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Supported Platinum-Zinc Oxide Core-Shell Nanoparticle Catalysts for Methanol Steam Reforming

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Experimental Section

Characterization

Powder X-ray diffraction (XRD) patterns were recorded using a Rigaku Geigerflex diffractometer with Cu-K_α radiation source. Temperature-Programmed-Oxidation (TPO) measurements were performed in a ¼-inch, quartz, tubular reactor equipped with an on-line quadrupole mass spectrometer. Experiments were conducted with 0.1 g of sample to determine when the carbon, organic ligands, are removed from the sample. The samples that were examined by TPO in this study were not calcined but simply dried at 338 K overnight and pressed into thin wafers before placing them in the reactor. The gas-phase composition was chosen to be 20% O_2 in He, with a total flow rate of 25 mL min^{-1}; and the heating rate was 3 K min^{-1}. The peaks in Figure S1 correspond to O_2 (*m/e* = 32). Temperature programmed reduction (TPR) was carried out on the Pt@ZnO/Si-Al_2O_3 catalyst that had been calcined at 773 K, using H_2 with a heating rate of 10 K min^{-1}.

Figures and Tables

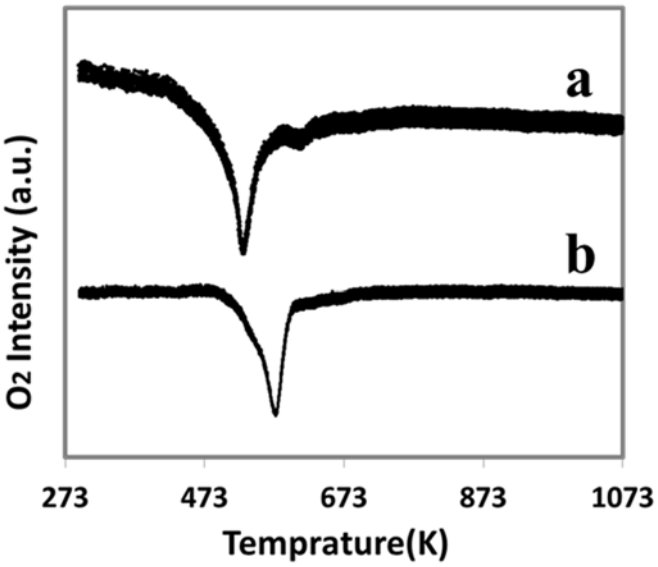

Fig. S1 Temperature programmed oxidation (TPO) results for uncalcined (a) Pt@ZnO/Si-Al_2O_3 and (b) Pd@ZnO/Si-Al_2O_3 samples.

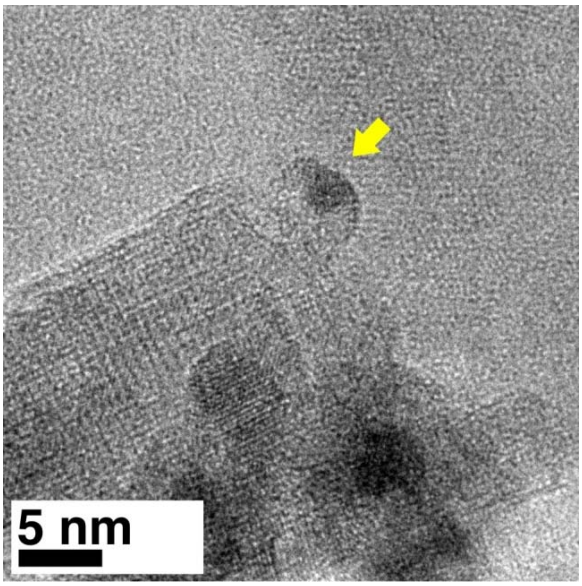

Fig. S2 Representative TEM image of Pd@ZnO/Si-Al_2O_3 sample calcined at 773 K in air. Yellow arrows point to core-shell structures where the higher contrast is attributed to Pd cores surrounded by a lighter, ZnO shell.

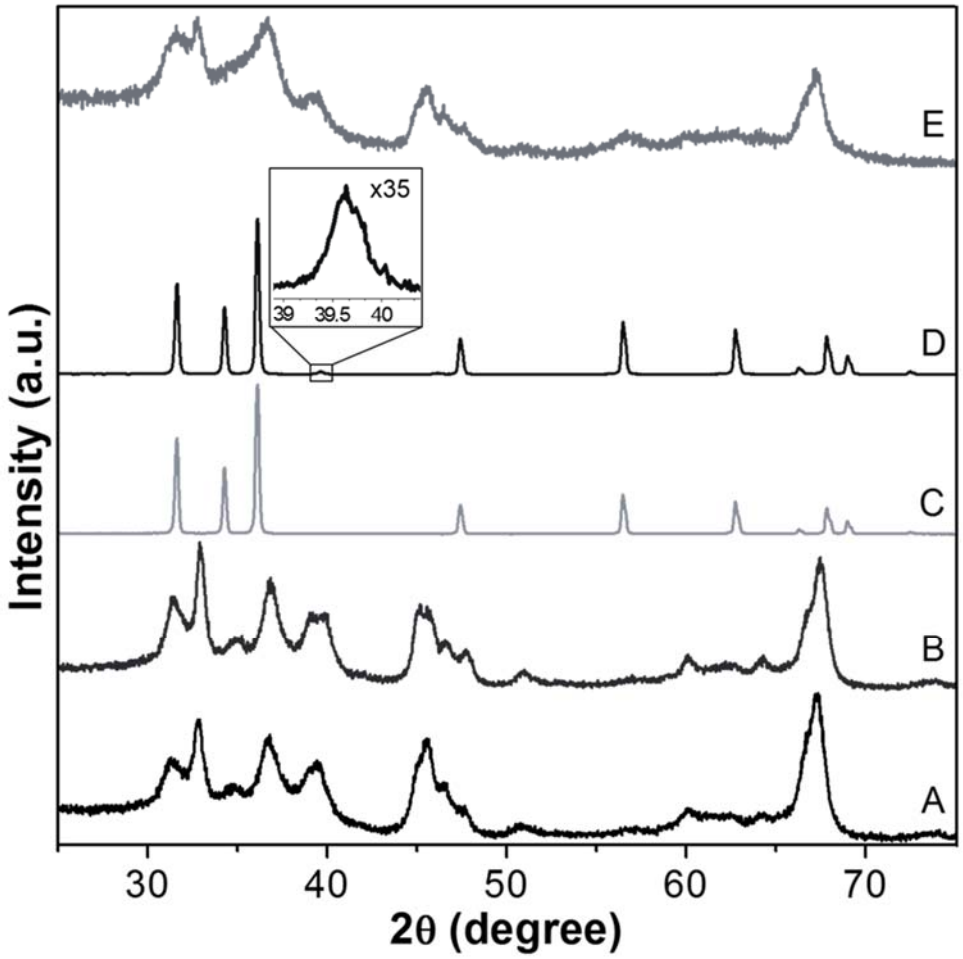

Fig. S3 X-ray diffraction (XRD) patterns of (A) Si-Al_2O_3, (B) Pt/Al_2O_3, (C) ZnO, (D) Pt/ZnO, and (E) Pt@ZnO/Si-Al_2O_3. Inset in (D) show magnification of the platinum (111) region.

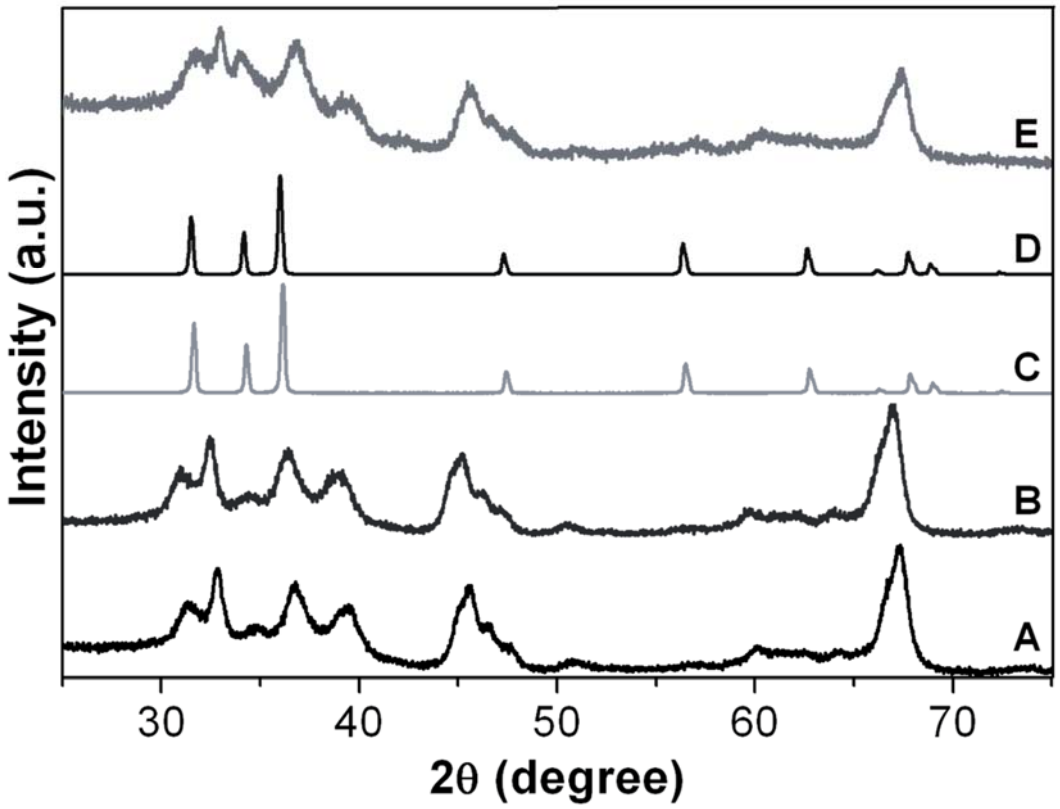

Fig. S4 X-ray diffraction (XRD) patterns of (A) Si-Al_2O_3, (B) Pd/Al_2O_3, (C) ZnO, (D) Pd/ZnO, and (E) Pd@ZnO/Si-Al_2O_3 calcined at 773 K.

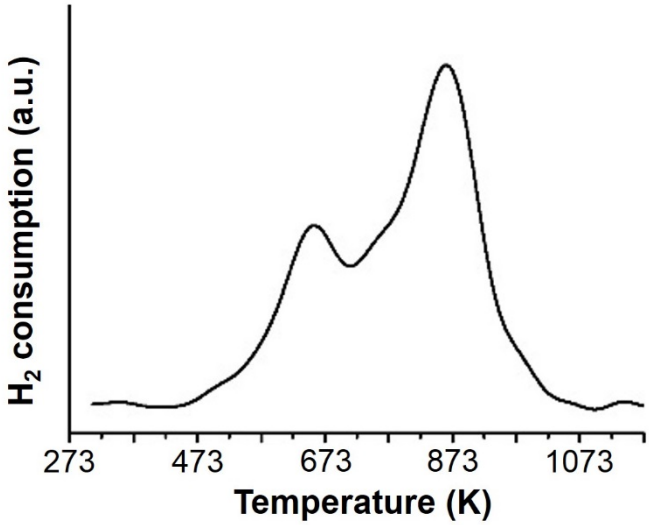

Fig. S5 Temperature programmed reduction (TPR) profile for the Pt@ZnO/Si-Al_2O_3 sample.

Table S1 Methanol steam reforming activity and CO_2 selectivity of the catalysts at 573 K.

Catalysts	Conversion (%)	CO_2 selectivity (%)
Pt@ZnO/Si-Al_2O_3	92	76
Pt/Al_2O_3	99	10
Pt/ZnO	92	66
Pd@ZnO/Si-Al_2O_3	95	34
Pd/ZnO	93	65
Pd/Al_2O_3	99	1