Supporting data

Materials: [$Y(NO_3)_3.6H_2O$, ≥99.0 %], [$Ce(NO_3)_3.6H_2O$, ≥99.0 %], [$La(NO_3)_3.6H_2O$, ≥99.0 %], [$Al(NO_3)_3.9H_2O$, ≥99.0 %], [$Pd(NH_3)_4Cl_2$, Pd≥43.0 %], [$Pd(NO_3)_2.2H_2O$, Pd≥39.5 %] and [$Zr(NO_3)_4.5H_2O$, ≥99.0 %] were supplied by Sinopharm Chemical Reagent Co., Ltd (Shanghai, China). Potassium hydroxide pellets (KOH, ≥96.0 %) also supplied by Sinopharm Chemical Reagent Co., Ltd (Shanghai, China) were used to adjust the pH. All chemicals were used as obtained. Distilled water was used in all experiments.

Preparation: Wet impregnation route was employed herein for the preparation of wi-0.5PdCZA sample, where accurately measured 1.4 g CZA nanopowders (containing appropriately 1 g CZ powders) was added into 100 ml aqueous solution of $Pd(NO_3)_2$ (0. 46 mM), followed by stirring for 48 h and subsequently drying at 80 °C for 18 h. Further heat-treatment at 400 °C for 3 h would yield even lower activity for toluene oxidation (see below).

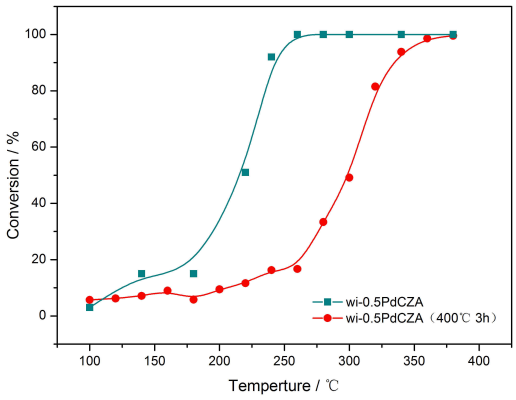

Figure Toluene conversions as a function of temperature for the catalysts.

Characterizations: Freeze-drying was performed using a Vacuum Freeze Dryer, Model LGJ-10C, supplied by Beijing Boyikang Laboratory Instruments Co., Ltd; the solids were frozen for 4 h at –50 °C and then freeze-dried for 24 h at 10 Pa. Surface elemental analysis was carried out by XPS using a Thermo ESCALAB 250 (USA) instrument with Al-Kα radiation (photon energy 1486.6 eV) at 150W. The signal of adventitious carbon (a binding energy of 284.8 eV) had been used to calibrate the binding energy scale for XPS measurements. Curve fits were performed using a Shirley background and a Gaussian peak shape with 30 % Lorentzian character.

Supplementary Figure

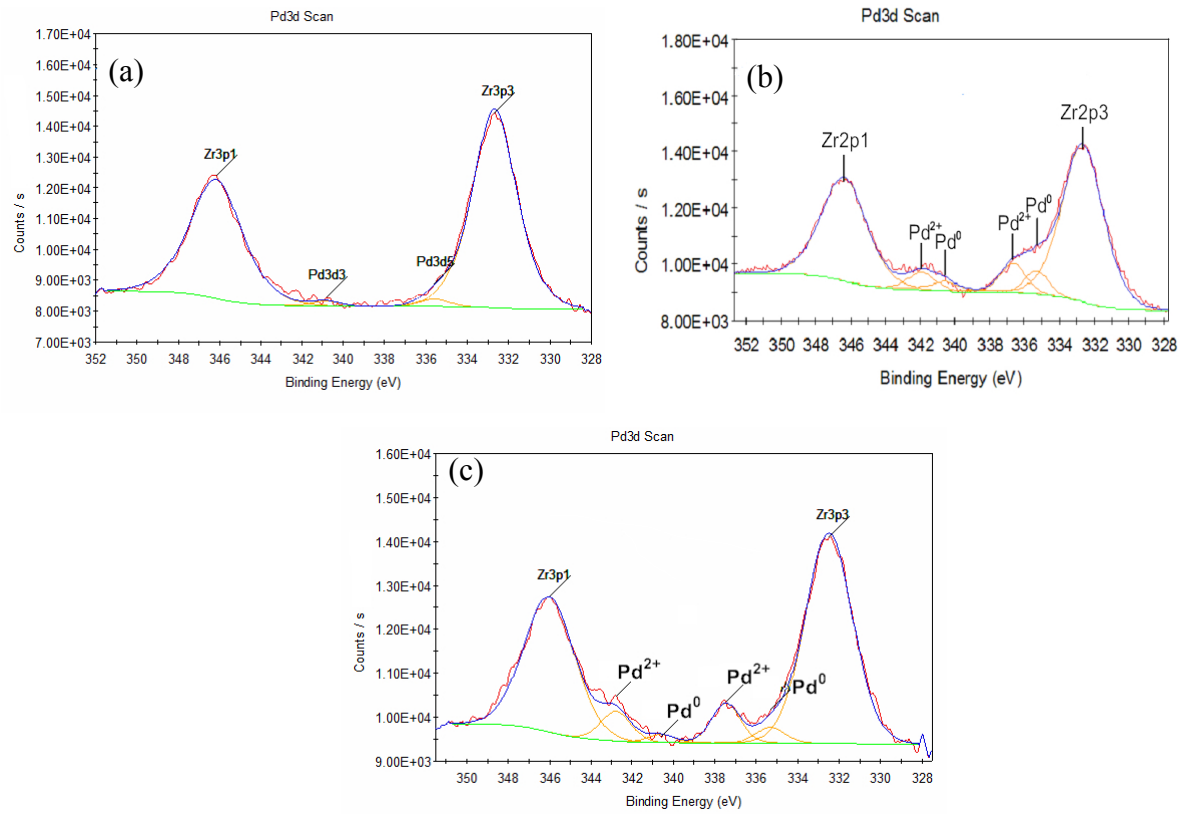

Figure S1. XPS spectra for Pd3d5 in (a) sc-0.5PdCZA sample, (b) etched sc-0.5PdCZA sample and (c) wi-0.5PdCZA sample.

Supplementary table

Table S1 ICP measurments for sc- and wi-0.5PdCZA samples

Samples	Content (mg/L)					
	Pd	Ce	Zr	La	Y	Al
wi-0.5PdCZA	0.36	22.13	9.97	1.44	1.26	19.25
Sc-0.5PdCZA	0.49	28.95	11.89	2.00	1.32	15.58