Highly Active TiO_2 Photocatalysts for Hydrogen Production through a Combination of Commercial TiO_2 Material Selection and Platinum Co-Catalyst Deposition Using a Colloidal Approach with Green Reductants

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1. Photocatalytic Experiments – Setups

Figure S1. Setup for the screening of TiO_2 photocatalysts (1: photoreactor, 2: stirrer, 3: 300 W Xe lamp (no filter), and 4: thermostat).

Further investigations were done in a photoreactor with defined geometry with a 300 W Xe lamp (full spectrum) via side irradiation.

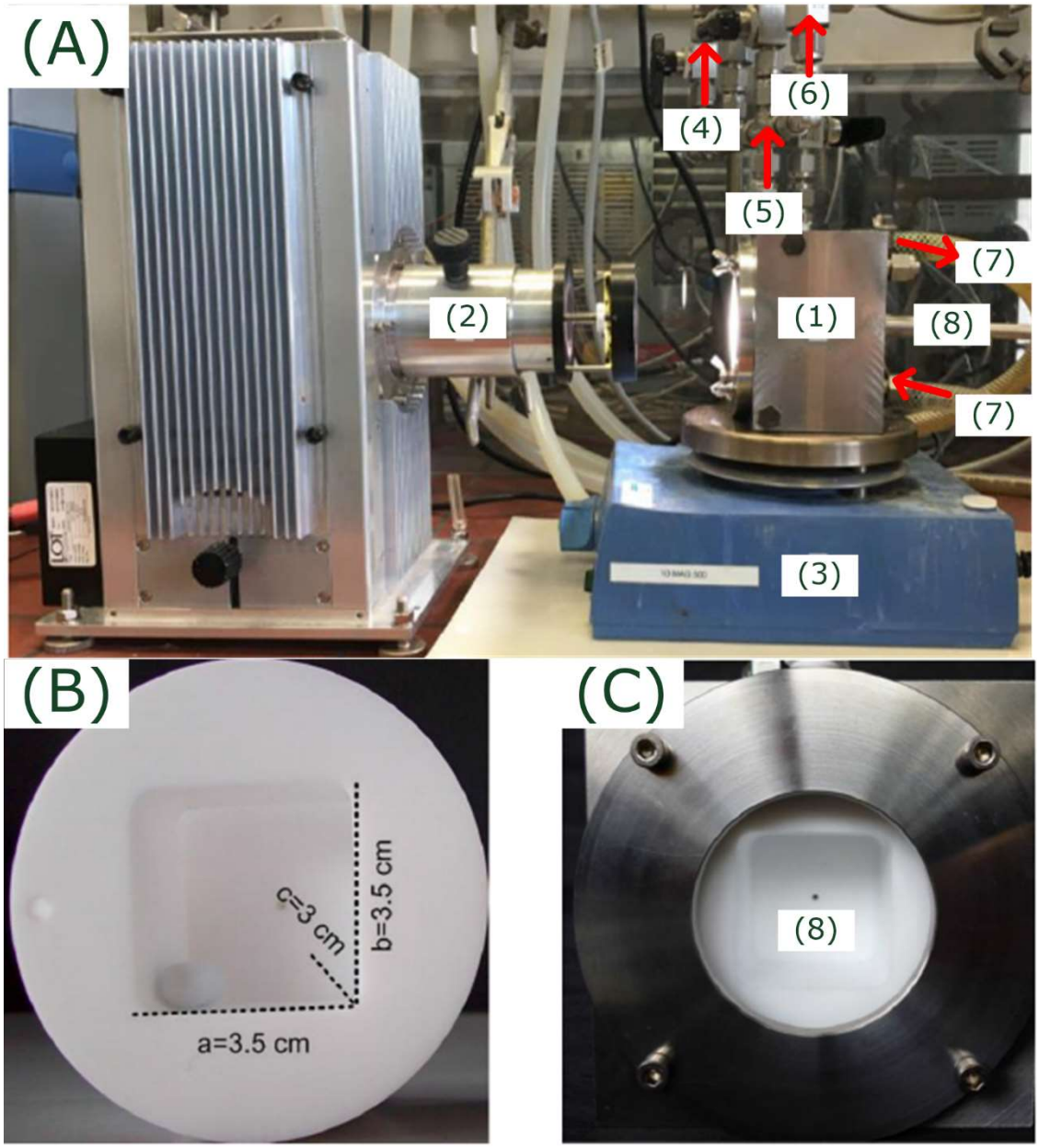


Figure S2. Setup for defined photocatalytic experiments (A) with used Teflon inlet (B) and photoreactor front view (C) (1: photoreactor with quartz glass window, 2: 300 W Xe lamp with filter holder, 3: stirrer, 4: pressure indicator, 5: pressure sensor, 6: gas sampling valve, 7: thermostat, and 8: temperature sensor).

In both cases, after irradiation, a gas sample was collected and analyzed by gas chromatography to obtain the gas phase composition.

2. Characterization of Photocatalysts

2.1 XRD

Commercial TiO_2 photocatalysts were characterized by XRD to verify the different compositions of anatase and rutile phases. XRD patterns of Pt@PC500 were measured, but no change was observed. Peaks for Pt were not obtained due to the small size of the nanoparticles and low loading of TiO_2 with Pt. Further characterizations (e.g., BET) are in the main text.

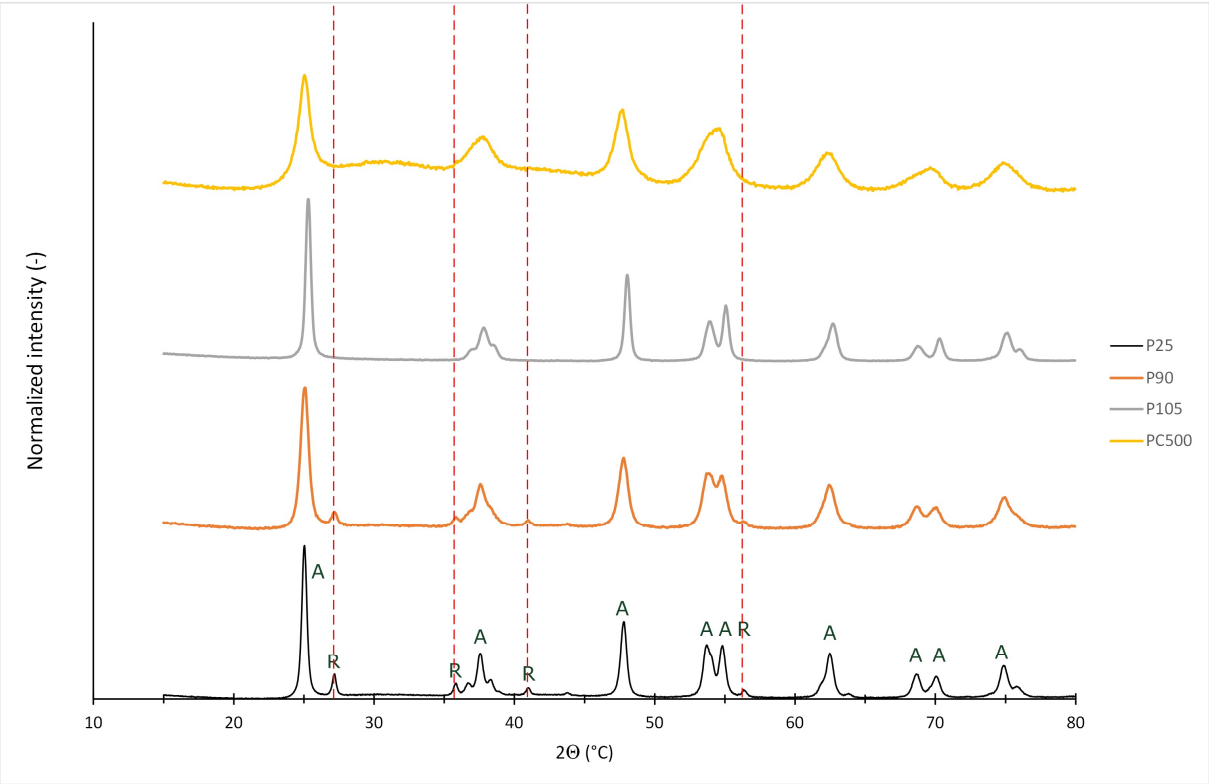


Figure S3. XRD pattern of investigated commercial TiO_2 photocatalysts (A: anatase phase, R: rutile phase).

2.2 Particle Size and Distribution

From the prepared Pt@TiO_2 photocatalysts, STEM HAADF images were recorded and evaluated using Gatan digital micrograph to obtain the mean particle size and the particle size distribution. Counted particles and/or agglomerates are marked with red circles. The data were evaluated using equations 1-3, with N being the number of particles and x_i the size of the selected particle. To obtain a better contrast between the Pt particles and the porous TiO_2 photocatalyst, the “sharpen” function of the software was applied to the images.

Mean value $$\bar{x} = \frac{\sum x_i}{N} \quad (1)$$

Error of mean value $$\Delta\bar{x} = \frac{s}{\sqrt{N}} \quad (2)$$

Standard deviation $$s = \sqrt{\frac{(\bar{x} - x_i)^2}{N - 1}} \quad (3)$$

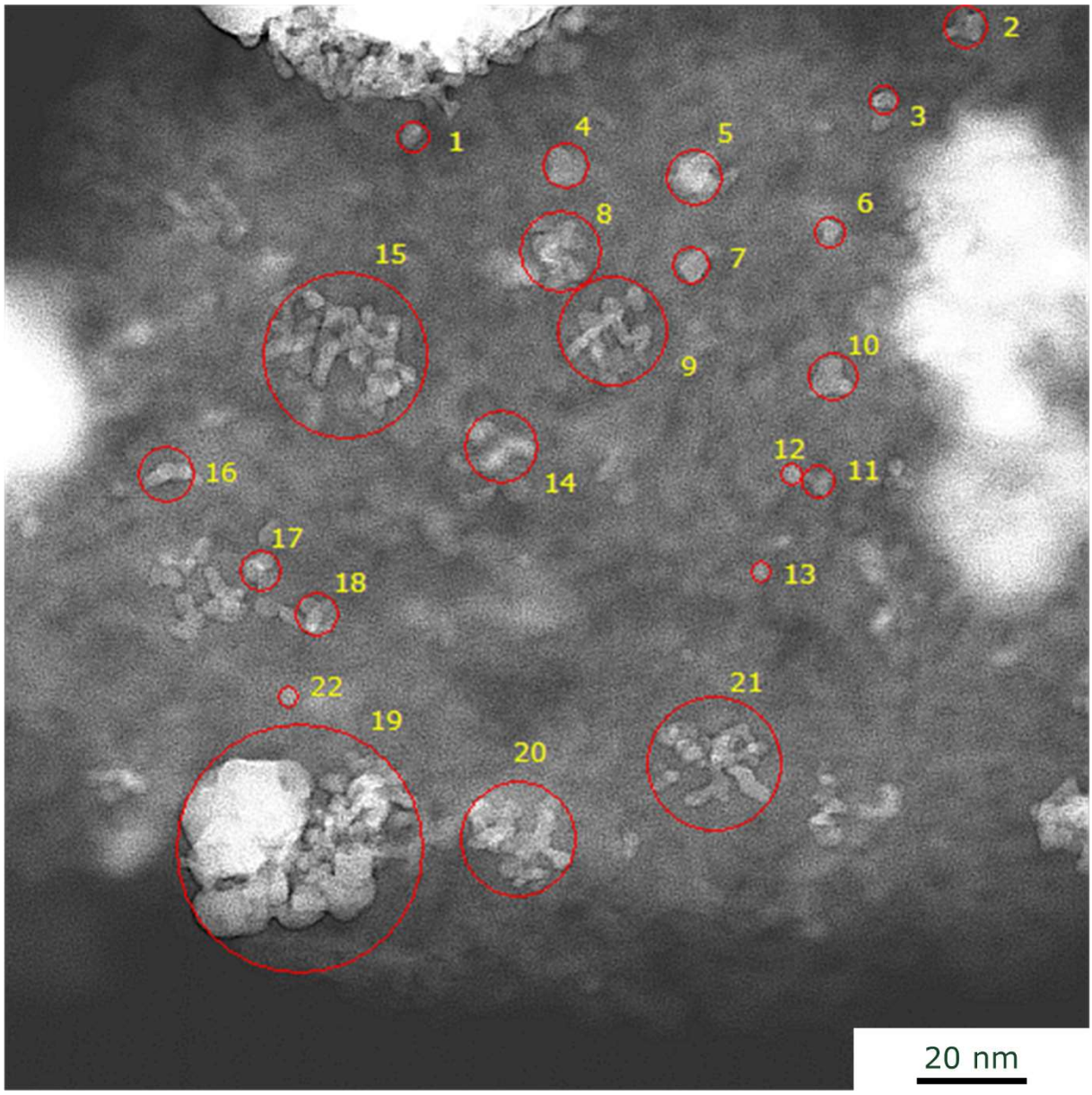
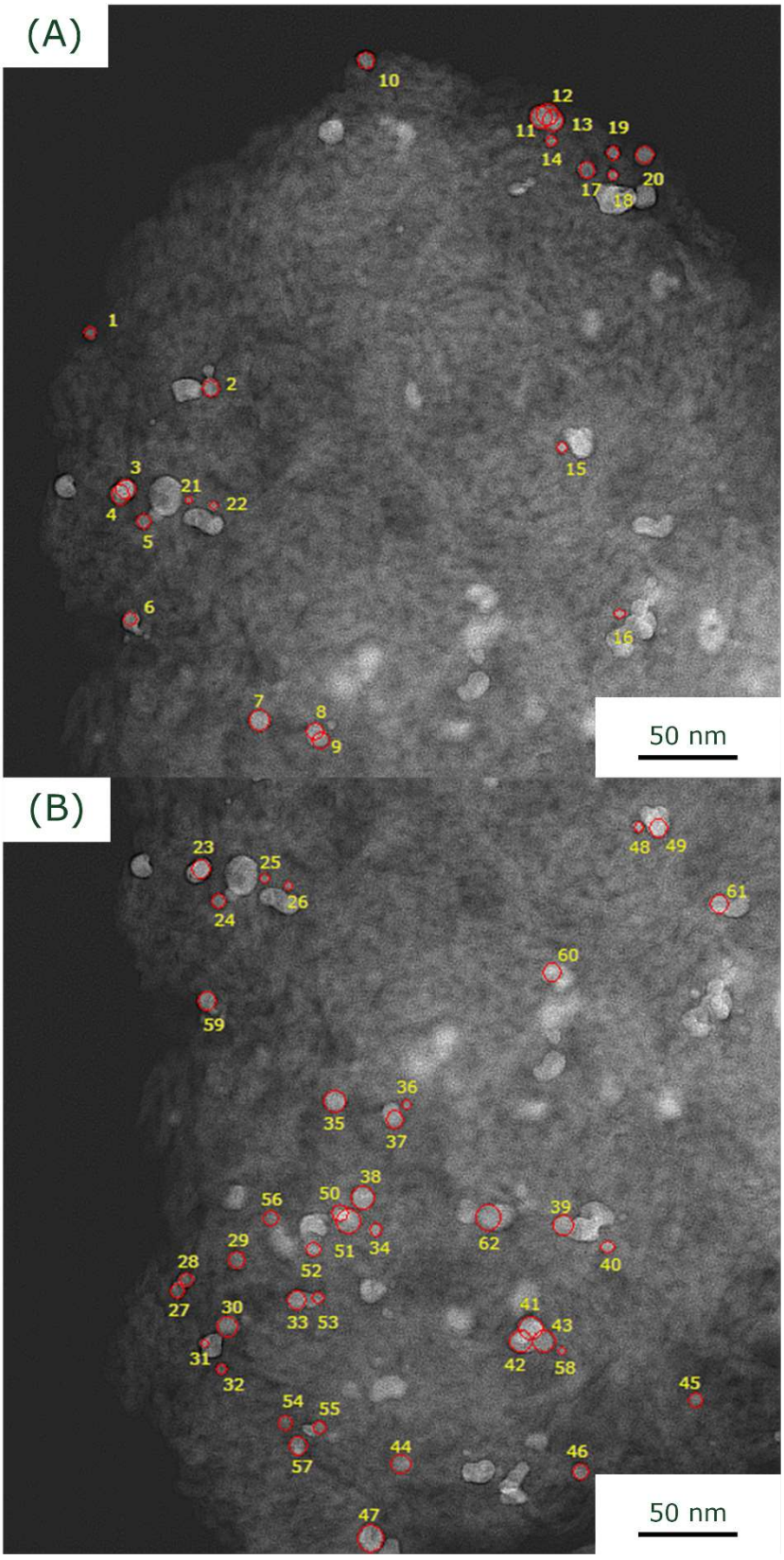


Figure S4. STEM HAADF image of Pt@PC500 that was prepared by simple photoreduction. It was not possible to get a mean particle size and distribution because of strong PtNP agglomeration.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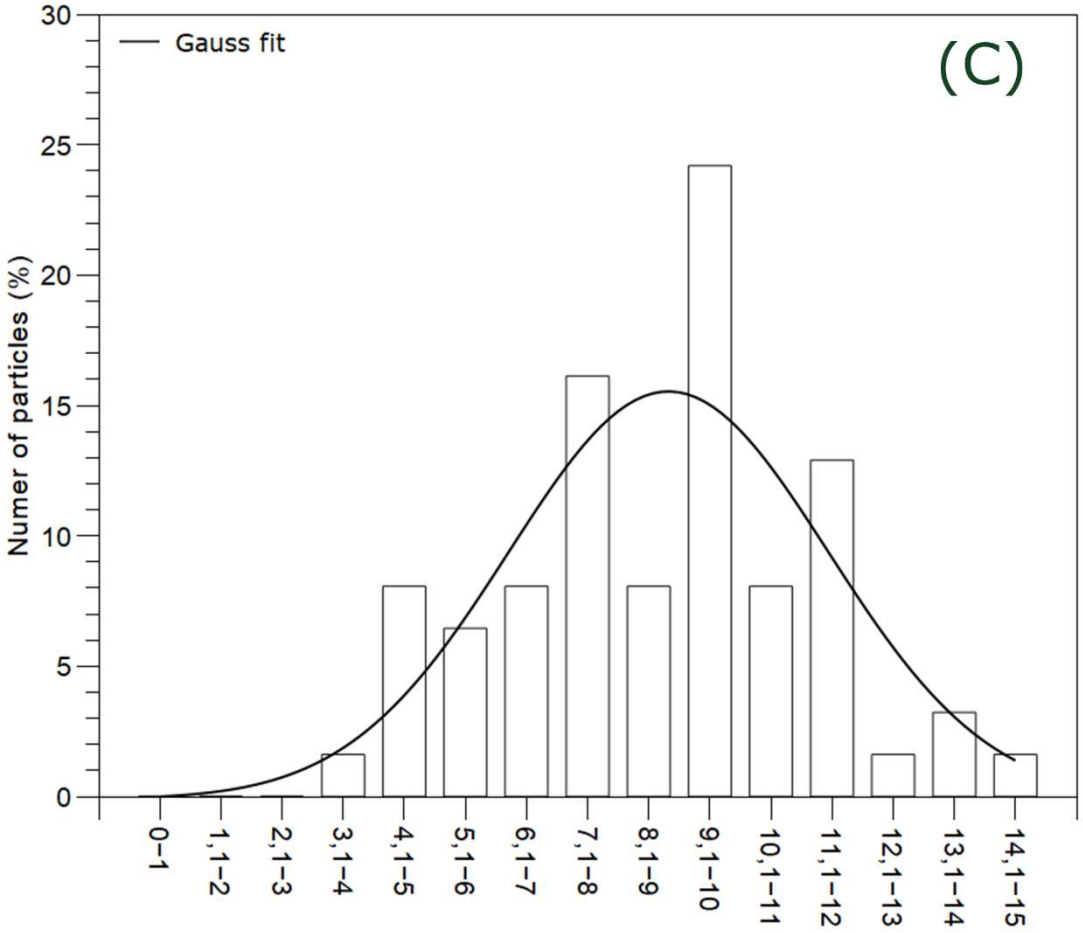
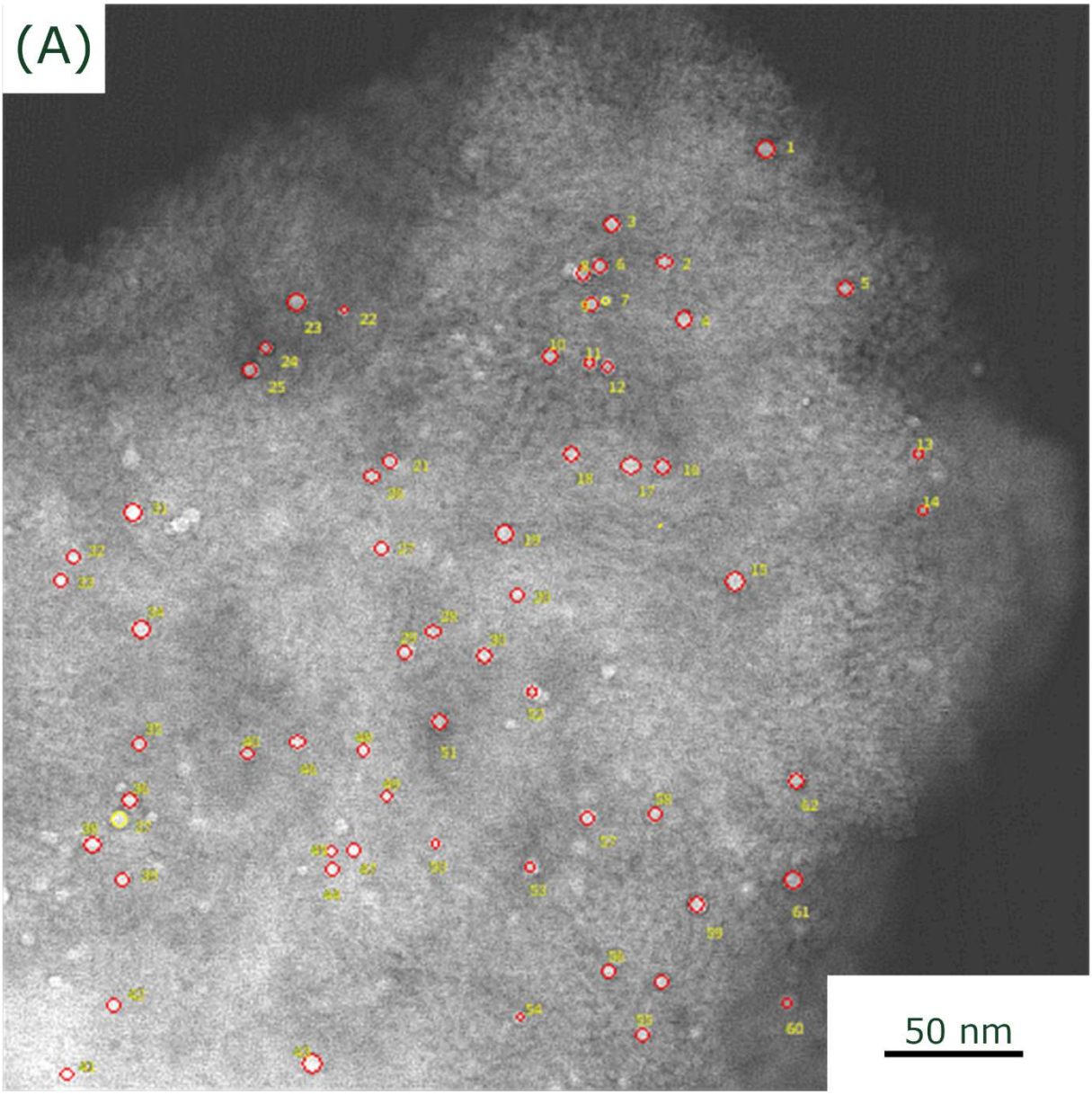


Figure S5. STEM HAADF images (A, B) and particle size distribution (C) of Pt@PC500 prepared by the colloidal method with ascorbic acid as the reducing agent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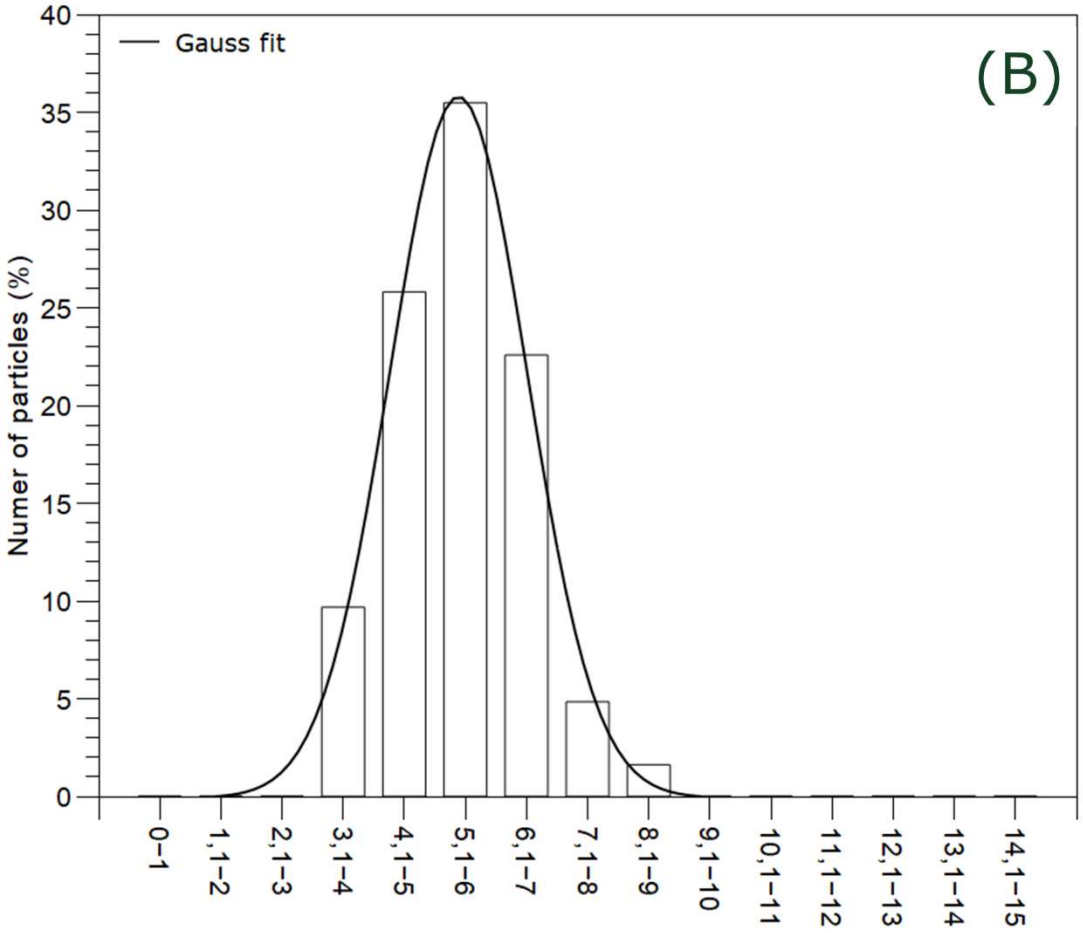
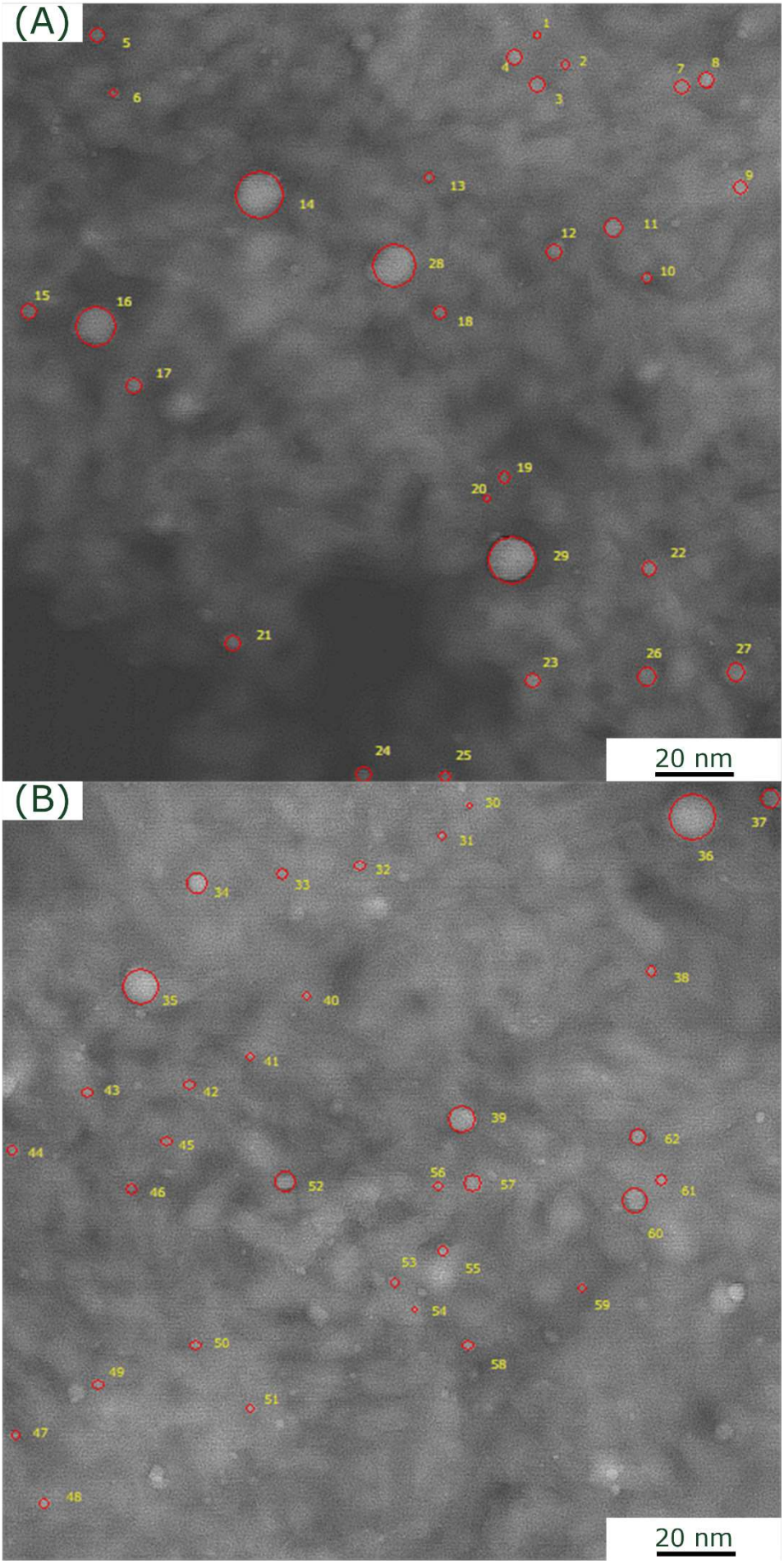


Figure S6. STEM HAADF image (A) and particle size distribution (B) of Pt@PC500 prepared by the colloidal method with clove as the reducing agent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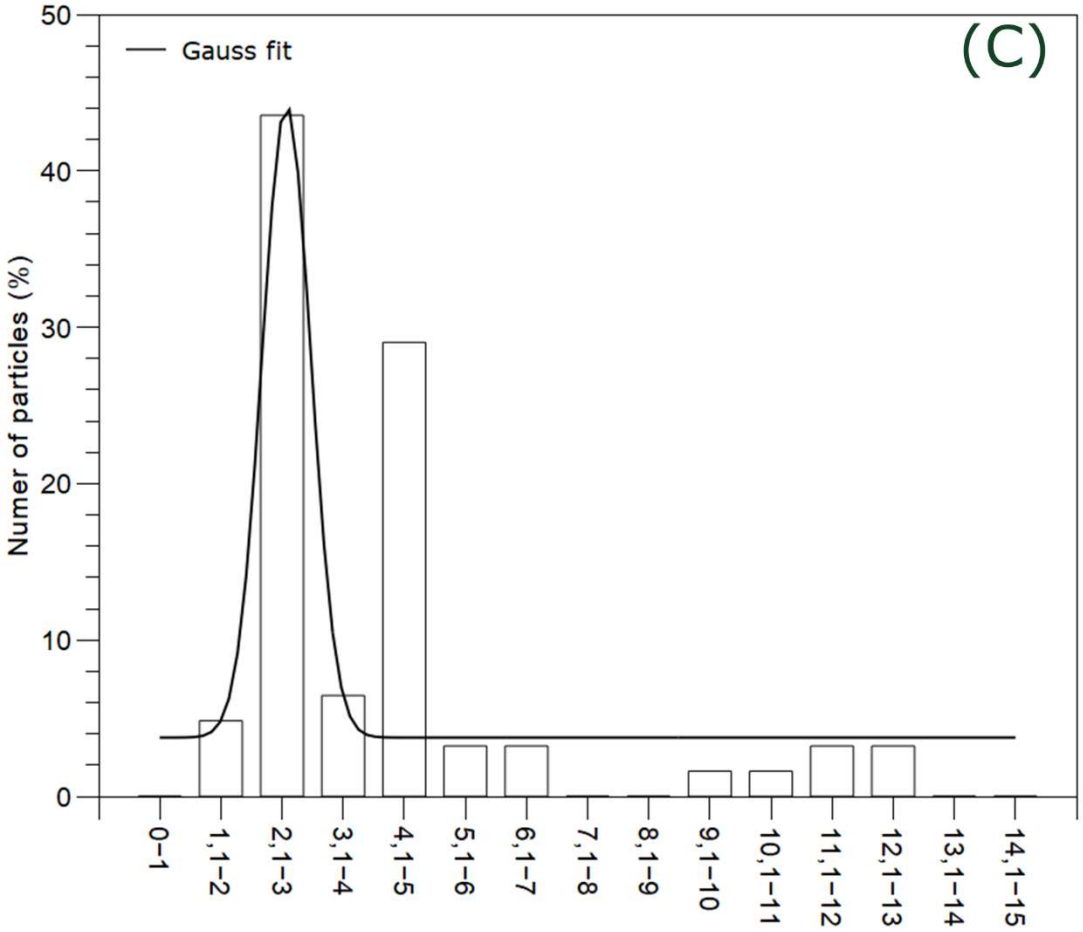
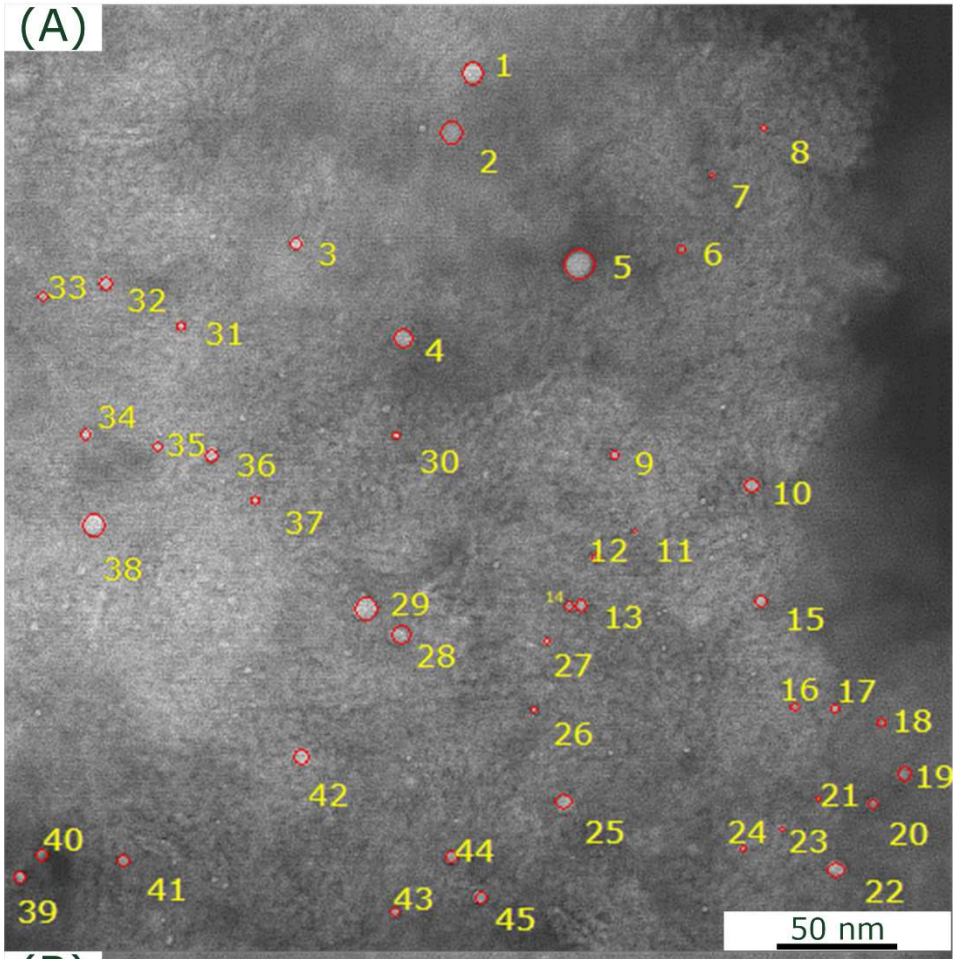


Figure S7. STEM HAADF images (A, B) and particle size distribution (C) of Pt@PC500 prepared by the colloidal method with grape seed as the reducing agent.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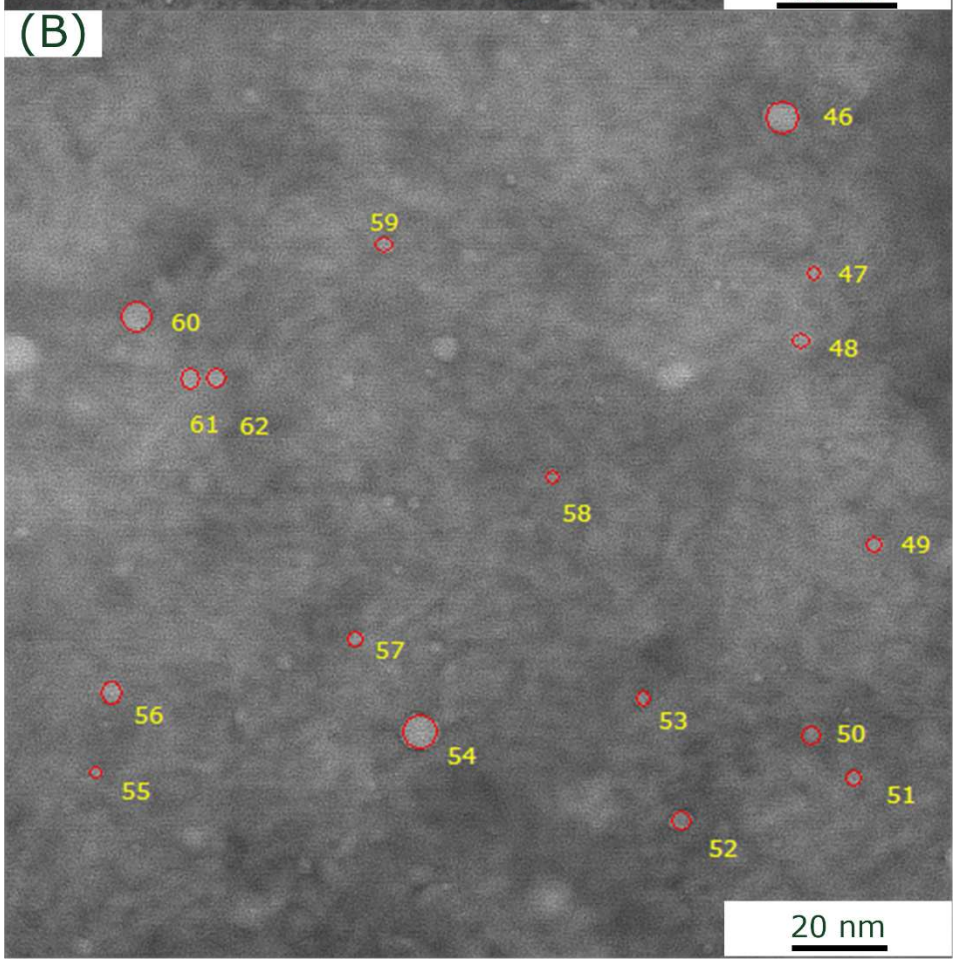
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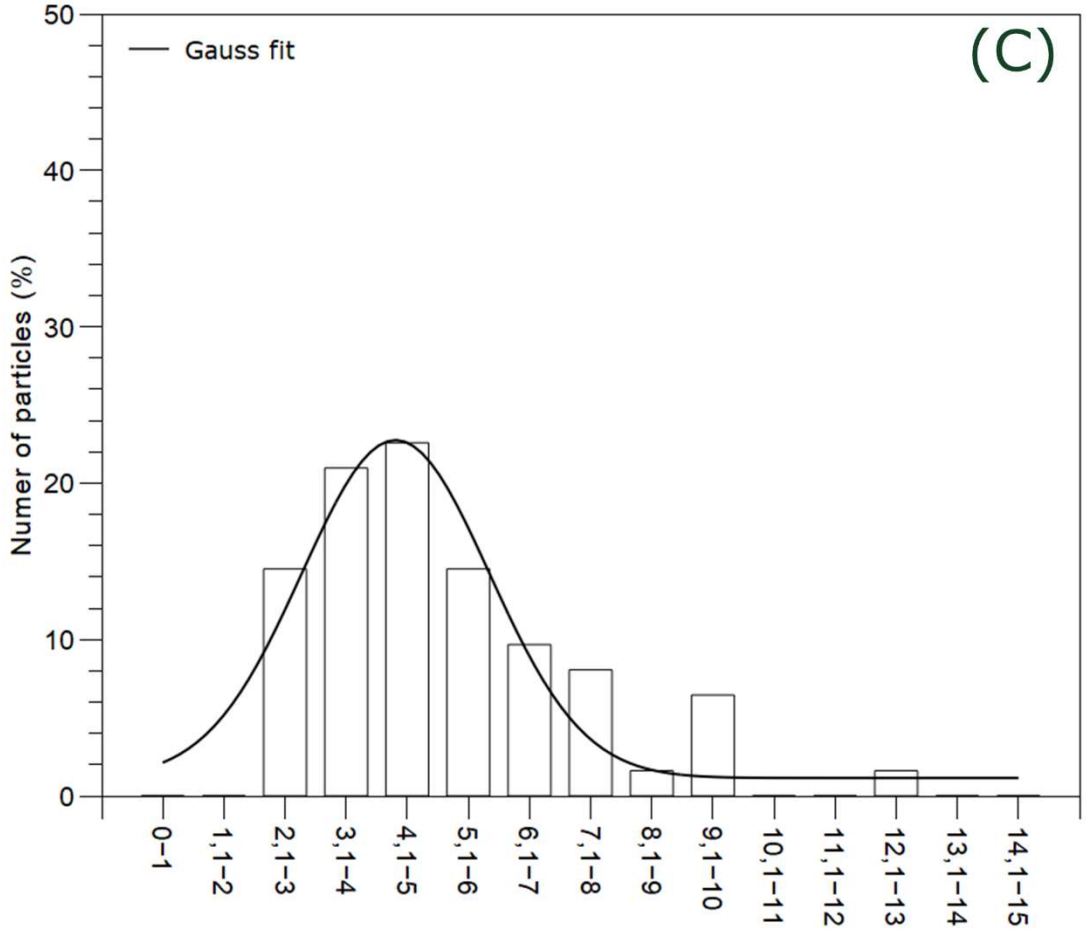

Figure S8. STEM HAADF images (A, B) and particle size distribution (C) of Pt@PC500 prepared by the colloidal method with mangosteen seed as the reducing agent.

3. Reducing Agents

Different reducing agents were used in the colloidal deposition method to prepare Pt@PC500. Except for ascorbic acid, all reducing agents (clove, grape seed, and mangosteen) are mixtures of different molecules. The main active compounds are shown below.

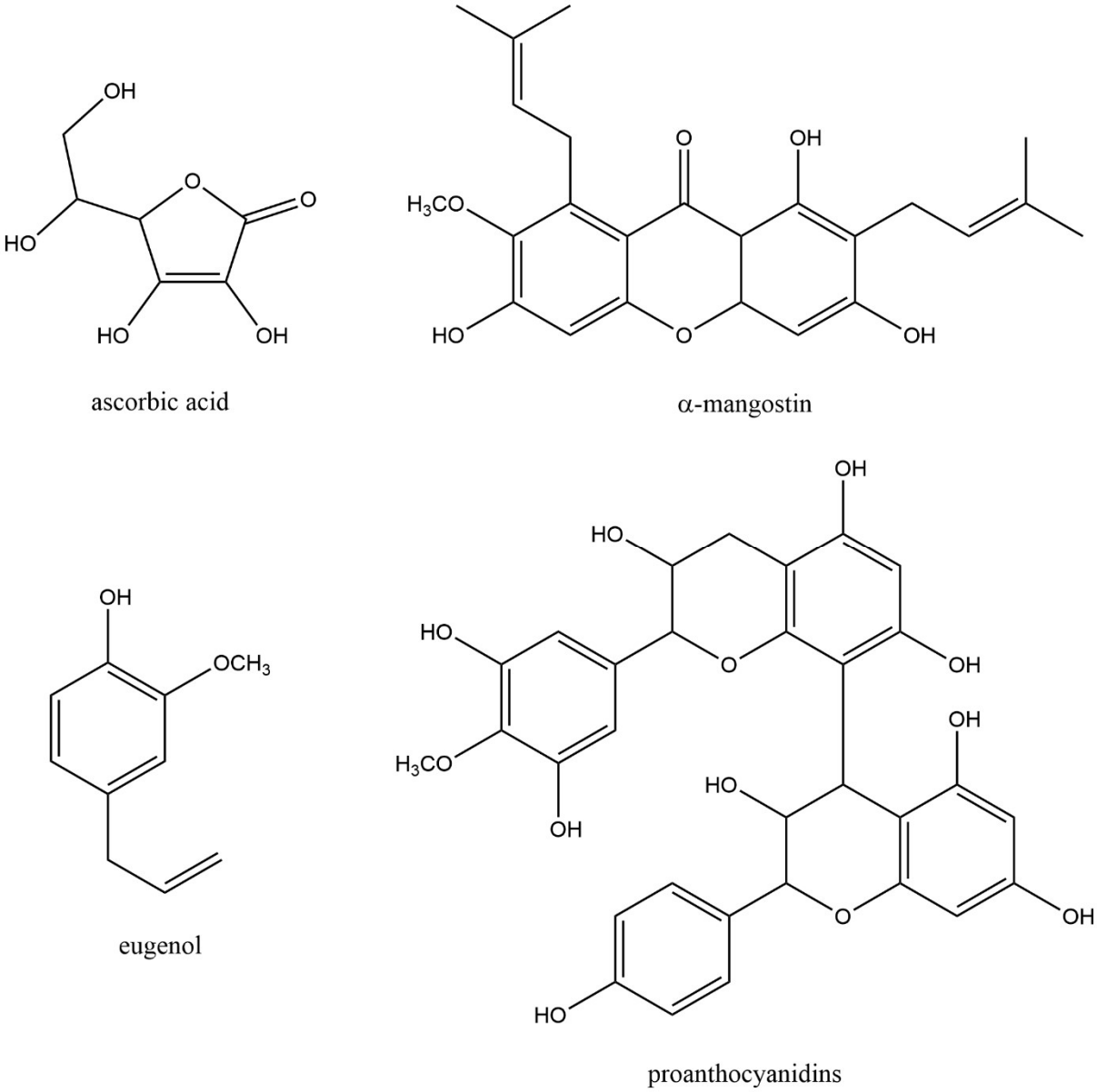

Figure S9. Chemical structures of active compounds in used reducing agents.