Supporting Information

Structural Dynamics of $PtSn/SiO_2$ for Propane Dehydrogenation

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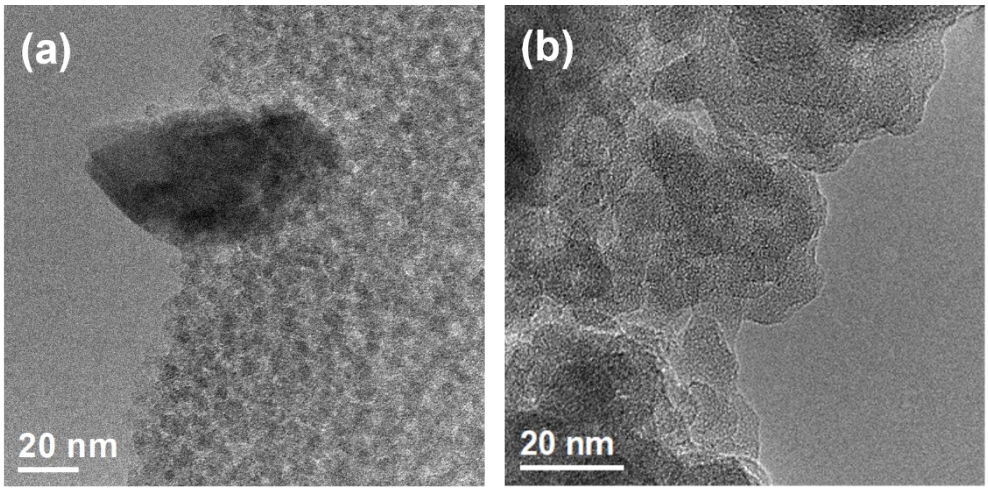

Figure S1. ***HRTEM images of Sn/SiO_2.*** *(a) HRTEM of Sn/SiO_2-500C; (b) HRTEM of Sn/SiO_2-500C-600R.*

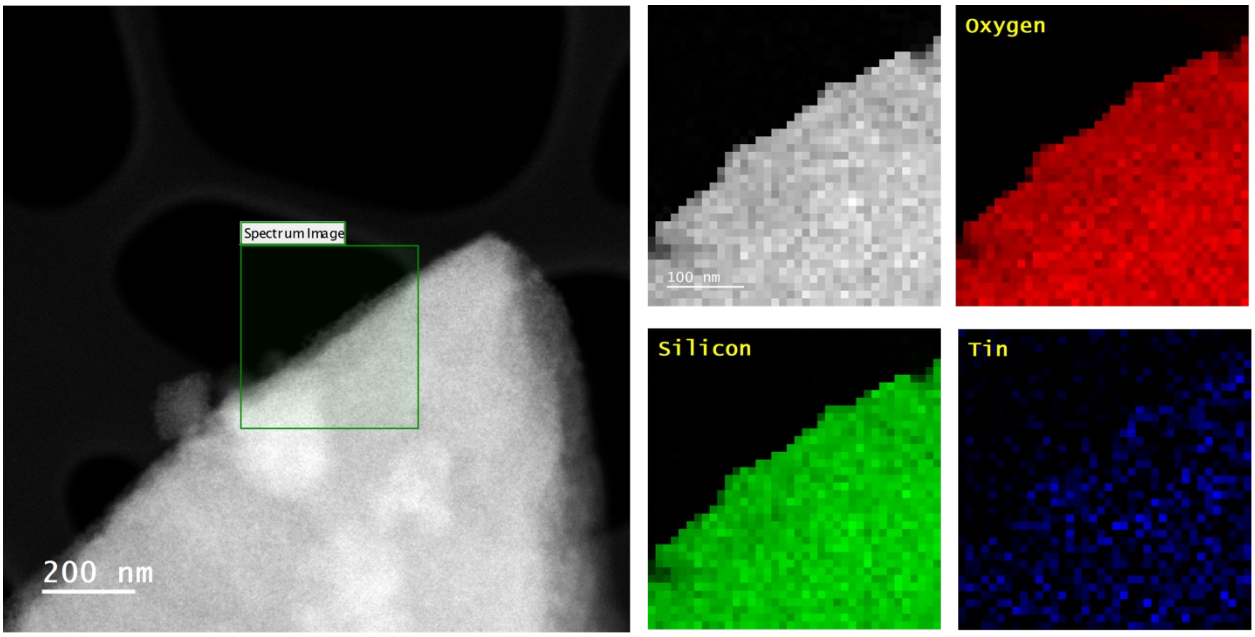

Figure S2. ***EDS mapping images of Sn/SiO_2****. Sn species are uniformly distributed on the SiO_2 support.*

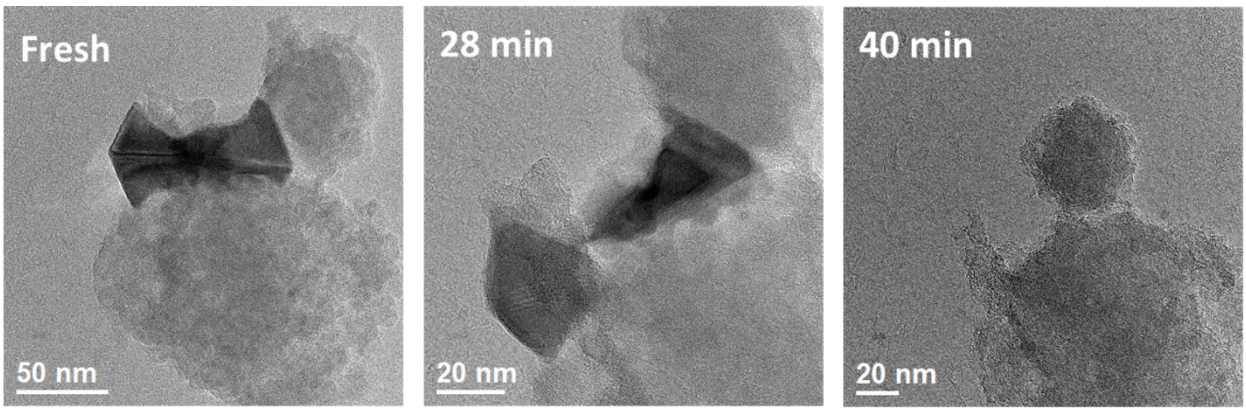

Figure S3. ***In situ heating HRTEM images of Sn/SiO_2 in vacuum at 600 °C.*** *Images are from a sample region with a large SnO_2 cluster, after the indicated duration of heating time. The SnO_2 cluster (a darker region in the first image) disappeared after heating for 40 min. Electrons from the TEM act as the reducing agent.*

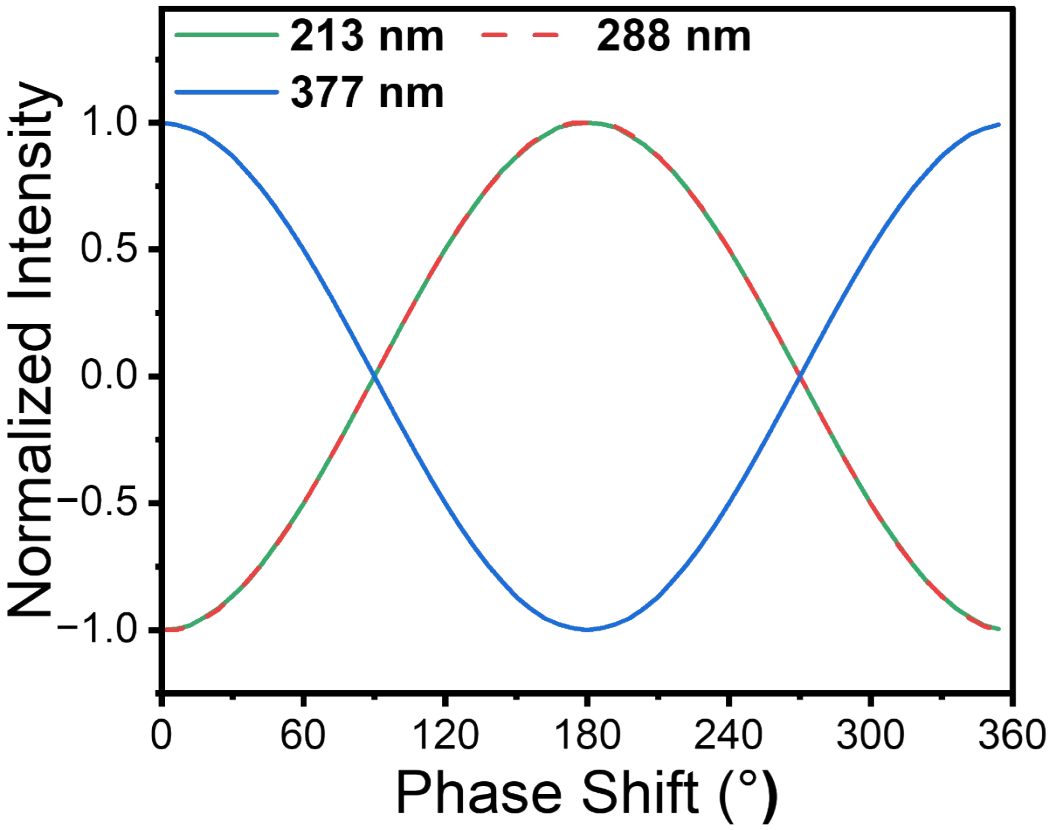

Figure S4. ***Phase plot for MES-UV-vis spectra.*** *Same phase for 213 nm and 288 nm bands, which are in opposite phase with 377 nm band.*

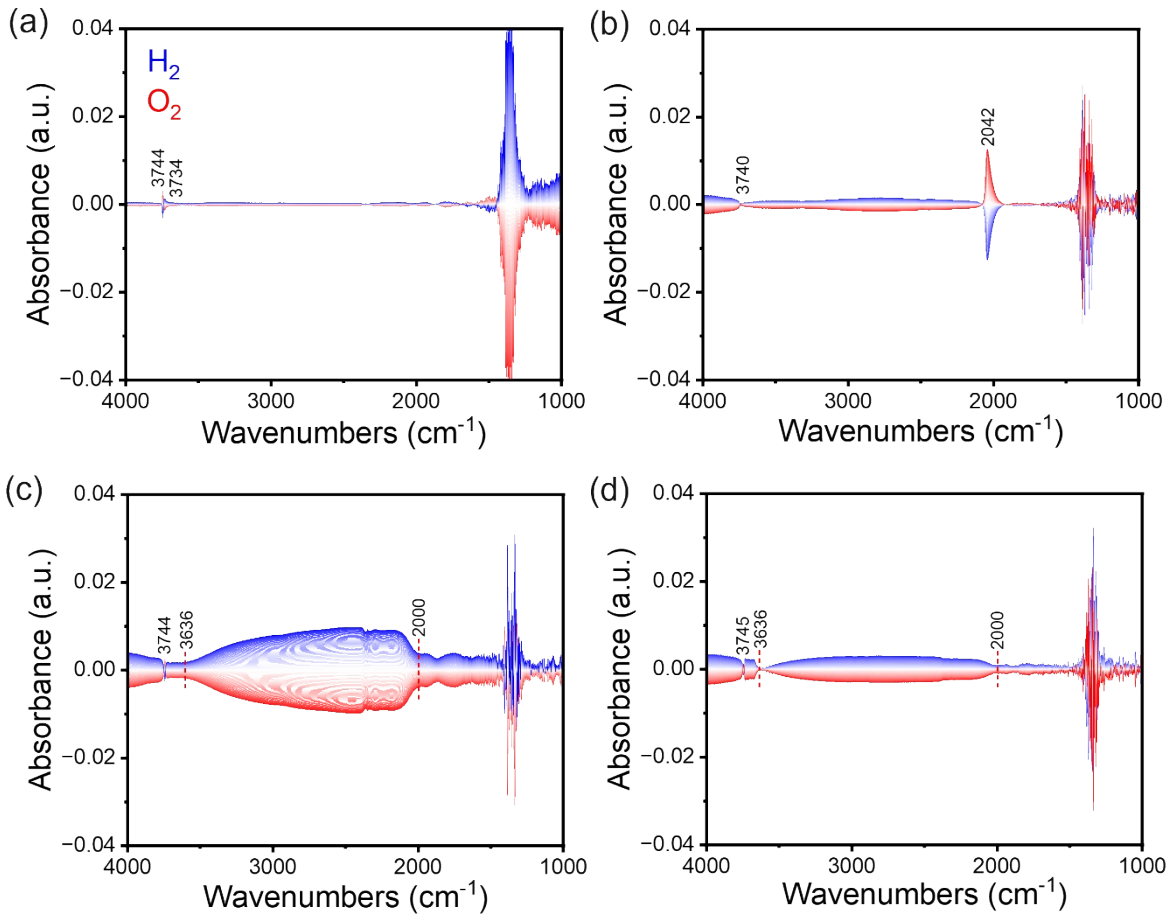

Figure S5. ***Phase domain MES-DRIFTS-FTIR in full range for:*** *(a) SiO_2; (b) Pt/SiO_2; (c) Sn/SiO_2; and (d) $1Pt3Sn/SiO_2$-seq. Gas feed: 10% O_2/Ar or 10% H_2/Ar, total 50 sccm gas flow. Modulation frequency = 1/120 Hz (period = 120 s). Temperature = 400 °C.*

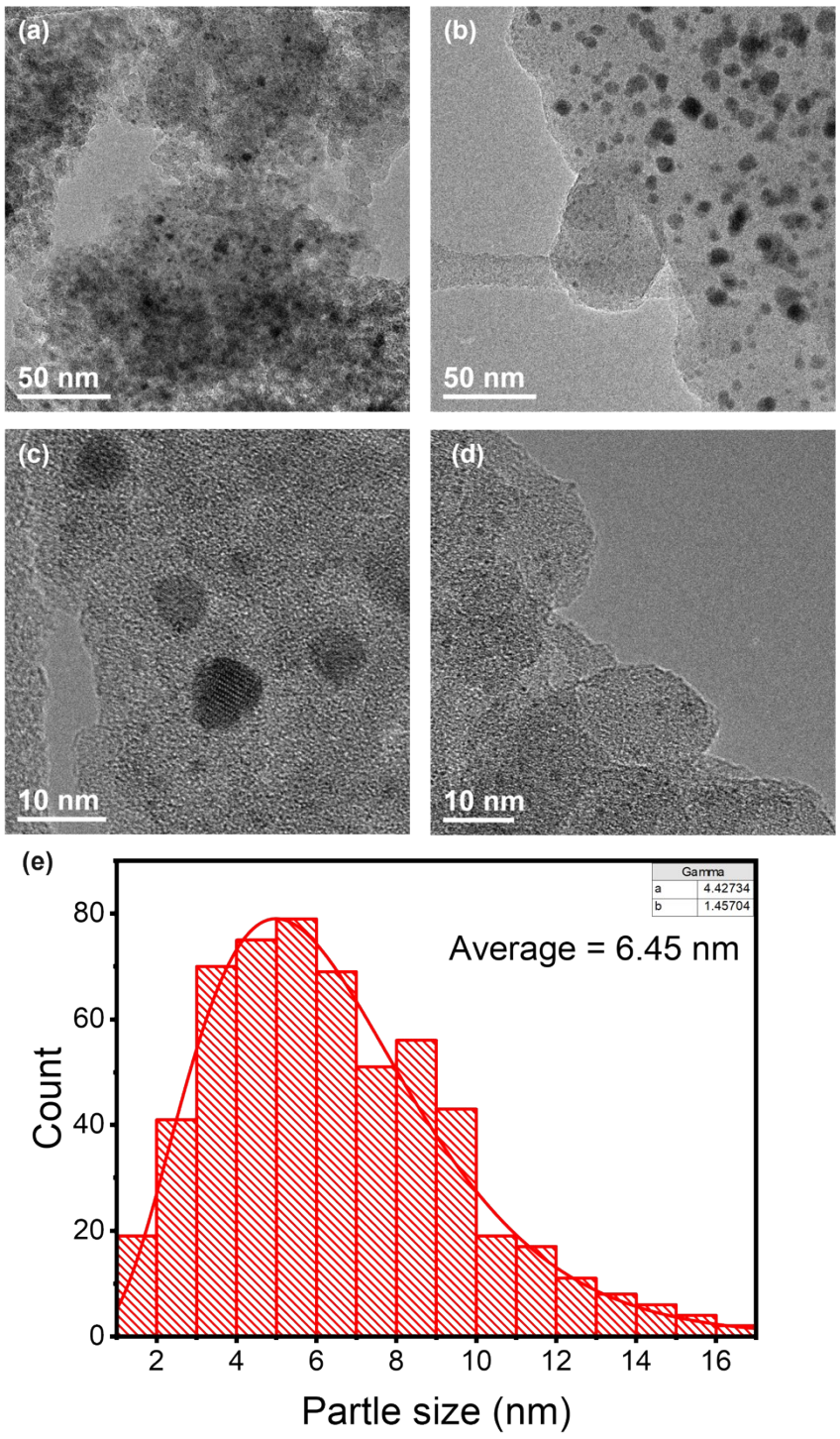

Figure S6. ***HRTEM images of 1Pt2Sn/SiO_2-co.*** *(a)-(d) TEM images. (e) Particle size distribution. Images indicate a wide particle size distribution, ranging from subnanometer clusters to particles larger than 10 nm.*

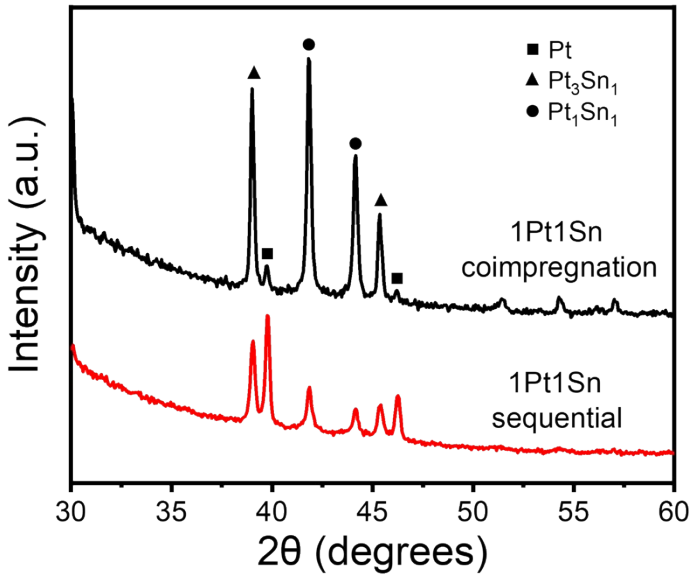

Figure S7. ***XRD of PtSn/SiO$_2$ catalysts synthesized through calcination-reduction****. 500 °C calcination in air, 600 °C reduction in 10% H_2.*

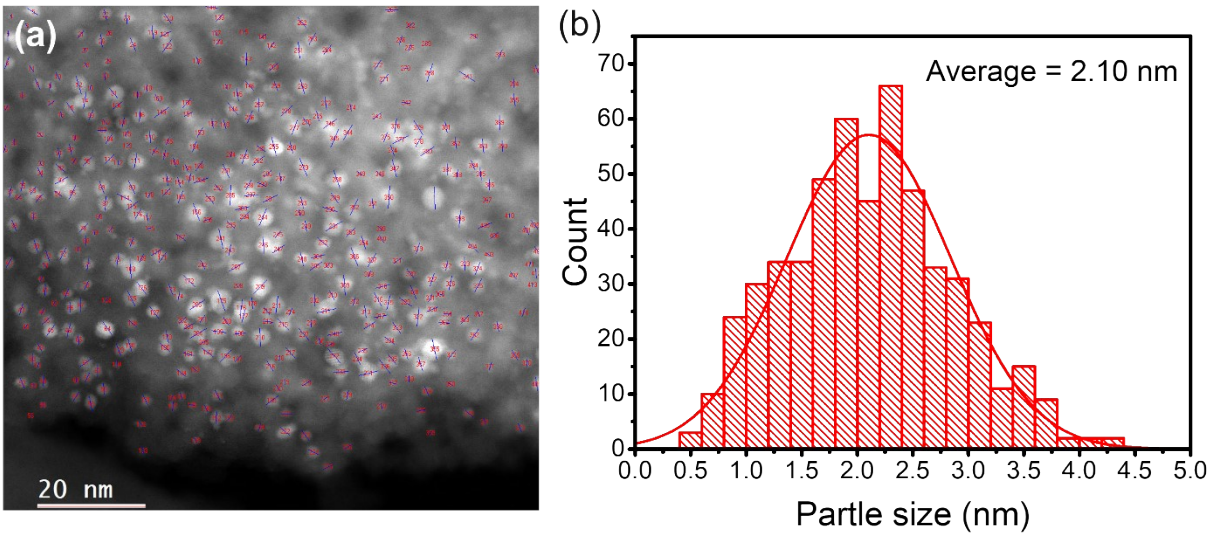

Figure S8. ***HAADF-STEM imaging of 1Pt3Sn/SiO_2-seq .*** *(a) STEM image; (b) particle size distribution and average particle size.*

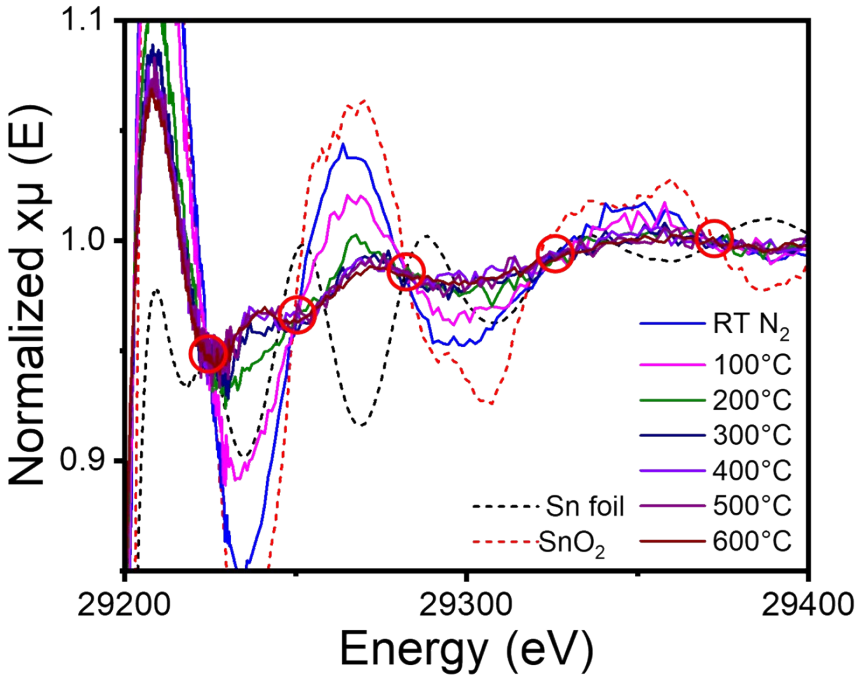

Figure S9. ***Sn K-edge XANES spectra of 1Pt3Sn/SiO_2-seq*** *(zoom in view). Isosbestic points indicated by the circles.*

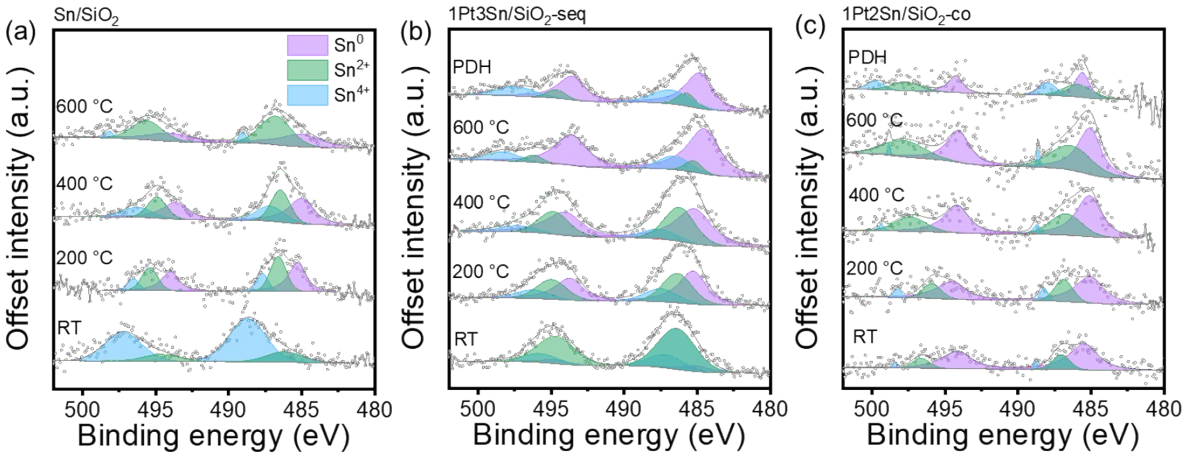

Figure S10. ***NAP-XPS Sn 3d spectra****. (a) Sn/SiO_2; (b) 1Pt3Sn/SiO_2-seq; (c) 1Pt2Sn/SiO_2-co. Spectra taken during reduction at indicated temperatures in 1 mbar H_2. PDH spectra taken in 1 mbar C_3H_8 at 600 ℃.*

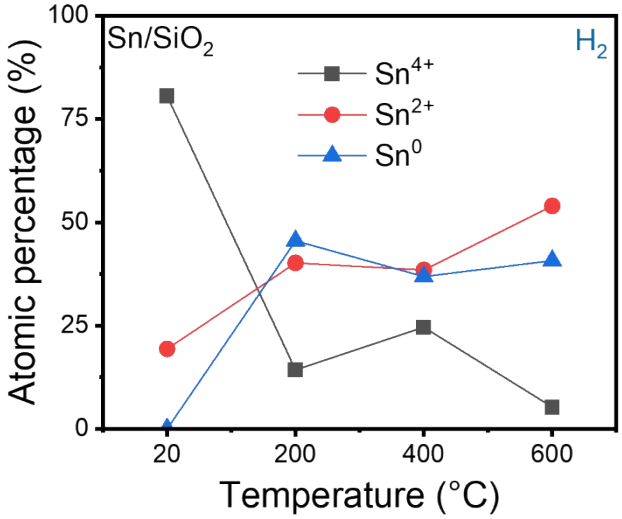

Figure S11. ***NAP-XPS surface Sn oxidation states composition evolution with temperature of Sn/SiO_2.***

Table S1. ***NAP-XPS surface Sn oxidation state percentage****. (a) 1Pt3Sn/SiO_2-seq; (b) Sn/SiO_2; (c) 1Pt2Sn/SiO_2-co. Measurement conducted 1 mbar H_2 or C_3H_8 at indicated temperatures.*

	Sn^{4+} (%)	Sn^{2+} (%)	Sn^0 (%)
1Pt3Sn/SiO_2-seq 1 mbar H_2 20 °C	21.021	69.20615	9.77285
1Pt3Sn/SiO_2-seq 1 mbar H_2 200 °C	17.55581	35.61	46.8342
1Pt3Sn/SiO_2-seq 1 mbar H_2 400 °C	11.54706	35.14118	53.31176
1Pt3Sn/SiO_2-seq 1 mbar H_2 600 °C	17.71299	7.93077	74.35625
1Pt3Sn/SiO_2-seq 1 mbar C_3H_8 600 °C	27.07032	12.14468	60.785
Sn/SiO_2 1 mbar H_2 RT	80.60708	19.39292	0
Sn/SiO_2 1 mbar H_2 200 °C	14.25745	40.19437	45.54818
Sn/SiO_2 1 mbar H_2 400 °C	24.60946	38.48766	36.90288
Sn/SiO_2 1 mbar H_2 600 °C	5.2814	53.9833	40.73531
1Pt2Sn/SiO_2-co 1 mbar H_2 20 °C	2.42285	20.34371	77.23343
1Pt2Sn/SiO_2-co 1 mbar H_2 200 °C	6.47813	27.19262	66.32925
1Pt2Sn/SiO_2-co 1 mbar H_2 400 °C	3.27675	32.7611	63.96215
1Pt2Sn/SiO_2-co 1 mbar H_2 600 °C	2.01534	41.82163	56.16304

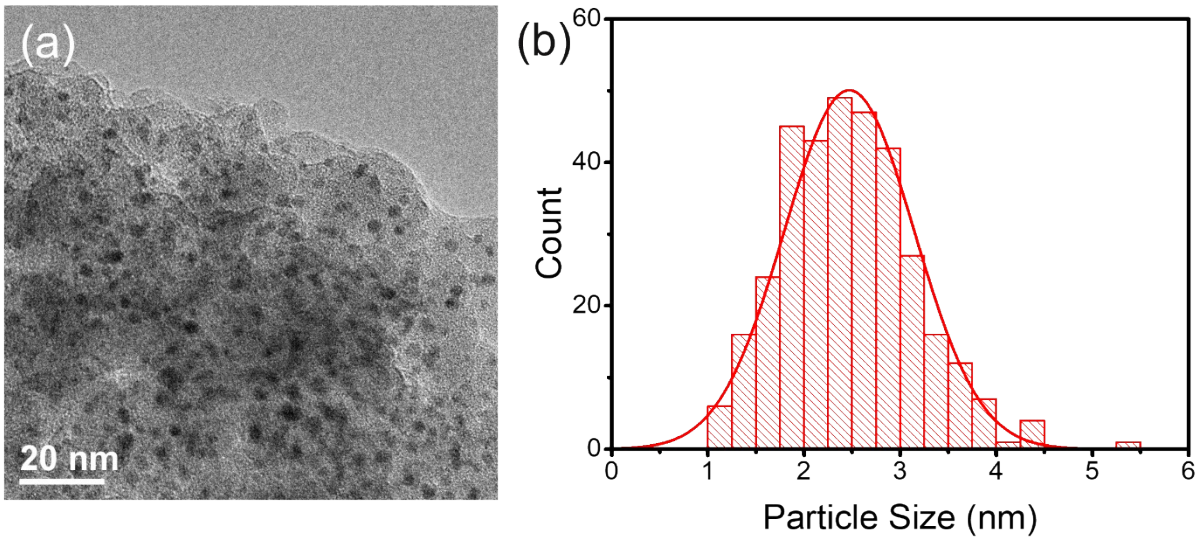

Figure S12. ***HRTEM of Pt/SiO$_2$****. (a) HRTEM image; (b) Particle size distribution. Average size is 2.47 nm.*

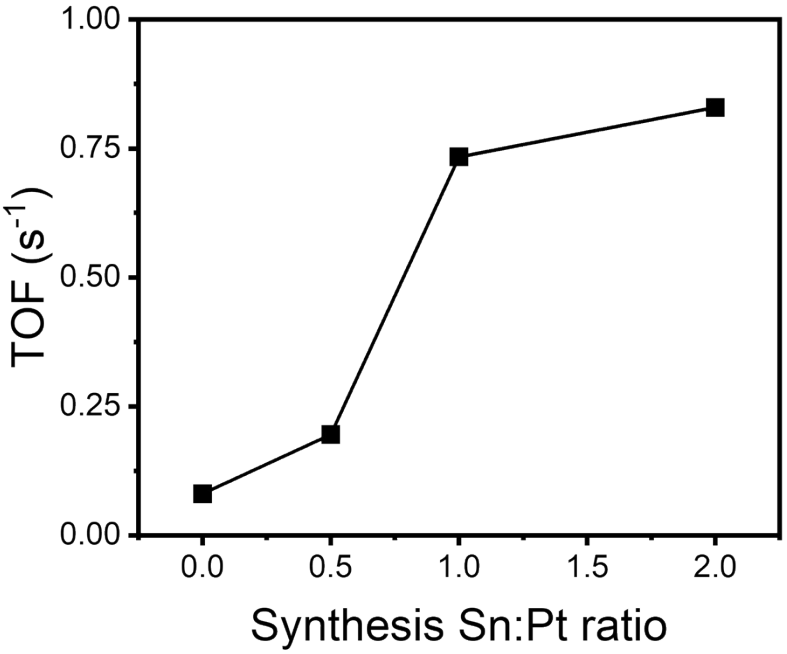

Figure S13. ***TOF vs. synthesis Sn:Pt ratio for PtSn/SiO_2-co.*** *Site densities are estimated based on the CO chemisorption result of Pt/SiO_2 and CO DRIFTS results of Sn-containing samples. PDH reaction rates are based on the initial conversion in the time on stream result in Figure 7.*