real time, with an electron beam dose rate of approximately 4080  $\text{e}/\text{\AA}^2\text{s}$ .

Movie S2: Growth trajectories of similar-sized or undisturbed nanobubbles. The movie

is played at 0.5 times real time, with an electron beam dose rate of approximately 4080 e/Å<sup>2</sup>s.

Movie S3: Merger and dissolution evolution of nanobubbles. The movie is played in real time, with an electron beam dose rate of approximately 4080 e/Å<sup>2</sup>s.