

## Electronic Supplementary Information

### **Ru-Promoted CO<sub>2</sub> activation for Oxidative Dehydrogenation of Propane over Chromium Oxide Catalyst**

Renxi Jin,<sup>a</sup> Justin Easa,<sup>a</sup> Dat T. Tran,<sup>b</sup> and Casey P. O'Brien<sup>a,b,\*</sup>

<sup>a</sup> *Department of Chemical and Biomolecular Engineering, University of Notre Dame, Notre Dame, Indiana 46556, United States*

<sup>b</sup> *Sensors and Electron Devices Directorate, FCDD-RLS-DE, CCDC Army Research Laboratory, 2800 Powder Mill Road, Adelphi, MD 20783*

Table S1 Catalytic performance of catalysts for the dehydrogenation reaction of propane with or without CO<sub>2</sub>, measured after 50 min on stream.

Sample	Reaction condition	Production rate (mmol/ g <sub>catal</sub> / h)			Conversion(%)		Selectivity(%)	Yield (%)
		C <sub>3</sub> H <sub>6</sub>	CO	H <sub>2</sub>	C <sub>3</sub> H <sub>8</sub>	CO <sub>2</sub>	C <sub>3</sub> H <sub>6</sub>	C <sub>3</sub> H <sub>6</sub>
Cr <sub>10</sub> O <sub>x</sub> /SiO <sub>2</sub>	With CO <sub>2</sub>	6.8	2.7	6.5	4.9	1.1	79	3.9
	Without CO <sub>2</sub>	6.9	/	8.5	4.8	/	82	3.9
Ru <sub>1</sub> Cr <sub>10</sub> O <sub>x</sub> /SiO <sub>2</sub>	With CO <sub>2</sub>	13.6	11.4	9.5	9	5.6	85	7.7
	Without CO <sub>2</sub>	6.4	/	7.4	4.1	/	88	3.6
Ru <sub>3</sub> Cr <sub>10</sub> O <sub>x</sub> /SiO <sub>2</sub>	With CO <sub>2</sub>	3.1	35.9	13	4.5	11.5	39	1.8
	Without CO <sub>2</sub>	5.9	/	6.9	3.8	/	86	3.7
Ru <sub>1</sub> /SiO <sub>2</sub>	With CO <sub>2</sub>	0	43.5	14.1	4.8	16.2	0	0

Table S2 Catalytic activities of reported chromium-based catalysts toward ODP reaction

Catalysts	WHSV (CO <sub>2</sub> -C <sub>3</sub> H <sub>8</sub> ) (ml / g /h)	T(°C)	CO <sub>2</sub> : C <sub>3</sub> H <sub>8</sub> ratio (feedgas)	Measure time	C <sub>3</sub> H <sub>8</sub> : CO <sub>2</sub> ratio (consumed)	C <sub>3</sub> H <sub>6</sub> (selectivity)	C <sub>3</sub> H <sub>6</sub> production rate (mmol/ g <sub>catal</sub> /h)	H <sub>2</sub> production rate (mmol/ g <sub>catal</sub> /h)	Ref
0.5wt%Ni- 10wt%CrO <sub>x</sub> /SBA- 15	9000 (10%-10%)	600	1:1	1 h	1:0.63	90	9.44	N/A	1
1.27wt% CrO <sub>x</sub> /mesoporous silica	9000 (10%-10%)	600	1:1	40 min	N/A	89	11.25	N/A	2
0.97wt%Cr <sub>2</sub> O <sub>3</sub> /SiO <sub>2</sub> - Ab	3600(No dilution)	600	5:1	0.75 h	N/A	94.5	3.96	N/A	3
5wt%Cr/SiO <sub>2</sub>	667 h <sup>-1</sup> (volume velocity,30%-15%)	550	2:1	20 min	N/A	90	N/A	N/A	4
2wt%Cr/SiO <sub>2</sub> - (disordered-porous)	200 h <sup>-1</sup> (volume velocity,30%-15%)	600	2:1	20 min	1:0.27	66	N/A	N/A	5
6wt%Cr/SiO <sub>2</sub> - Ethenol vapor	6000 (90%-10%)	600	9:1	/	N/A	83.2	8.58	N/A	6
5wt% Cr <sub>2</sub> O <sub>3</sub> -SiO <sub>2</sub>	15000 (20%-12%)	550	1.6:1	10 min	N/A	/	12.85	N/A	7
7wt%Cr/SBA-1	9000 (33%-6.6%)	550	5:1	10 min	1:0.45	85	8.58	N/A	8
Cr/SiO <sub>2</sub> -Ab (Si:Cr=57)	7500(68%-12%)	550	5.7:1	0.5 h	N/A	90	6	4.5	9
3.4wt%Cr/SBA	9000(33%-6.6%)	550	5:1	10 min	1:0.69	87.9	7.74	5.8	10
1wt%Ru- 10wt%Cr/SiO <sub>2</sub>	12000(33%-33%)	493	1:1	50 min	1:0.76	85	13.6	9.5	This work

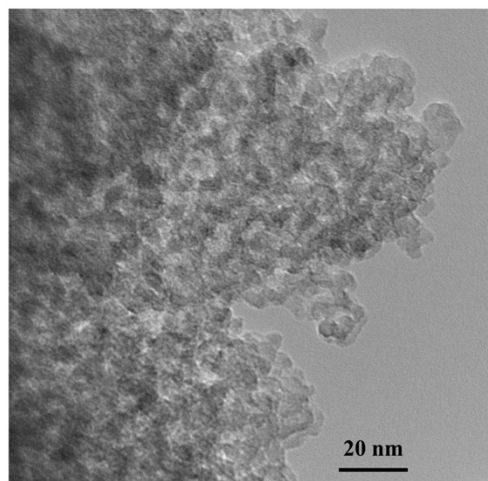


Fig. S1 TEM image of silica gel support

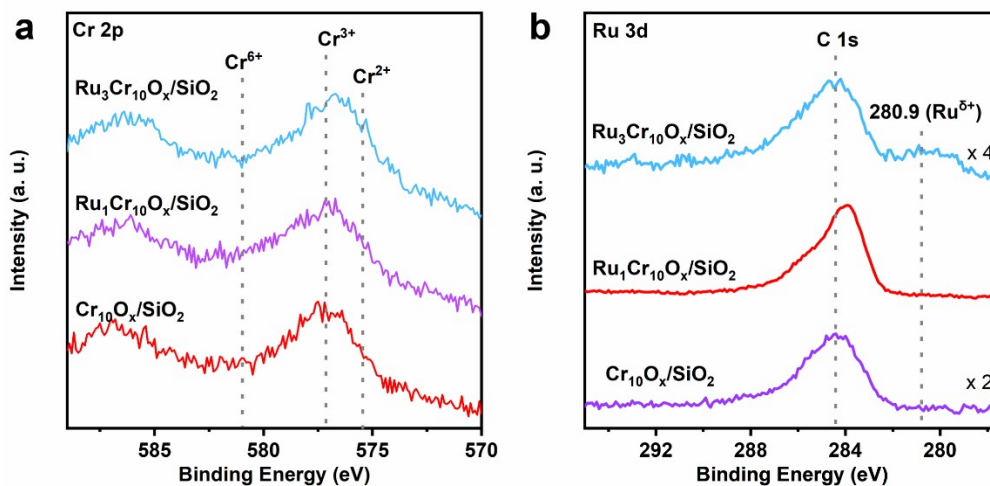


Fig. S2 Cr 2p (a) and Ru 3d (b) XPS spectra of  $\text{Cr}_{10}\text{O}_x/\text{SiO}_2$  (purple),  $\text{Ru}_1\text{Cr}_{10}\text{O}_x/\text{SiO}_2$  (red), and  $\text{Ru}_3\text{Cr}_{10}\text{O}_x/\text{SiO}_2$  (blue) after 50 min of reaction.

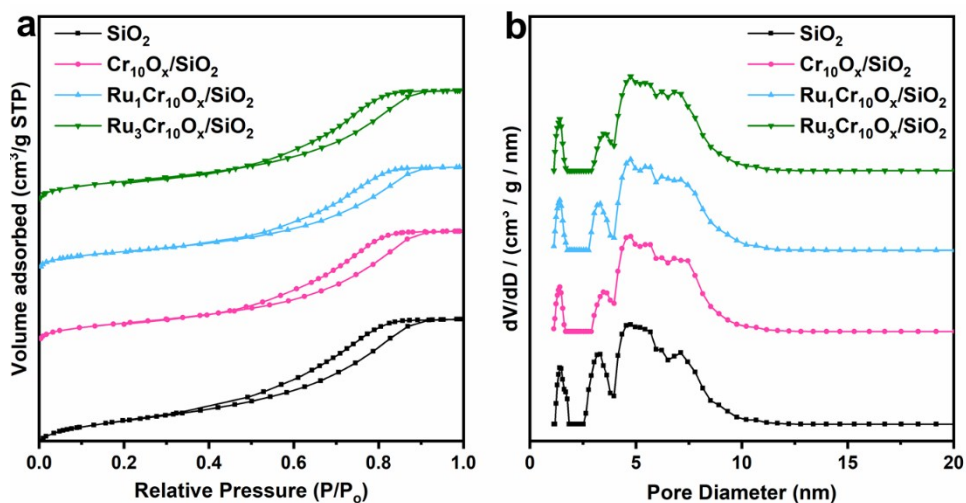


Fig. S3 Nitrogen adsorption-desorption isotherm (a) and the corresponding pore-size distribution curve (b) of the different samples.

Table S3 Textural properties of different samples

Sample	BET (m <sup>2</sup> /g)	Pore Volume (cm <sup>3</sup> /g)	Pore size (nm)
SiO <sub>2</sub>	511.3	0.81	2-10
Cr <sub>10</sub> O <sub>x</sub> /SiO <sub>2</sub>	400.2	0.72	2-10
Ru <sub>1</sub> Cr <sub>10</sub> O <sub>x</sub> /SiO <sub>2</sub>	413.5	0.72	2-10
Ru <sub>3</sub> Cr <sub>10</sub> O <sub>x</sub> /SiO <sub>2</sub>	410.9	0.72	2-10

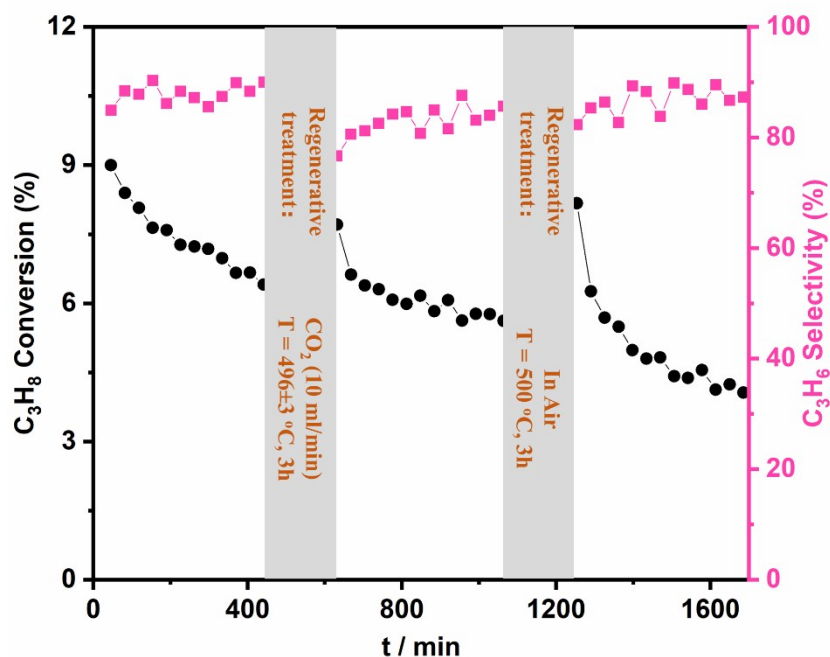


Fig. S4 Regenerative test of Ru<sub>1</sub>Cr<sub>10</sub>O<sub>x</sub>/SiO<sub>2</sub> catalyst.

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