

## Supporting Information

### **Design of CrZrO<sub>x</sub> - Cu<sub>2</sub>MnO<sub>x</sub>@Na<sub>2</sub>WO<sub>4</sub> Catalyst-Oxygen Carrier System for Efficient Chemical Looping Oxidative Dehydrogenation of Propane**

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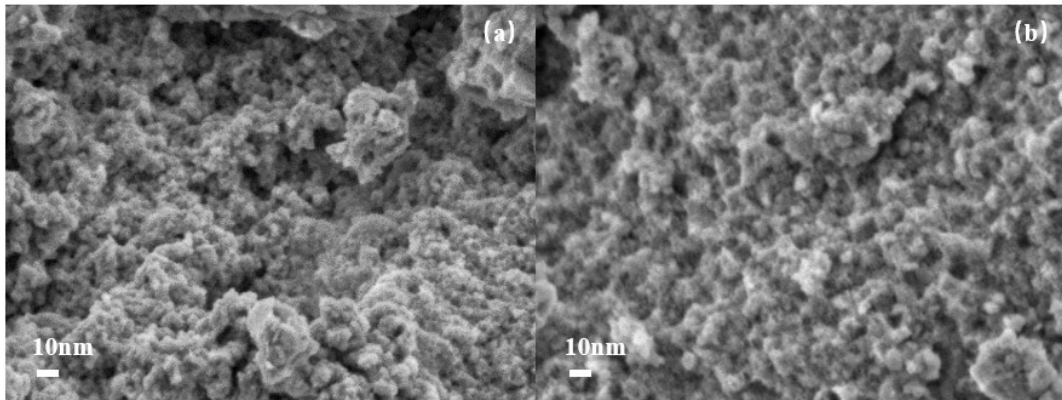


Figure S1. SEM images of sample CZ-10 (a) and CZ-20 (b)

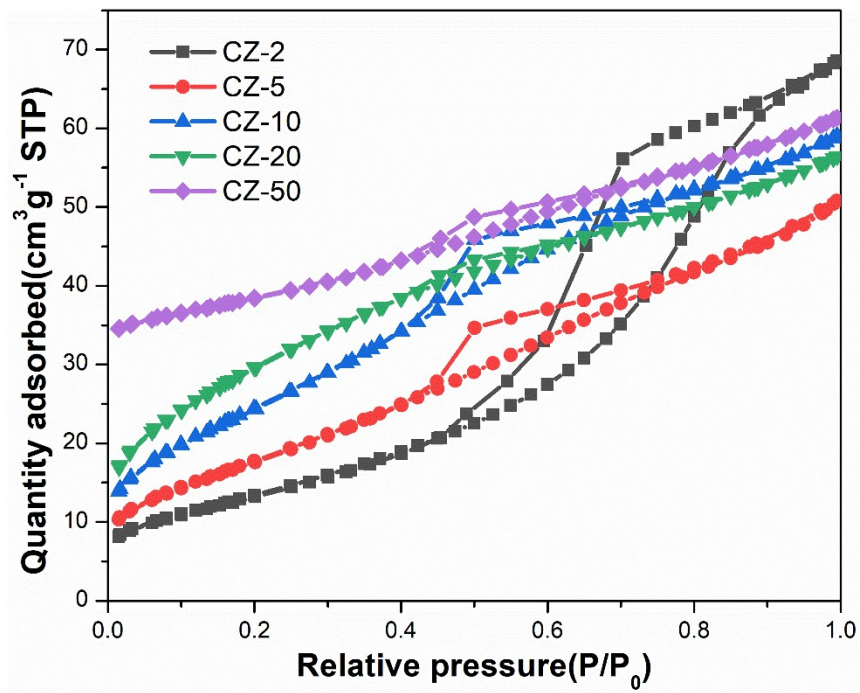


Figure S2. Isotherm linear plots of CrZrOx series catalysts

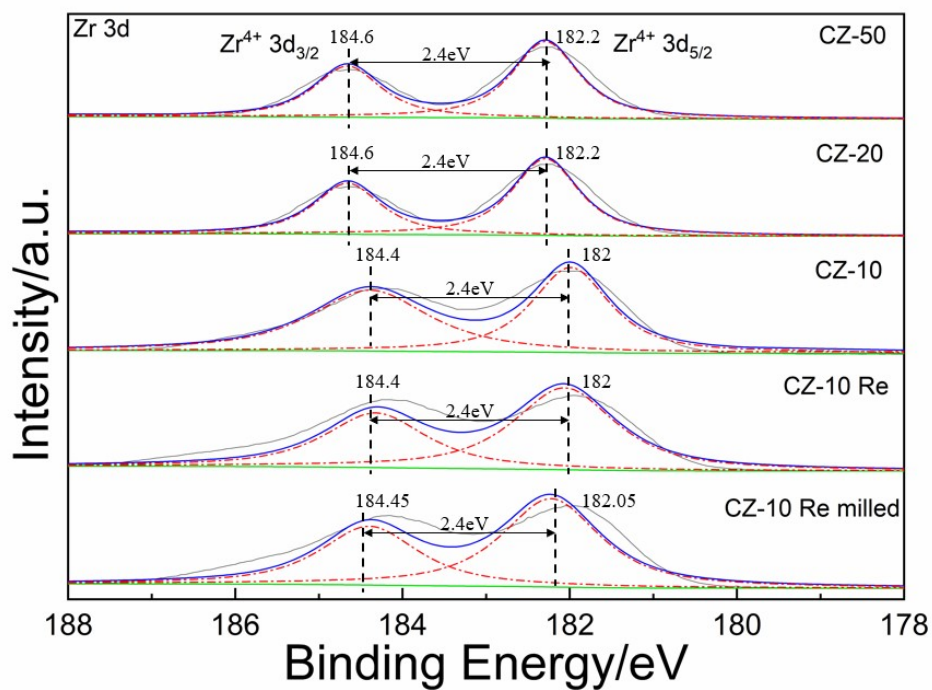
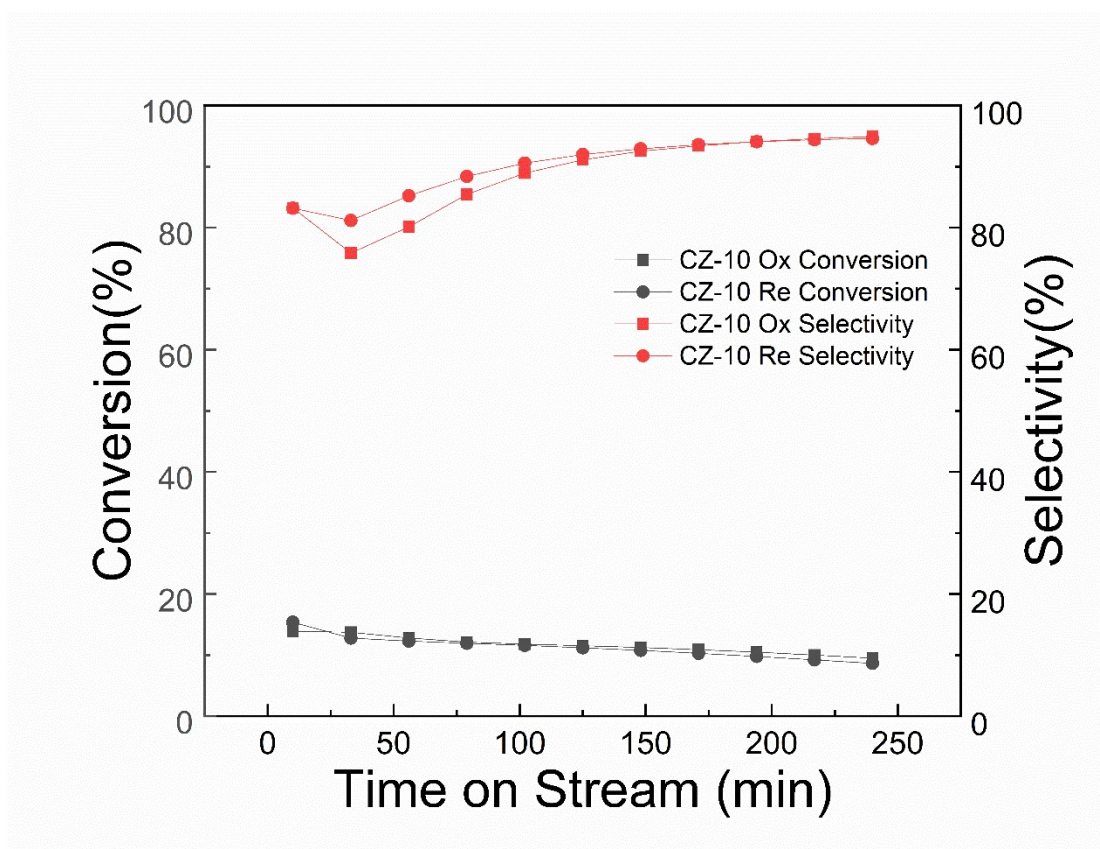


Figure S3. Zr 3d XPS spectra of sample: from top to bottom, CZ-50 and CZ-20 and CZ-10 samples are in oxidation state; (CZ-10 Re) stand for sample in reduction state; (CZ-10 Re milled) stands for CZ-10 Re sample milled with exposed internal surface



**Figure S4. Conversion and selectivity of CZ-10 in oxidation and reduction State, (Reaction conditions: pure C<sub>3</sub>H<sub>8</sub> feed, 550 °C, atmospheric pressure, WHSV=2.94 h<sup>-1</sup>)**

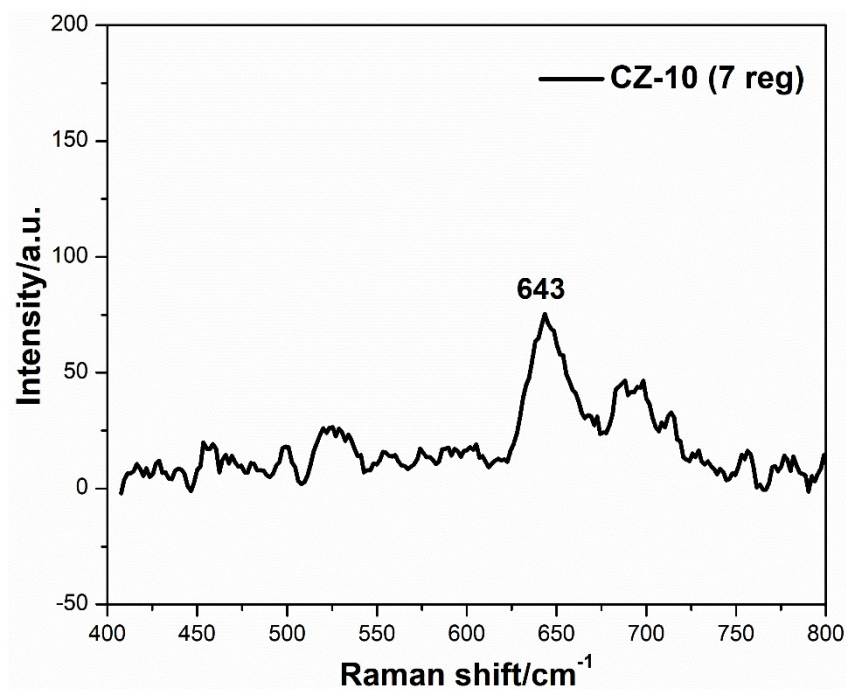


Figure S5. Raman spectrum of CZ-10 (7 reg) sample.

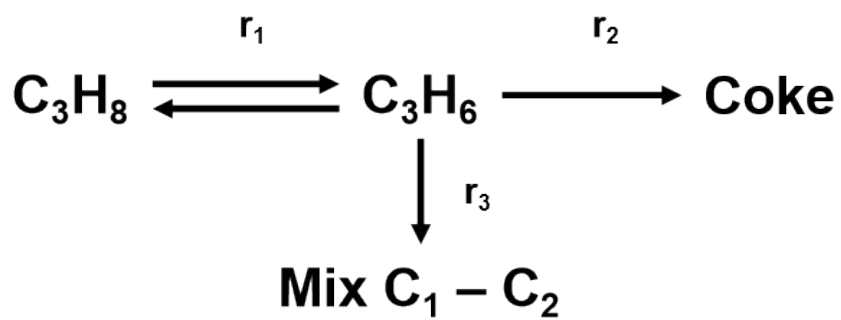


Figure S6. Reaction mechanism from propane to various products

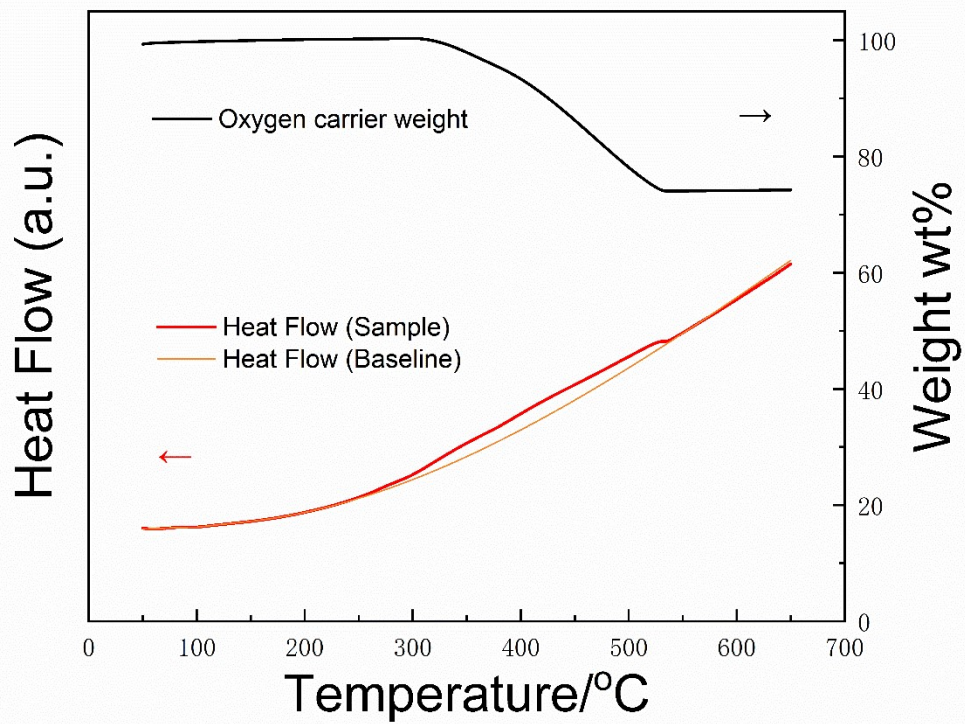


Figure S7. TG curve of oxygen carrier in 5% $H_2$ /Ar flow

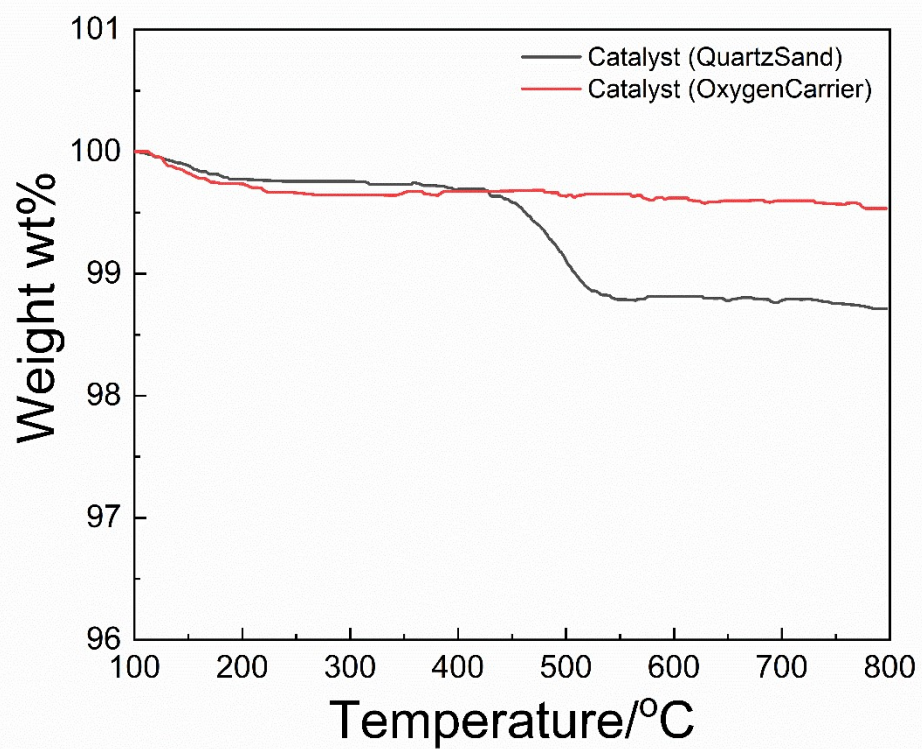


Figure S8. TG curves of deactivated CZ-10 weight loss in air with quartz and oxygen carrier

**Table S1. Textural properties of CrZrO<sub>x</sub> samples**

Sample	BET surface area (m <sup>2</sup> /g)	Pore volume (cm <sup>3</sup> /g)	Mean pore diameter (nm)
CZ-2	50	0.1	6
CZ-5	67	0.07	4
CZ-10	92	0.08	3
CZ-20	108	0.07	3
CZ-50	34	0.05	4

**Table S2. Weight gained in CaCl<sub>2</sub> tube due to water generated in CL-ODH reaction**

Reaction	Weight /g (before reaction)	Weight /g (after reaction)	Weight /g (water generated in CL-ODH)
Fresh	101.317	101.387	0.070
1	101.403	101.473	0.070
2	101.490	101.563	0.073
3	101.579	101.652	0.072
4	101.668	101.734	0.066
5	101.751	101.822	0.071
6	101.838	101.912	0.074

**Table S3. Operation parameters of CATOFIN process and this work**

Operation parameters	CATOFI N	This work
Catalyst amount	100t	0.7g
Feed flowrate*	30t/hr	10ml/min
WHSV	0.3	1.68
Inlet temperature(°C)	~650	580
Outlet Temperature(°C)	~530	580
Average temperature(°C)	~590	580
Absolute Pressure**	0.3-0.5bar	1 bar
Propane per-pass Conversion	>50%	Max 35.9%
Propylene Selectivity	>89%	Max 88.6%

\* Due to mass flow meter accuracy limit, set the flow rate with minimum 10ml/min.

\*\* It is a high risk to operate this reaction with negative pressure in lab condition.