Supplementary Information

Unraveling the correlation of dielectric barrier discharge power and performance of Pt/CeO_2 catalyst for toluene oxidation

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CO-pulse chemisorption

Static CO-pulse chemisorption was used to evaluate the metal dispersion and particle size of Pt on CeO_2 by Micromeritics AutoChem II 2920. A 100 mg samples were pre-reduced at 300 °C for 3 h in 10% H_2/Ar flow (30 ml min^{-1}). After the subsequent temperature was cooled to 30 °C under Ar flow (30 ml min^{-1}), and then 10% CO/Ar pulse stream was periodically injected until the adsorption reached the saturation of the catalysts. Then, the dispersion ($D2_{Pt}$) and particle size ($d2_{Pt}$) of the Pt nanoparticles (NPs) were evaluated by Eq. (S1) and (S2).

$$d2_{Pt} = \frac{60X_{Pt}}{\rho_{Pt} S_{Pt}} \quad \text{(S1)}$$

$$D2_{Pt} = \frac{10 S_{Pt} M_{Pt}}{X_{Pt} a_{Pt} N_A} \quad \text{(S2)}$$

where X_{Pt} the amount of Pt loaded (%), M_{Pt} the molar weight of Pt (195.08 g mol^{-1}), ρ_{Pt} the density of Pt (21.45 g cm^{-3}), α_{Pt} the cross-sectional area of Pt atoms (8.06×10^{-20} m^2 $atom^{-1}$), N_A Avogadro constant (6.019×10^{23} atom mol^{-1}) and S_{Pt} the surface area of Pt relative to the sample obtained from CO pulse chemisorption (m^2 g^{-1}). The stoichiometric ratio of CO and the Pt atom was set as 1:1.

Table S1 Particle size and dispersion

Catalysts	[f] Pt particle size (nm)	[f] Dispersion (%)
Pt/CeO_2	3.32	33.85
Pt/CeO_2-P1	3.18	35.41
Pt/CeO_2-P2	3.04	37.05
Pt/CeO_2-P3	3.05	36.84
Pt/CeO_2-P4	3.25	34.58
Pt/CeO_2-P5	3.48	32.33
Pt/CeO_2-P6	3.31	33.94
Pt/CeO_2-P7	3.07	36.65
Pt/CeO_2-P8	4.14	27.20

[f] Diameter of the loading Pt NPs measured by CO chemisorption, conducted at 303 K.

O_2-pulse chemisorption

Through saturated O_2 chemisorption at room temperature, the consumption of O (OSC_{Catal}) was directly obtained, and the consumption of Pt (OSC_{Pt}) was calculated based on Eq. (S3). The stoichiometric ratio of O and the metal atom was set as 2:1. And the surface oxygen vacancy concentration (OSC_{surf}) was calculated by Eq. (S4). (the calculations shown in table S2)

$$OSC_{\mathrm{Pt}} = \frac{2\mathrm{D}2_{\mathrm{Pt}}X_{Pt}}{M_{Pt}}10^2 \quad \text{(S3)}$$

$$OSC_{\mathrm{Surf}} = OSC_{\mathrm{Catal}} - OSC_{\mathrm{Pt}} \quad \text{(S4)}$$

where X_{Pt}, M_{Pt} are the same meaning prementioned. And before the measurement, all catalysts were pre-reduced under 10% H_2/Ar at 300 °C for 3 h.

Table S2 Relative concentration of OSC from O_2 chemisorption

Catalysts	OSC_{Pt} (μmol O g^{-1})	OSC_{Surf} (μmol O g^{-1})
Pt/CeO_2	28	176
Pt/CeO_2-P1	27	179
Pt/CeO_2-P2	28	183
Pt/CeO_2-P3	28	180
Pt/CeO_2-P4	27	162
Pt/CeO_2-P5	24	185
Pt/CeO_2-P6	25	189
Pt/CeO_2-P7	30	170
Pt/CeO_2-P8	21	182

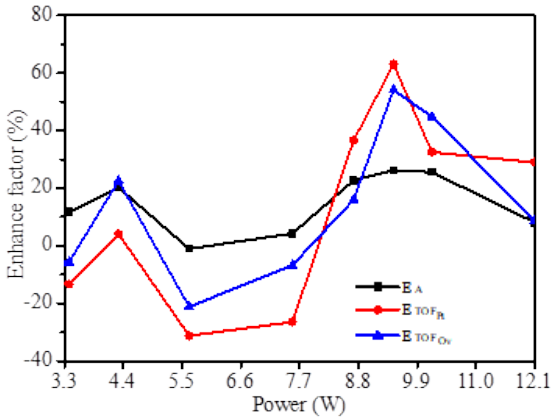

Figure S1 Relationship between T_{90}, TOF_{Pt} and TOF_{Ov} and varying discharge power

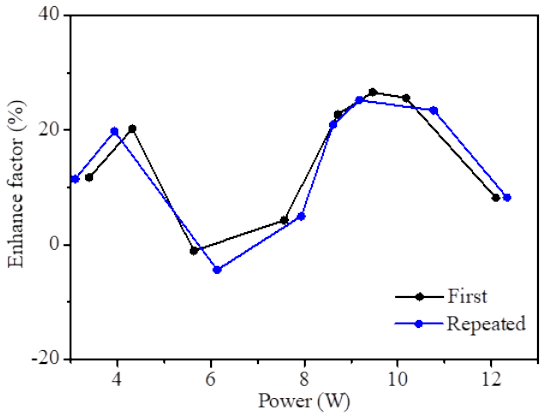

Figure S2 Activity evaluation of repeated experiment

The catalytic activities had been repeated for fresh samples which were re-prepared and treated by plasma with various discharge power to verify before drawing a conclusion. There are differences in the various discharge power, the reason that it is difficult to control the discharge power staying at the same power point due to the catalyst material and DBD discharge properties. But the Pt/CeO_2 catalyst's activity (T_{90}) shown the similar trends with increasing discharge power.

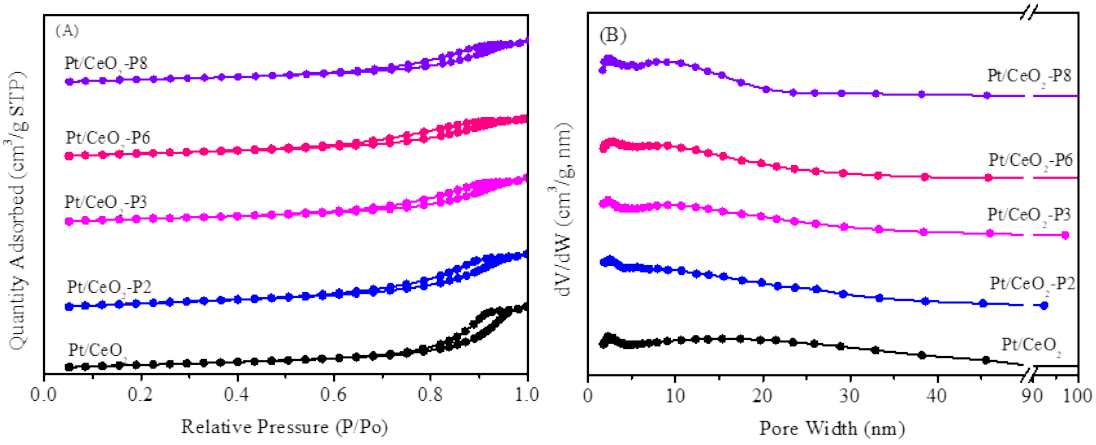

Figure S3 N_2 adsorption-desorption (A) and pore size distributions (B) of all samples

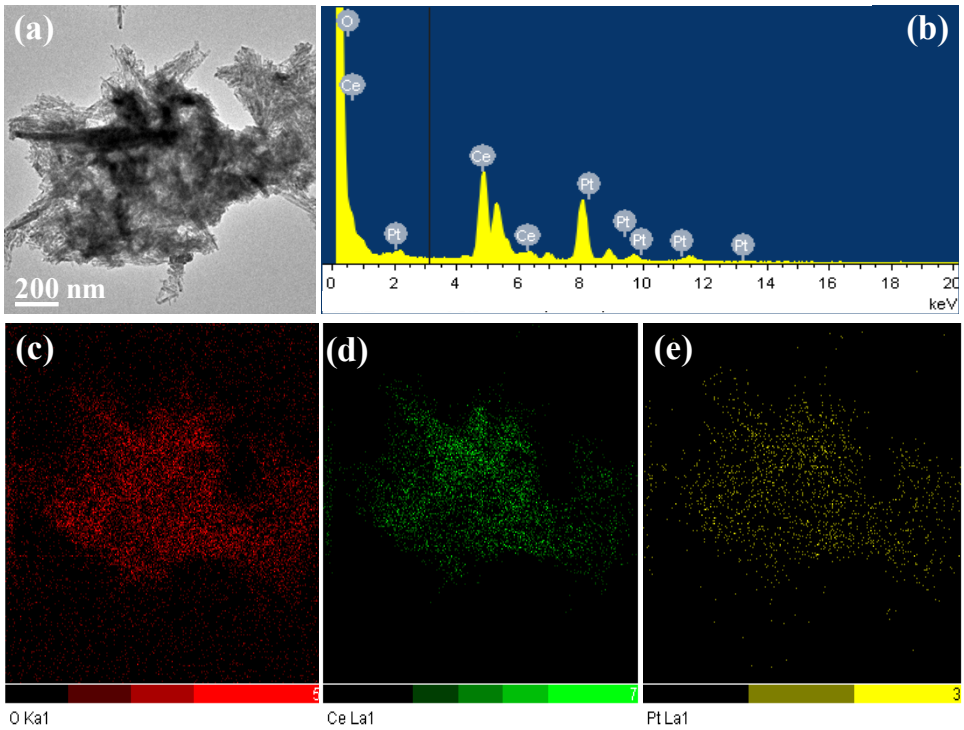

Figure S4 EDX mapping of Pt/CeO_2 catalyst (STEM image (a) and elemental (b) with corresponding distribution of O (c), Ce (d) and Pt (e) elements)

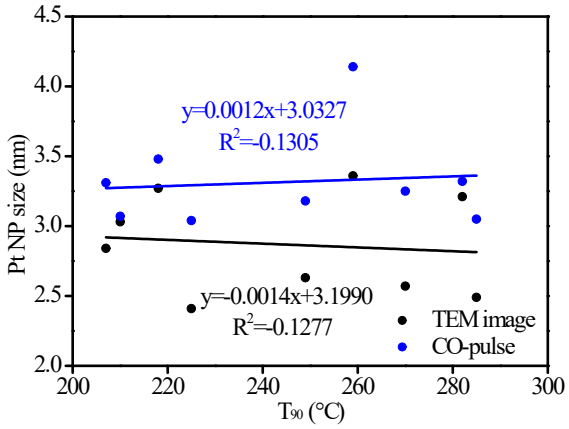

Figure S5 Relationship between activity and Pt NP size for all catalysts

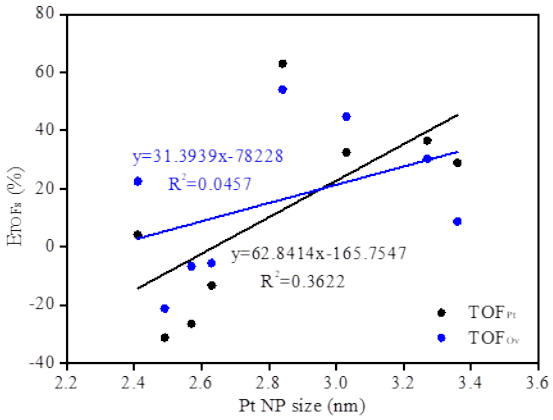

Figure S6 Relationship between Pt NP size and TOFs for all catalysts

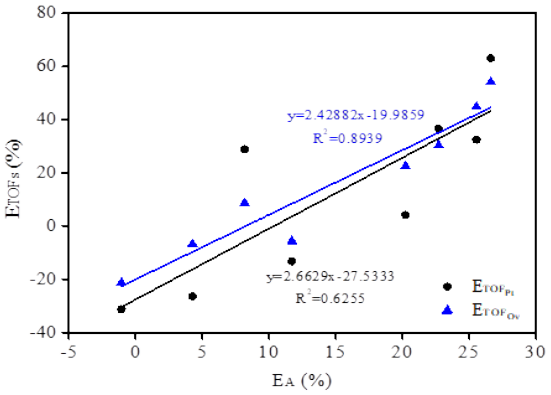

Figure S7 Relationship between activity and TOFs (TOF_{Pt} and TOF_{Ov}) for all catalysts by plasma treatment with various discharge power