

Supplementary Materials

Green-Routed Carbon Dot-Adorned Silver Nanoparticles for the Catalytic Degradation of Organic Dyes

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Materials

Terminalia chebula fruits were obtained from the Market, Tamil Nadu, India. Silver nitrate (AgNO₃), sodium borohydride (NaBH₄), methylene blue (MB), and methyl orange (MO) were purchased from Sigma-Aldrich, Seoul, Republic of Korea. All of the chemicals were used exactly as they were purchased, and distilled water was used across the experiment.

Instrumentation Methods

Terminalia chebula fruits-derived CDs@AgNPs were characterized by various physicochemical techniques such as field emission scanning electron microscopy (FESEM) with energy-dispersive X-ray spectroscopy (EDS), high-resolution transmittance electron microscopy (HRTEM), X-ray diffraction (XRD), Raman spectroscopy, attenuated total reflectance Fourier transform infrared (ATR-FTIR) spectroscopy, and X-ray photoelectron spectroscopy (XPS). FESEM with EDS analysis was carried out on a Hitachi S-4800 equipped with EDX at an accelerating voltage of 10 kV. TEM/HRTEM images were performed with an FEI-Tecna TF-20 transmission electron microscope with an operating accelerating voltage of 120 kV. XRD measurements were made with a PANalytical X'Pert3 MRD diffractometer using monochromatized Cu K α radiation ($\lambda = 1.54 \text{ \AA}$) at 40 kV and 30 mA in the range of 10 to 80° (2 θ). At Yeungnam University's key research support center for natural products and medical materials, the Raman spectrum was measured on an XploRA Micro-Raman spectrophotometer (Horiba) with a range of 50 to 4000 cm⁻¹. ATR-FTIR spectra in the wavenumber range of 400 to 4000 cm⁻¹ were obtained in transmittance mode on a Perkin Elmer Spectrum Two by the addition of 8 scans at a resolution of 8 cm⁻¹. Thermo Scientific's K-Alpha was used to get XPS spectra. The high-resolution XPS spectra were deconvoluted using CasaXPS software. The catalytic degradation measurements of MB and MO dyes were carried out in the neutral aqueous medium at room temperature by using UV-vis absorbance. The UV-vis absorption spectra were recorded from 200 to 750 nm using an OPTIZEN 3220UV spectrophotometer.

Catalytic Degradation Measurements

Catalytic performance of synthesized CDs@AgNPs was tested against the degradation of MB and MO in the presence of sodium borohydride (SB). The degradation experiments were carried out in a quartz UV cuvette, where 2 mL (50 μ M) of MB or MO was mixed with 0.95 mL (0.005 M) of aqueous SB and 0.05 mL of CDs@AgNPs composite. Similarly,

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the degradation of MB/MO measurements was conducted in the absence of catalyst (CDs@AgNPs composite), where 2 mL (50 μ M) of MB or MO was mixed with 0.95 mL (0.005 M) of aqueous SB and 0.05 mL of distilled water and absence of NaBH_4 , where 2 mL (50 μ M) of MB or MO was mixed with 0.95 mL of distilled water and 0.05 mL of CDs@AgNPs composite. The degradation dynamics of MB/MO were observed using an OPTIZEN 3220UV spectrophotometer.

The degradation efficiency (%) and kinetic rate constant as per the pseudo-first-order were calculated using the following equations (1), (2).

$$\text{Degradation efficiency (\%)} = \left(\frac{A_0 - A_t}{A_0} \right) \times 100 \quad (1)$$

$$\text{Pseudo-first-order } (-kt) = \ln \left(\frac{A_t}{A_0} \right) \quad (2)$$

where, A_0 is the initial absorbance of MB/MO, A_t is the absorbance of MB/MO at time t , and k is the rate constant.

Structural and optical characterizations of the synthesized TCE and CDs@AgNPs

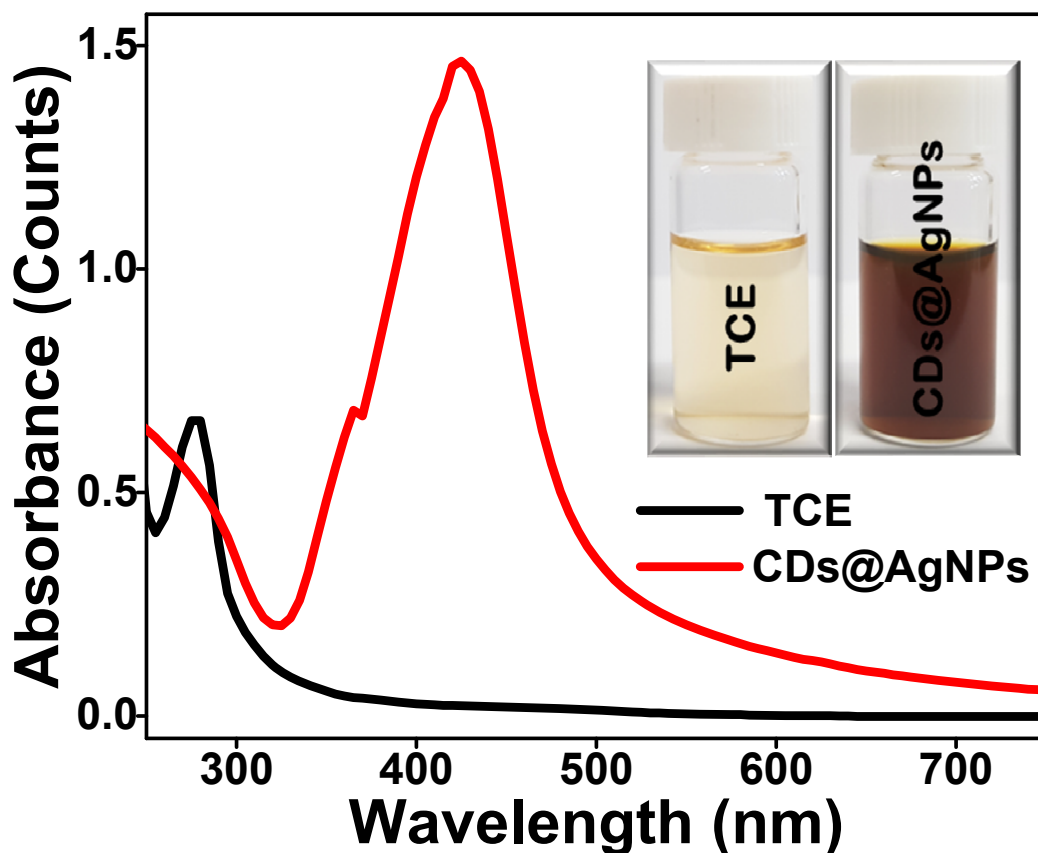


Figure S1. UV-Vis spectra of the *Terminalia chebula* fruit extract and synthesized CDs@AgNPs.

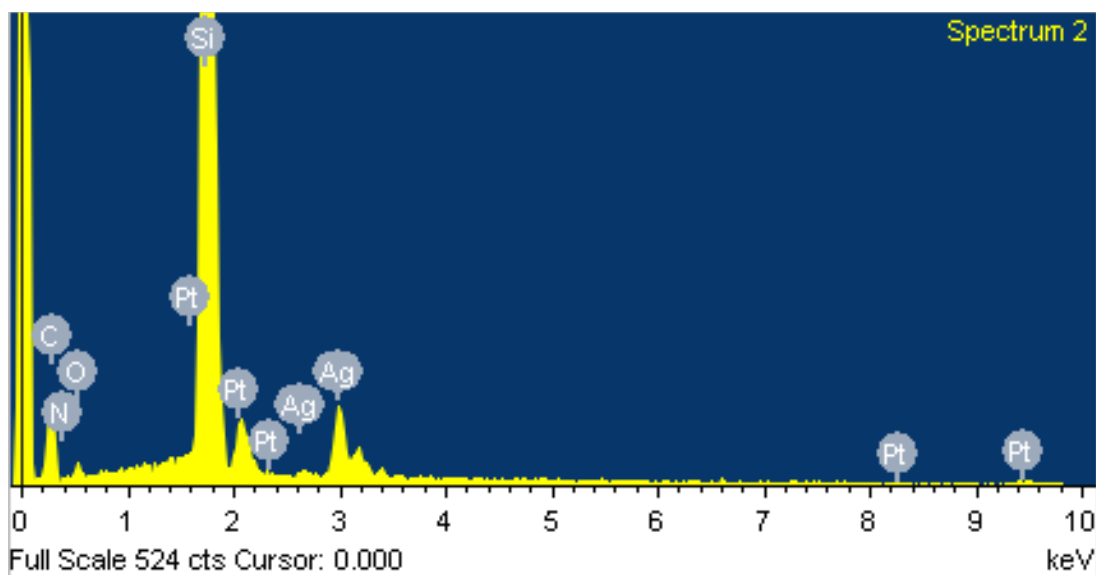


Figure S2. EDAX spectrum of the synthesized CDs@AgNPs.

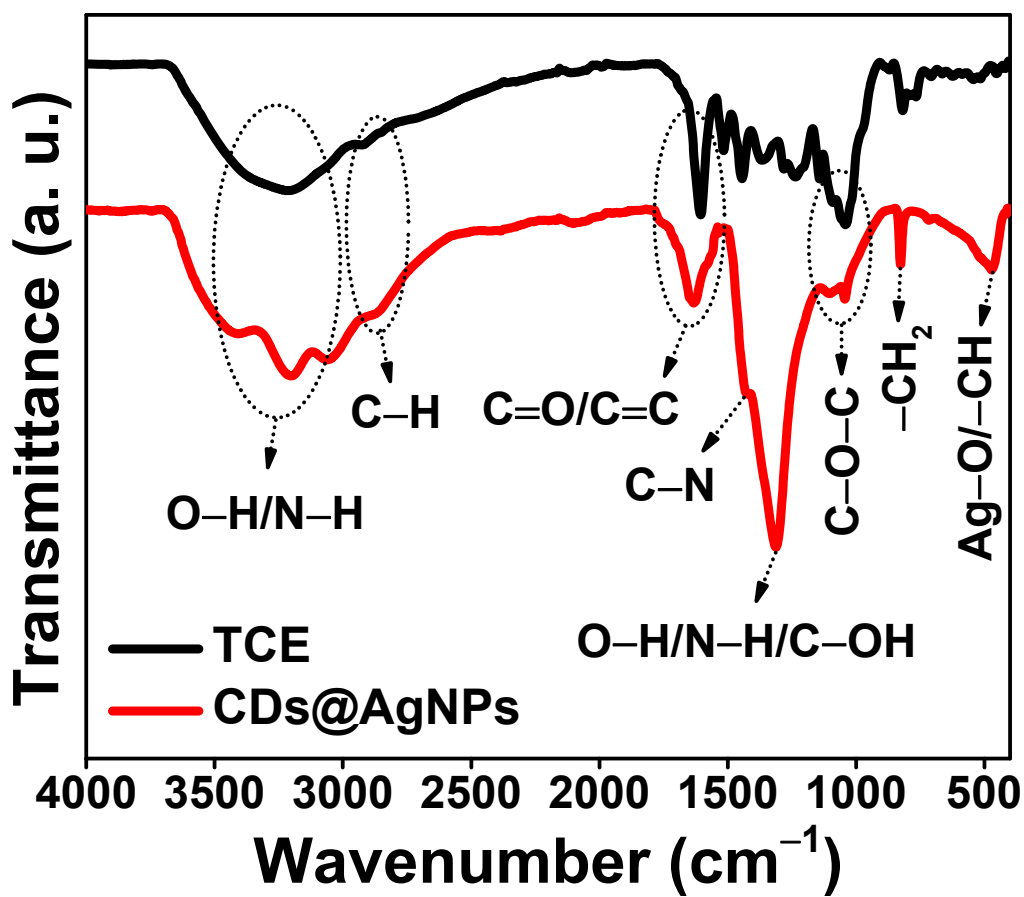


Figure S3. ATR-FTIR spectra of the *Terminalia chebula* fruit extract and synthesized CDs@AgNPs.

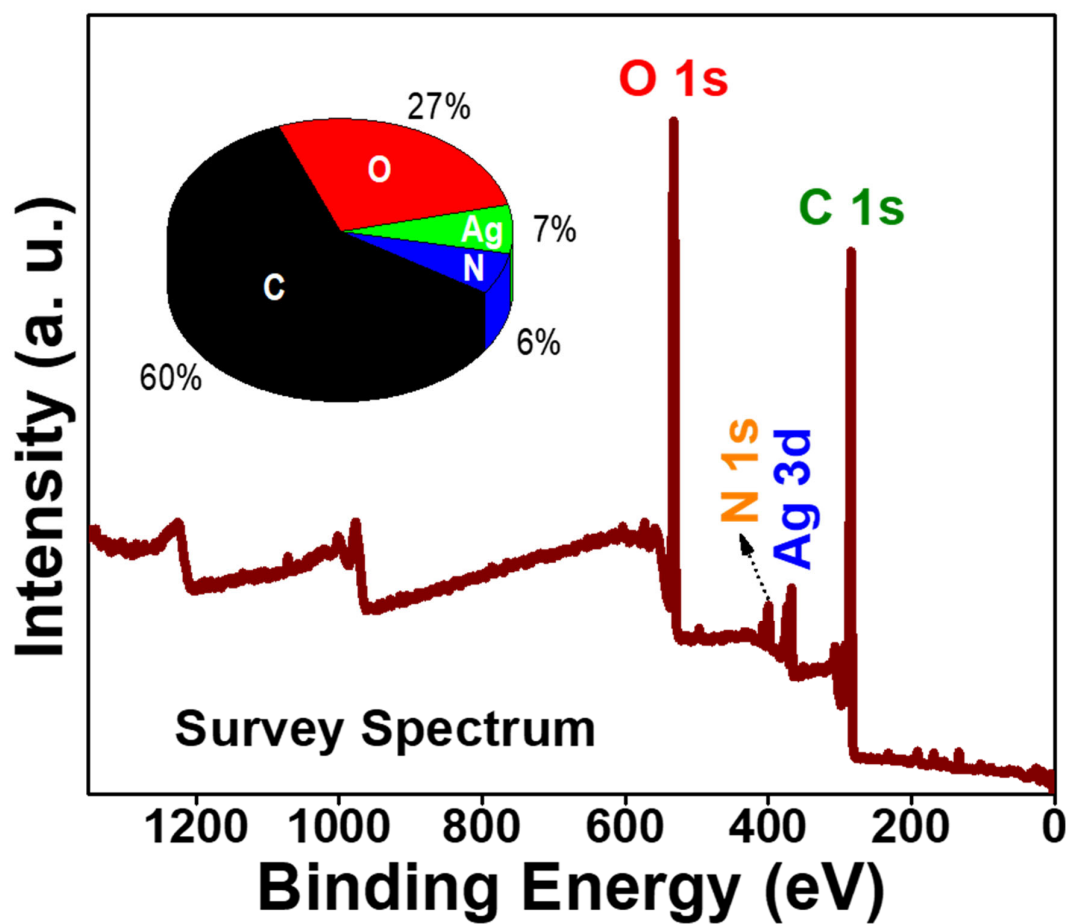


Figure S4. XPS survey spectrum of the synthesized CDs@AgNPs and inset is a pie chart of the elemental composition of the synthesized CDs@AgNPs.

Catalytic activity of the synthesized CDs@AgNPs for the degradation of organic dyes

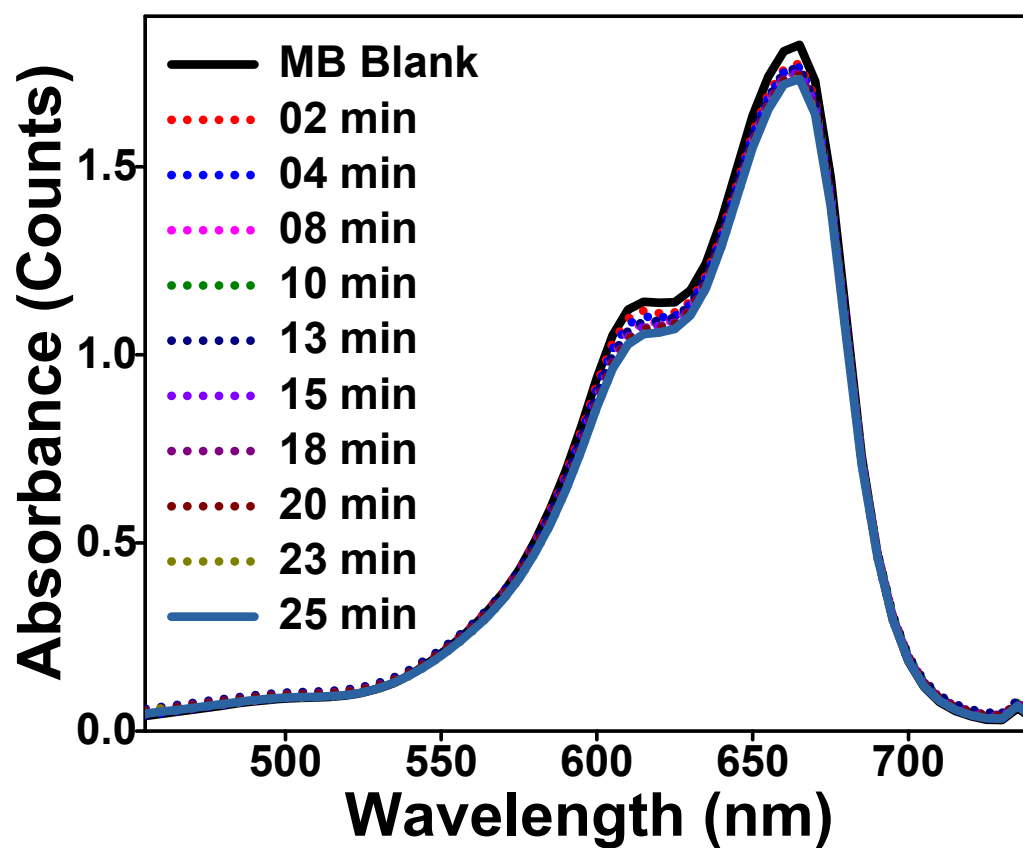


Figure S5. UV-vis absorbance spectra of MB in the presence of SB at different reaction times.

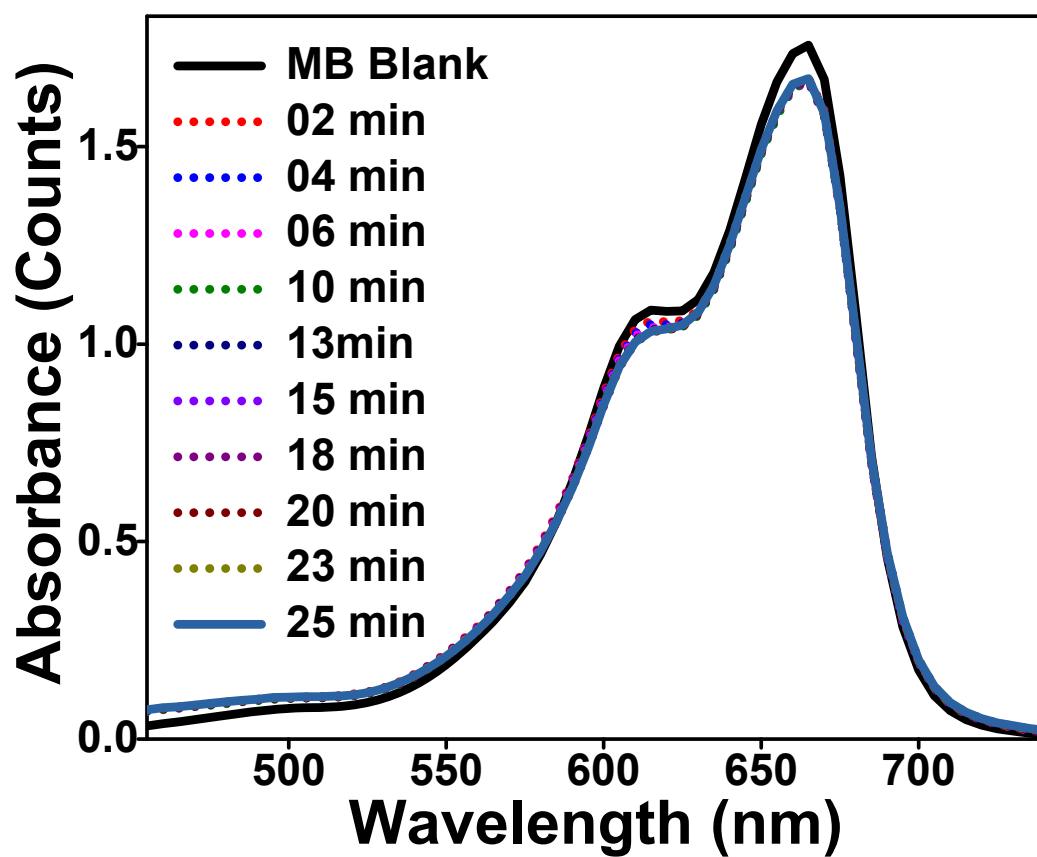


Figure S6. UV-vis absorbance spectra of MB in the presence of CDs@AgNPs at different reaction times.

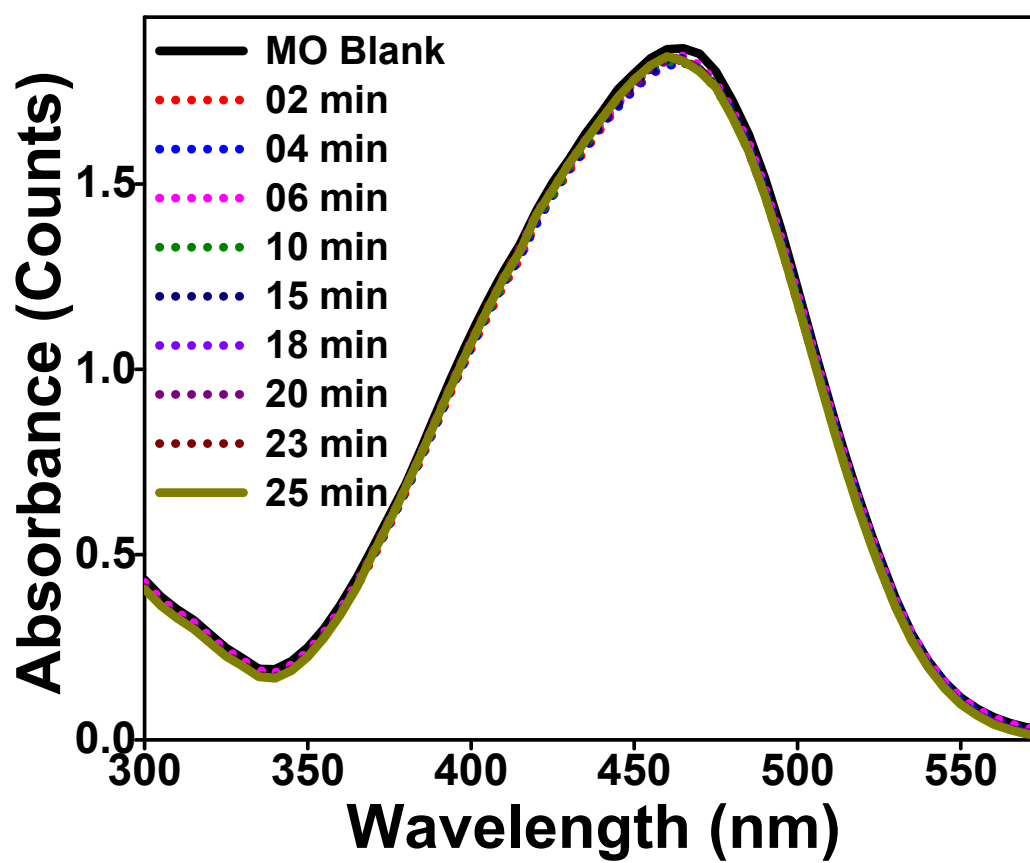


Figure S7. UV-vis absorbance spectra of MO in the presence of SB at different reaction times.

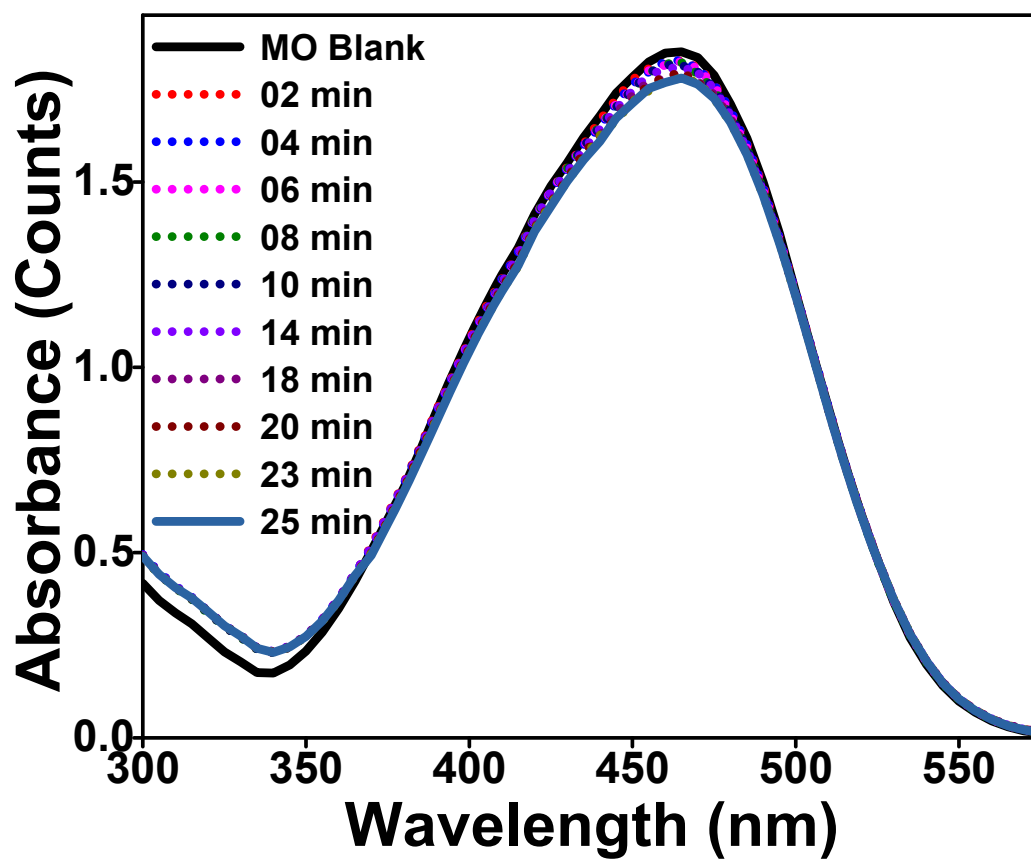


Figure S8. UV-vis absorbance spectra of MO in the presence of CDs@AgNPs at different degradation times.

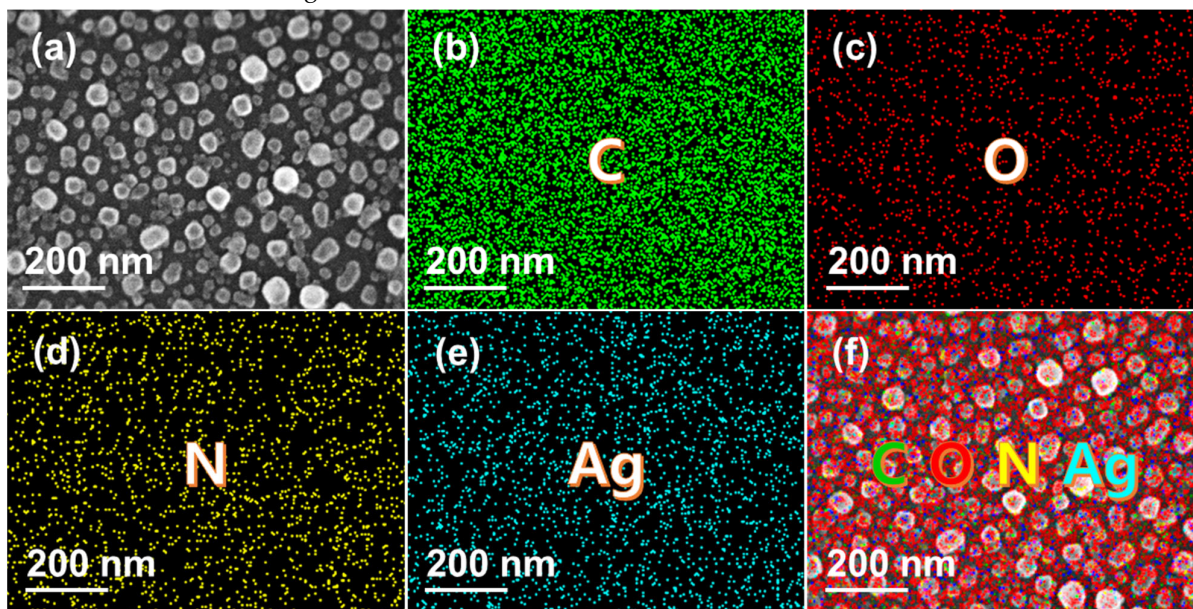


Figure S9. (a) FESEM electron image and (b-e) the corresponding elemental mapping of (b) carbon, (c) oxygen, (d) nitrogen, and (e) silver in the CDs@AgNPs after the degradation of organic dyes; (f) overlapping image of all elements (a-e) of the CDs@AgNPs after the degradation of organic dyes.