Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.

Electronic Supplementary Information

for

Single-Particle Study: Effects of Oxygen Plasma Treatment on Structural and Spectral Changes in Anisotropic Gold Nanorods

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Experimental Methods

Materials and Sample Preparation. CTAB-stabilized AuNRs with an average size of 25 nm × 73 nm were obtained from Nanopartz (Loveland, CO, USA). The AuNR colloid solution was diluted with 18.2-MΩ pure water to the proper concentration and the diluted solution was sonicated for 15 min at room temperature to avoid the NR aggregation. The samples were then prepared by drop casting a diluted solution containing AuNRs on the pre-cleaned glass slide. Afterward, a 20 mm × 20 mm no. 1.5 coverslip (Corning, NY) was placed on the glass slide.

Structural Characterizations. After the AuNR samples were treated with oxygen plasma, structural characterizations of CTAB-stabilized AuNRs were carried out using a scanning electron microscope (SEM, JSM6500F, JEOL, Japan). Then, we checked the structural changes of singe AuNRs from SEM images and determined their length and diameter.

Oxygen Plasma Treatment. Oxygen plasma treatment is commonly used for removing CTAB capping material coated on the surface of AuNRs. In this study, the oxygen plasma treatment was performed using a plasma cleaner (PDC-32G-2, Harrick plasma, U.S.A.). All oxygen plasma treatments were carried out with a maximum RF power of 18W at various plasma treatment times.

Scattering-based Dark-Field Microscopy. DF images were obtained under a Nikon inverted microscope (ECLIPSE Ti–U). In DF mode, we utilized a Nikon Plan Fluor 100× 0.5-1.3 oil iris objective and a Nikon DF condenser. An Andor iXon^{EM+} CCD camera (iXon Ultra 897, UK) was

used to obtain the DF images of the AuNRs. In this study, collected images were analyzed with Image J and Matlab.

Single Particle Scattering Spectroscopy. DF scattering spectra were acquired with an Andor spectrophotometer (SHAMROCK 303i, SR-303I-A) connected with an Andor CCD camera (Newton DU920P-OE). When obtaining a spectrum, the scanning stage moved the sample to the desired location so that only scattered light from the selected location was collected by the objective. The scattered light was directed to the entrance of the spectrophotometer, dispersed by a grating (300 l/mm), and detected by the Newton CCD camera. The background was measured at a region without any particles. Data analysis was performed with specially designed Matlab programs.

Supplementary Figures

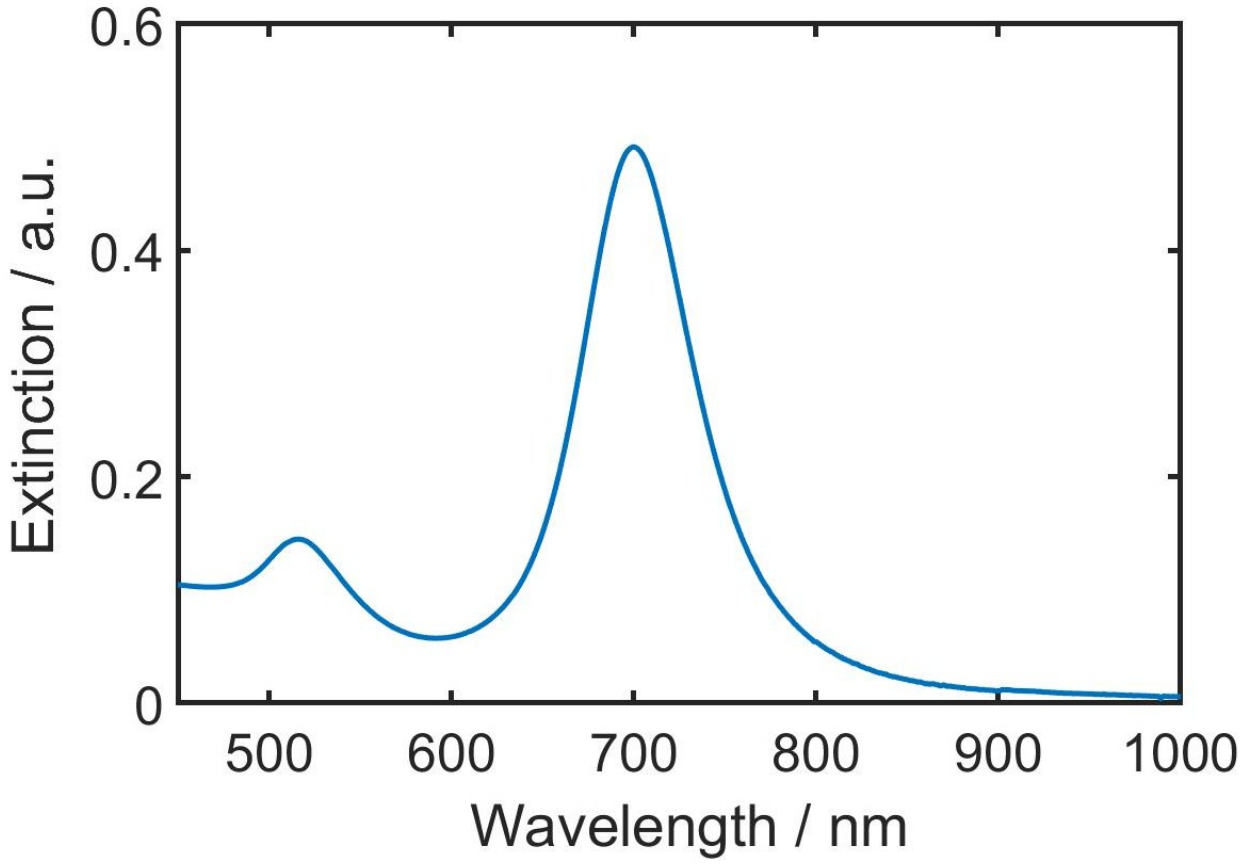

Fig. S1 UV–Vis extinction spectrum of AuNRs (25 nm × 73 nm on average) showing two distinct transverse and longitudinal LSPR peaks

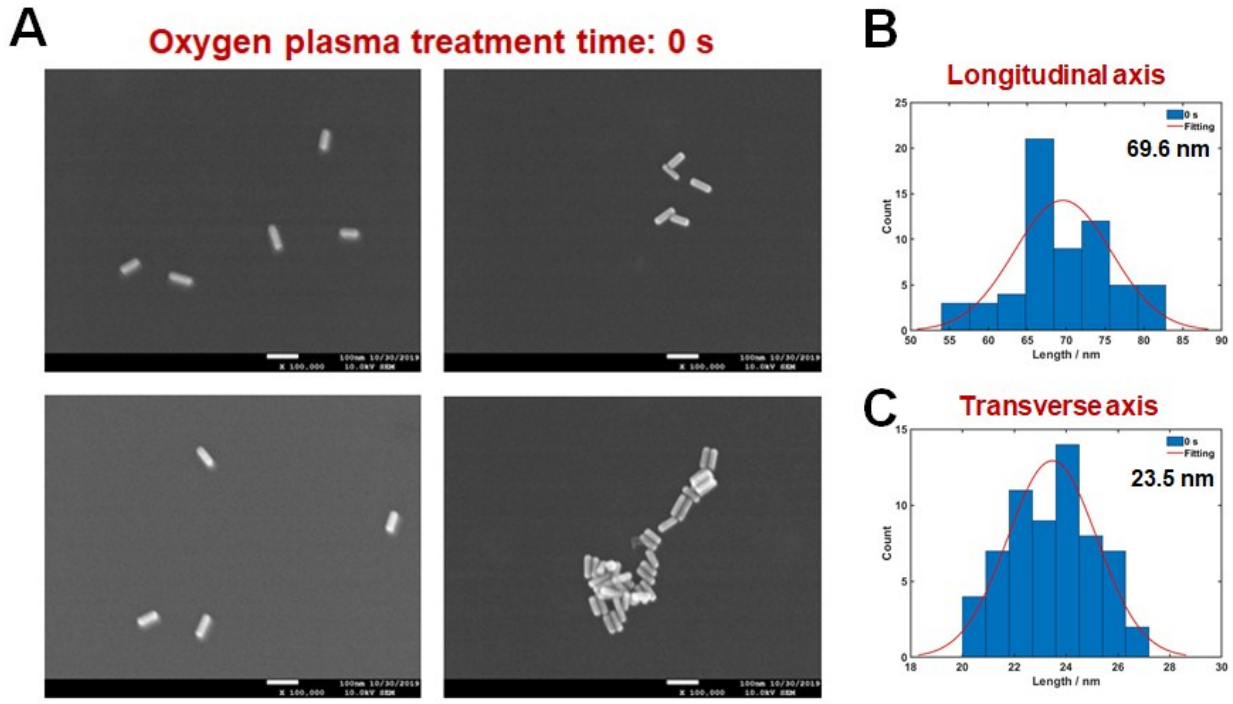

Fig. S2 (A) SEM images of AuNRs before the oxygen plasma treatment (0 s). (B, C) Histograms of longitudinal axis (length, B) and transverse axis (width, C) of AuNRs. The sizes of AuNRs were determined by their SEM images in this study.

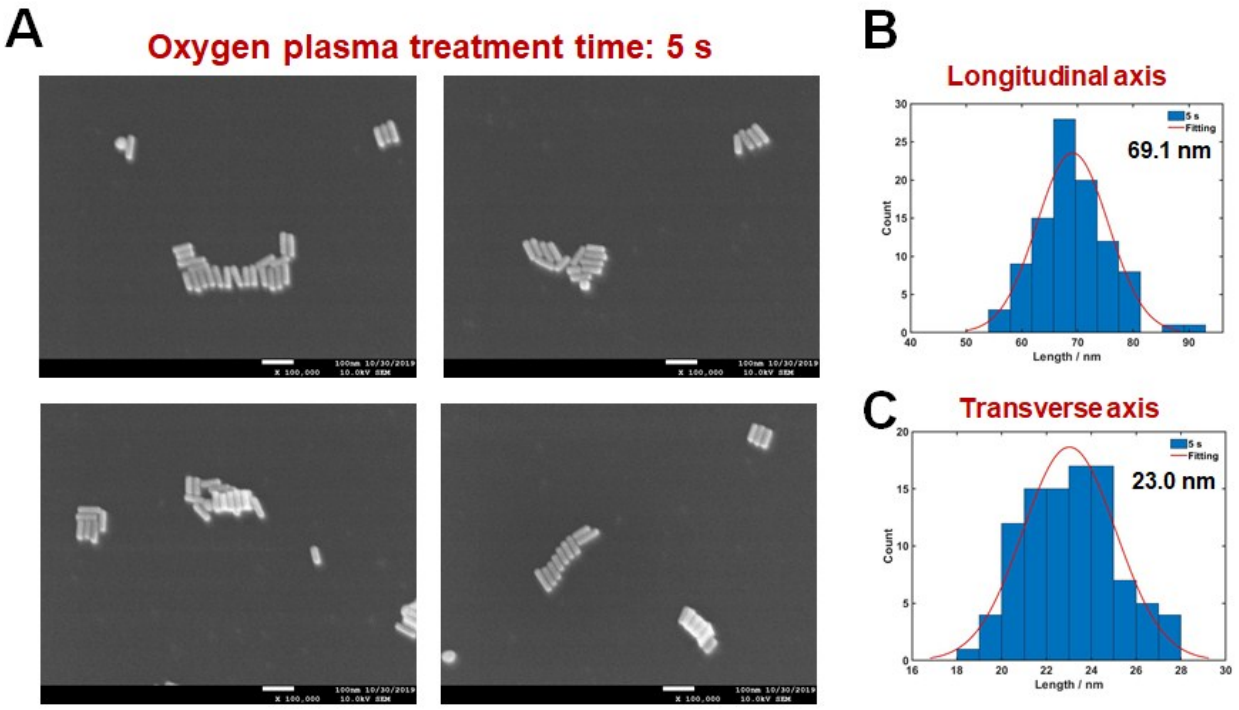

Fig. S3 (A) SEM images of AuNRs after the oxygen plasma treatment of 5 s. (B, C) Histograms of longitudinal axis (length, B) and transverse axis (width, C) of AuNRs.

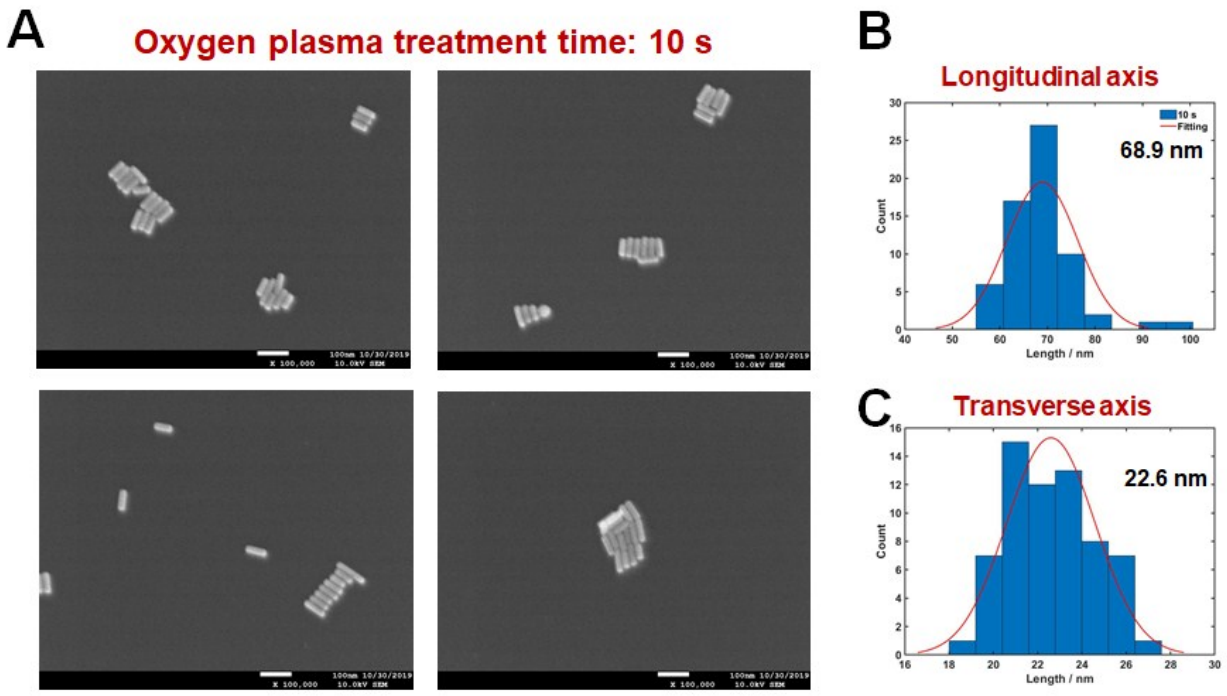

Fig. S4 (A) SEM images of AuNRs after the oxygen plasma treatment of 10 s. (B, C) Histograms of longitudinal axis (length, B) and transverse axis (width, C) of AuNRs.

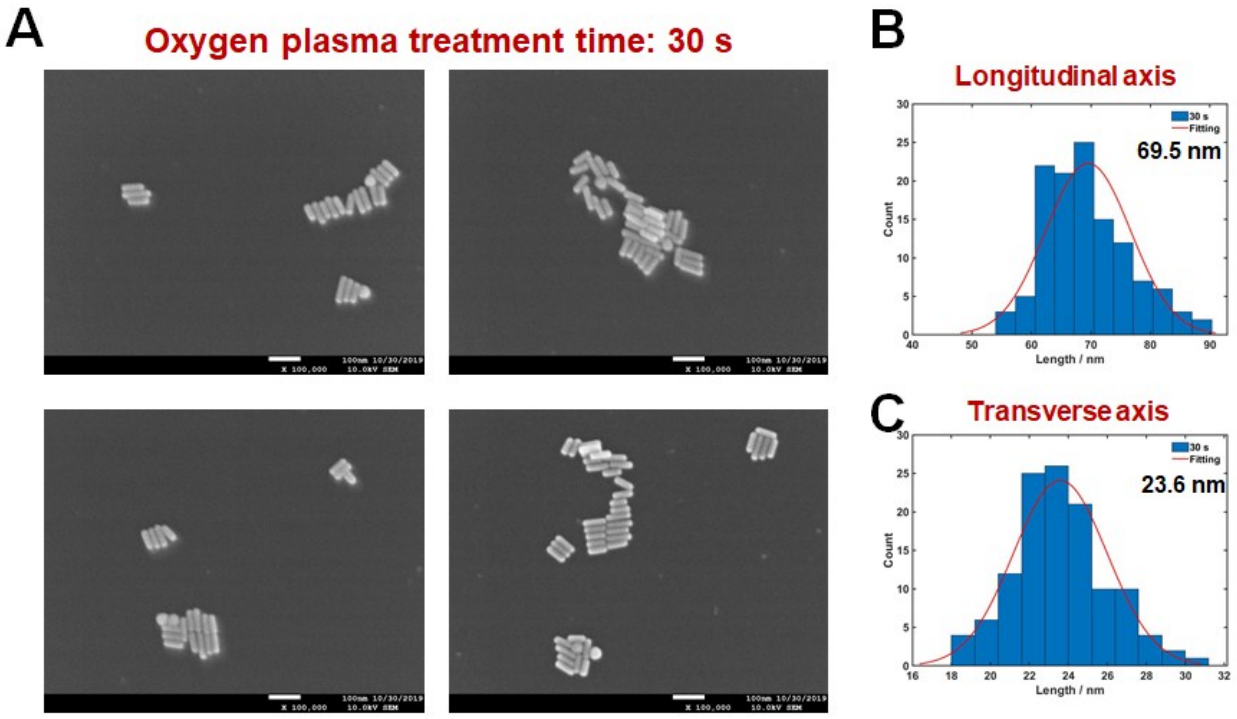

Fig. S5 (A) SEM images of AuNRs after the oxygen plasma treatment of 30 s. (B, C) Histograms of longitudinal axis (length, B) and transverse axis (width, C) of AuNRs.

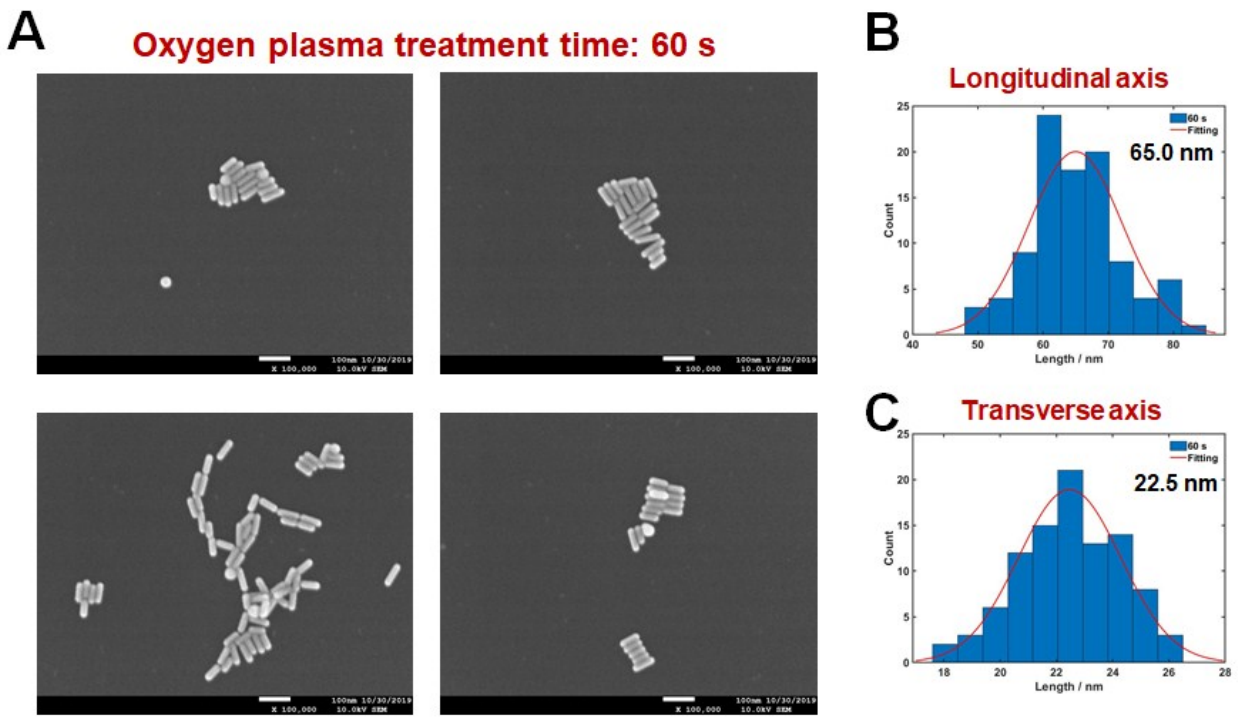

Fig. S6 (A) SEM images of AuNRs after the oxygen plasma treatment of 60 s. (B, C) Histograms of longitudinal axis (length, B) and transverse axis (width, C) of AuNRs.

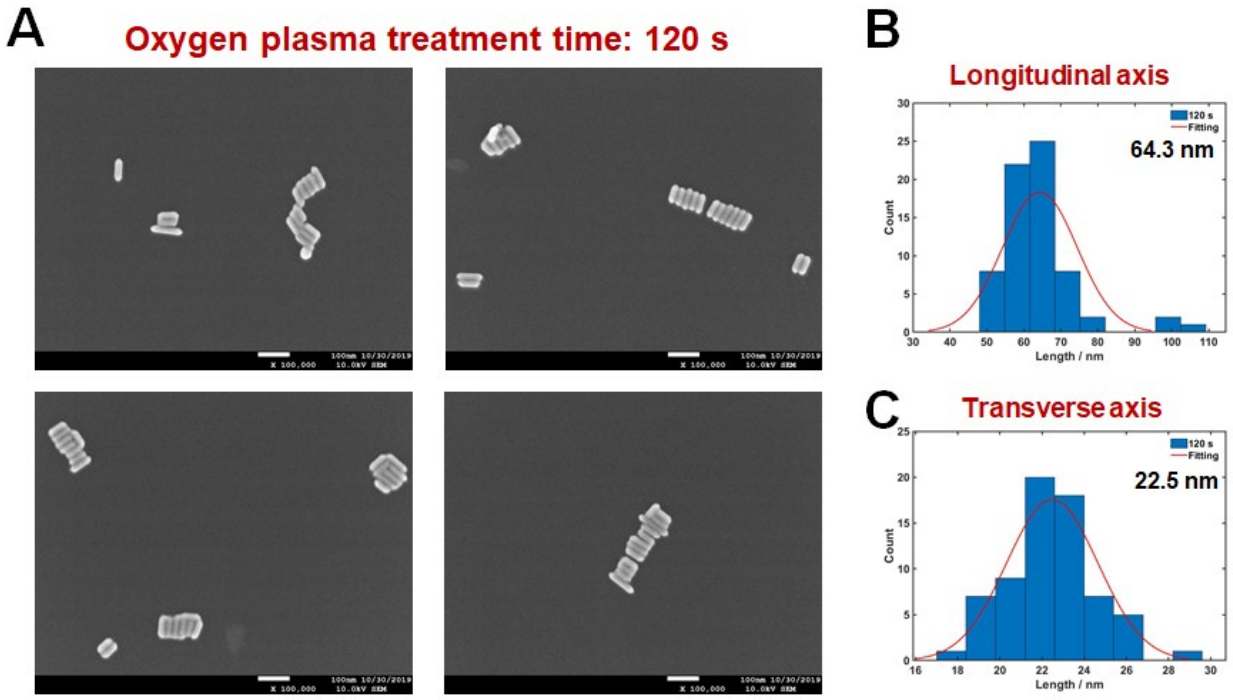

Fig. S7 (A) SEM images of AuNRs after the oxygen plasma treatment of 120 s. (B, C) Histograms of longitudinal axis (length, B) and transverse axis (width, C) of AuNRs.

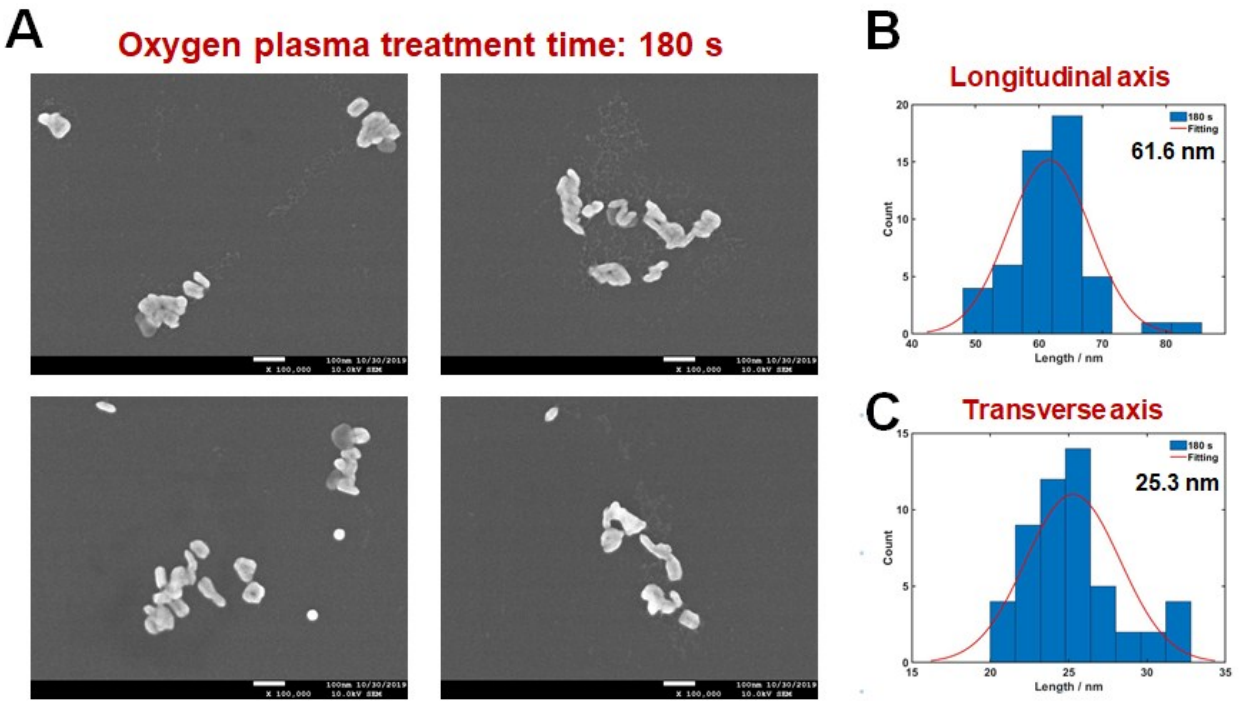

Fig. S8 (A) SEM images of AuNRs after the oxygen plasma treatment of 180 s. (B, C) Histograms of longitudinal axis (length, B) and transverse axis (width, C) of AuNRs.

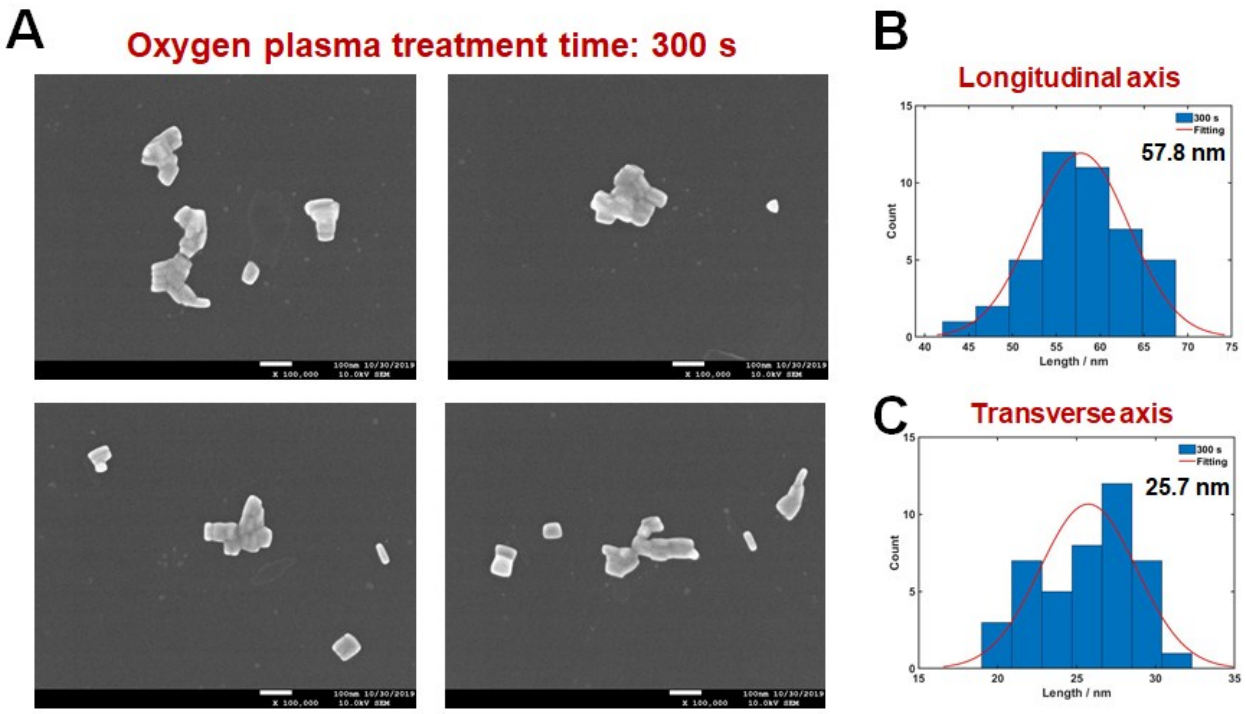

Fig. S9 (A) SEM images of AuNRs after the oxygen plasma treatment of 300 s. (B, C) Histograms of longitudinal axis (length, B) and transverse axis (width, C) of AuNRs.

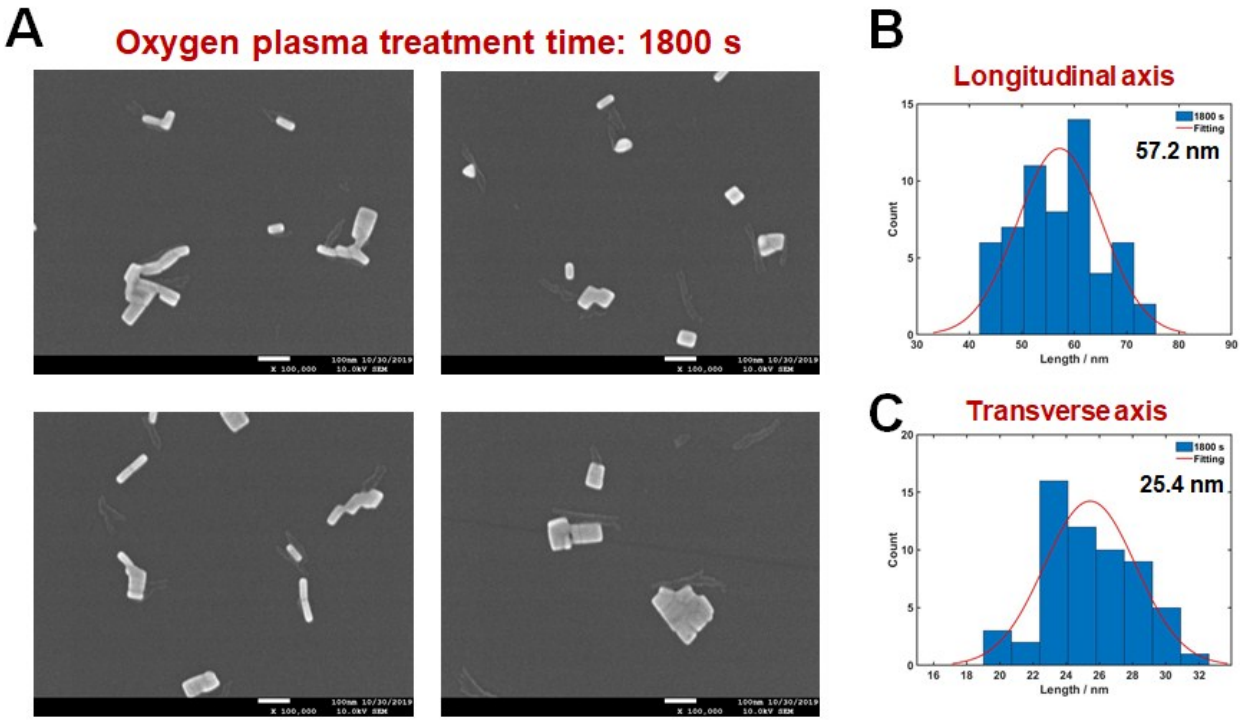

Fig. S10 (A) SEM images of AuNRs after the oxygen plasma treatment of 1800 s. (B, C) Histograms of longitudinal axis (length, B) and transverse axis (width, C) of AuNRs.

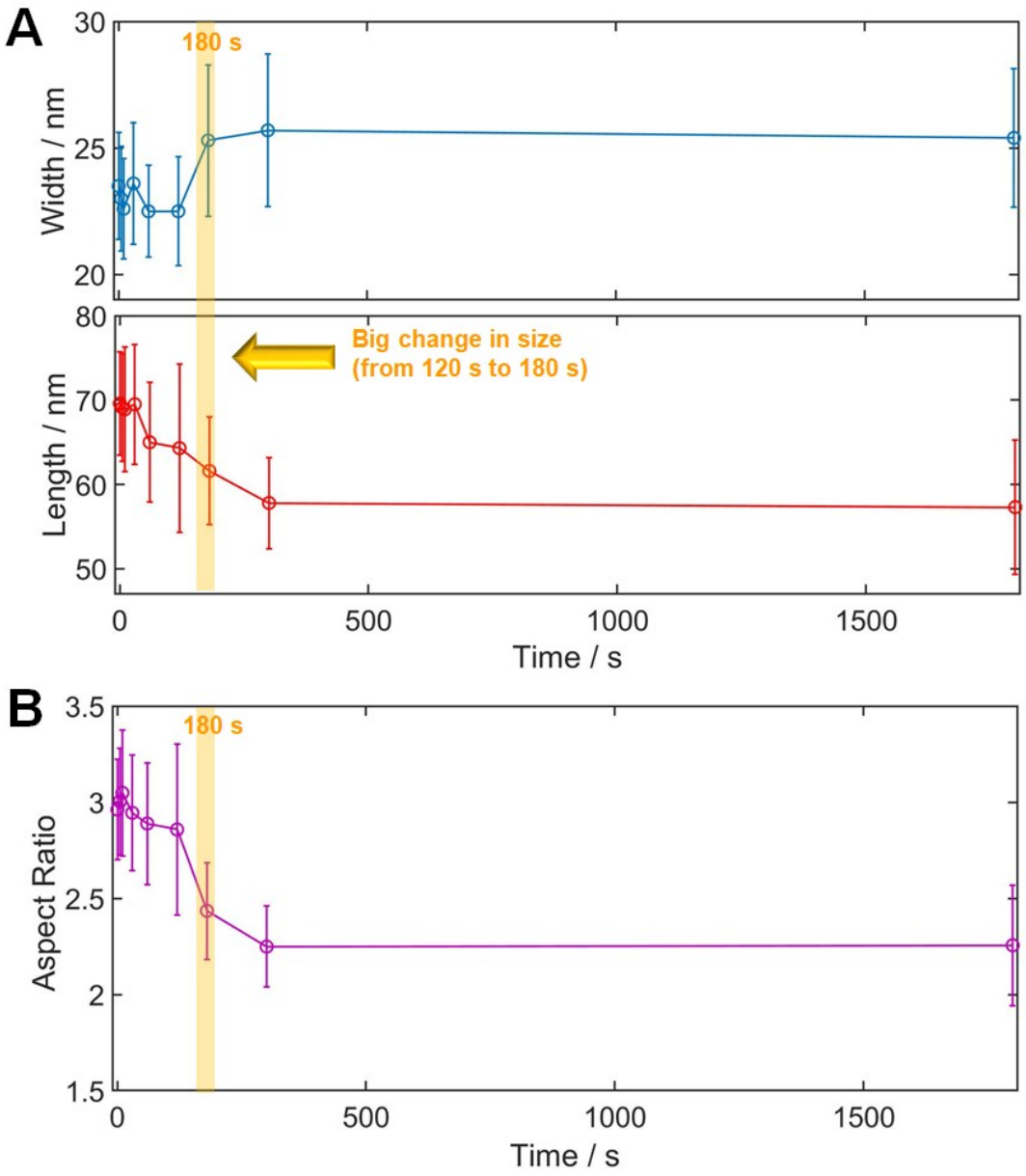

Fig. S11 (A) Changes in the width (top) and length (bottom) of AuNRs as a function of the plasma treatment time (0, 5, 10, 30, 60, 120, 180, 300, and 1800 s). (B) Corresponding change in aspect ratio (AR) of AuNRs.

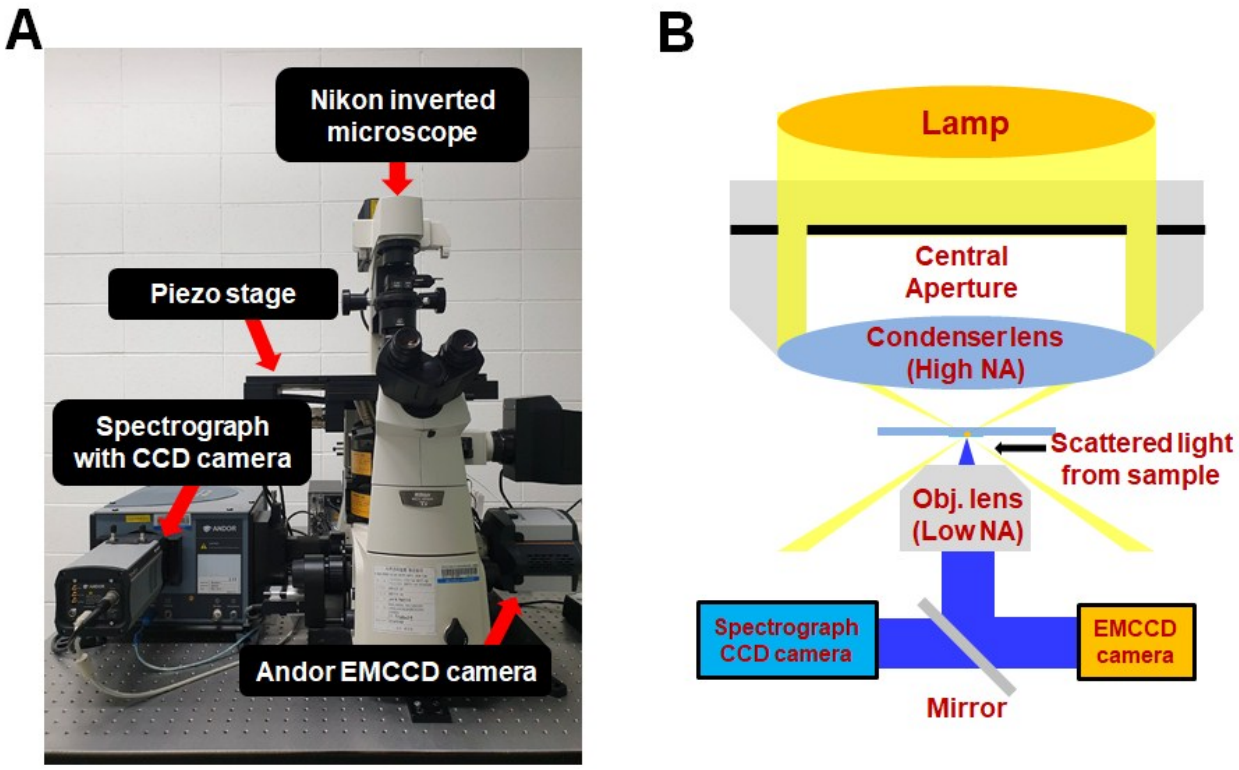

Fig. S12 (A) A photograph showing the experimental setup for DF single particle scattering spectroscopy. (B) A schematic to depict the working principle of DF microscopy and spectroscopy.

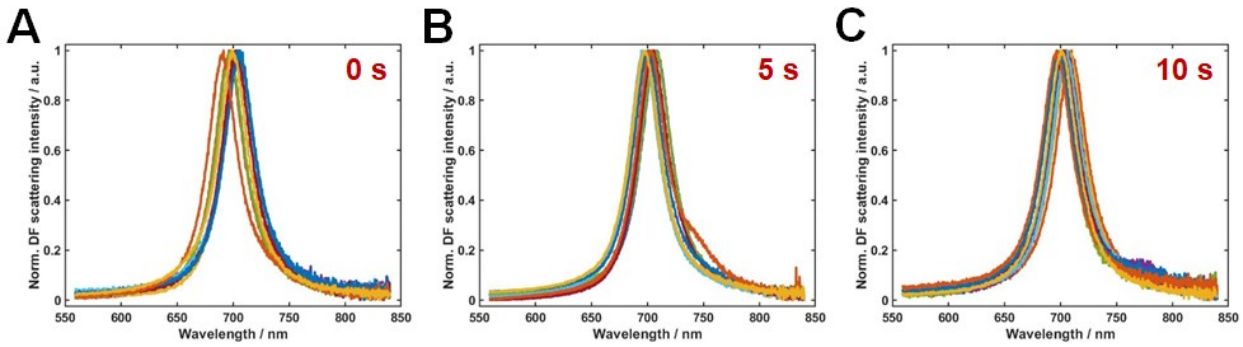

Fig. S13 Single particle scattering spectra of many AuNRs at various oxygen plasma treatment times of (A) 0 s, (B) 5 s, and (C) 10 s.

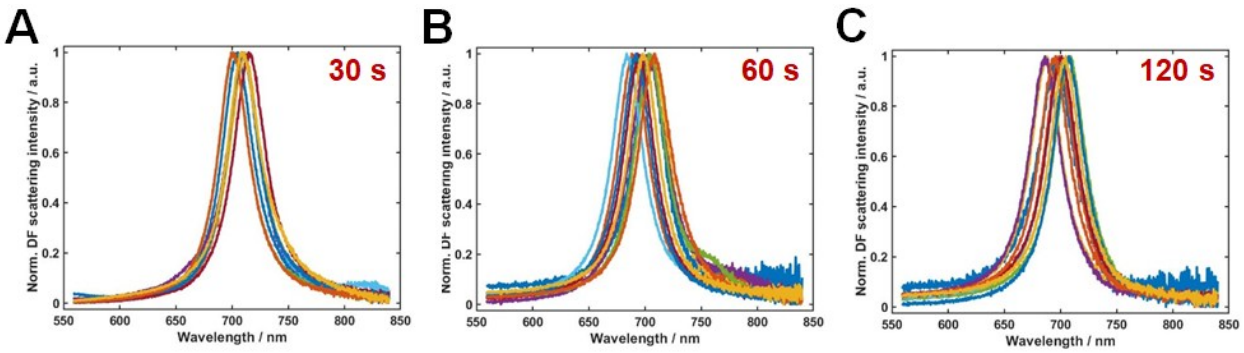

Fig. S14 Single particle scattering spectra of many AuNRs at various oxygen plasma treatment times of (A) 30 s, (B) 60 s, and (C) 120 s.

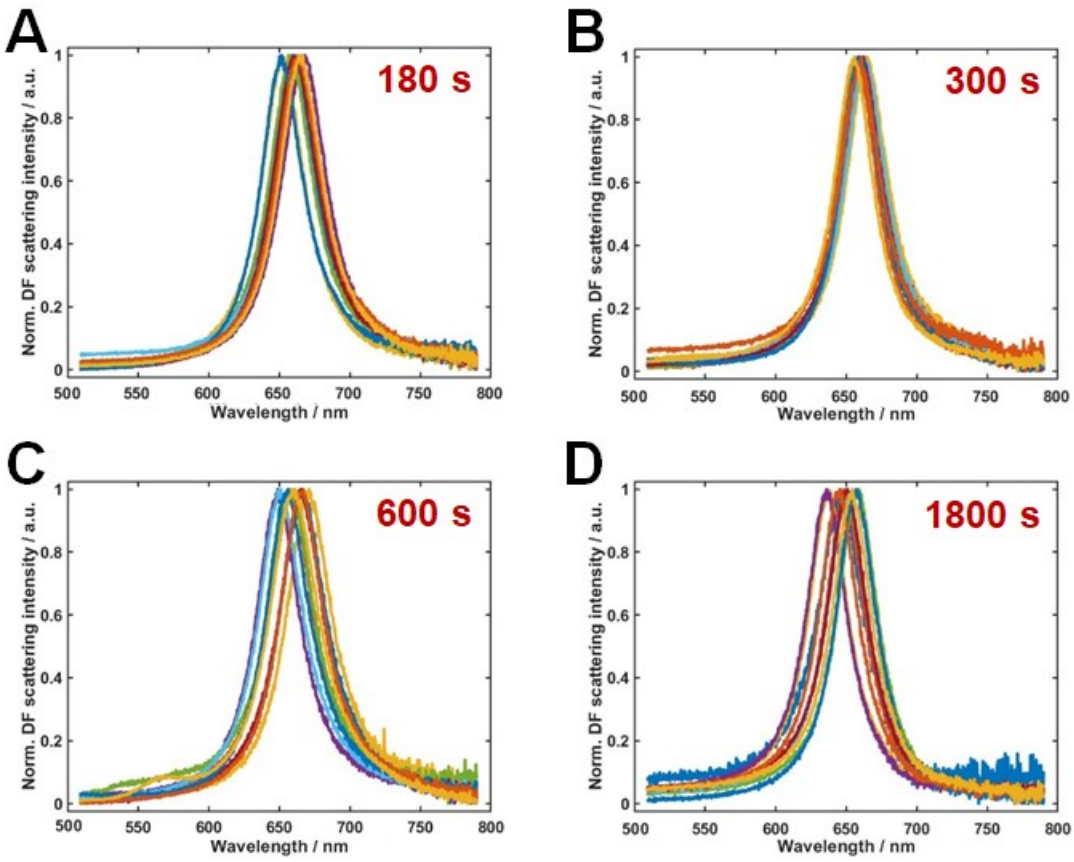

Fig. S15 Single particle scattering spectra of many AuNRs at various oxygen plasma treatment times of (A) 180 s, (B) 300 s, (C) 600 s, and (D) 1800 s.

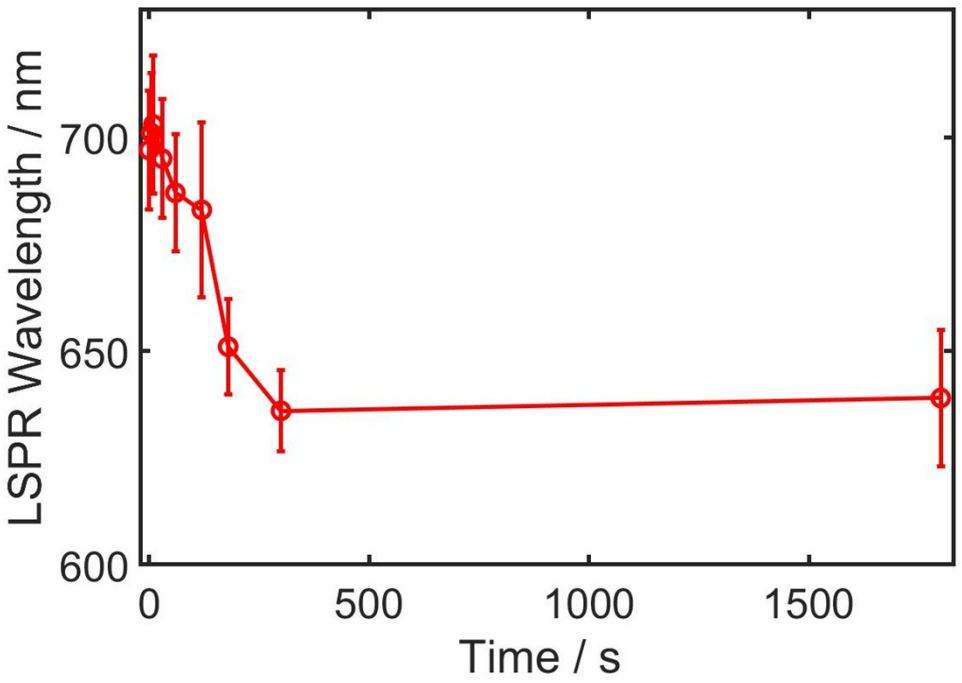

Fig. S16 Changes in the LSPR wavelength of AuNRs as a function of the plasma treatment time (0, 5, 10, 30, 60, 120, 180, 300, and 1800 s).