Supporting Information:

Direct and Selective Hydrogenation of CO_2 to Ethylene and Propene by Bifunctional Catalysts

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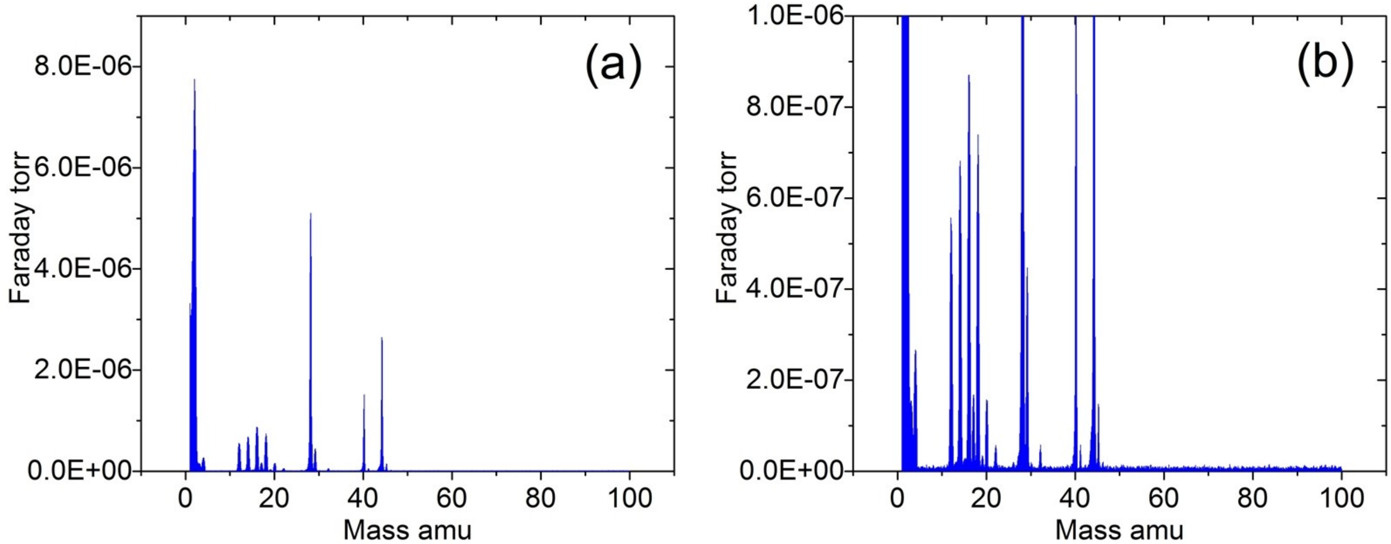

Figure S1. (a) Mass signal of the gas products at 400 ^{o}C and 30 bar with space velocity of 3 $L\,g_{cat}^{-1}\,h^{-1}$ and (b) the corresponding enlarged picture of (a).

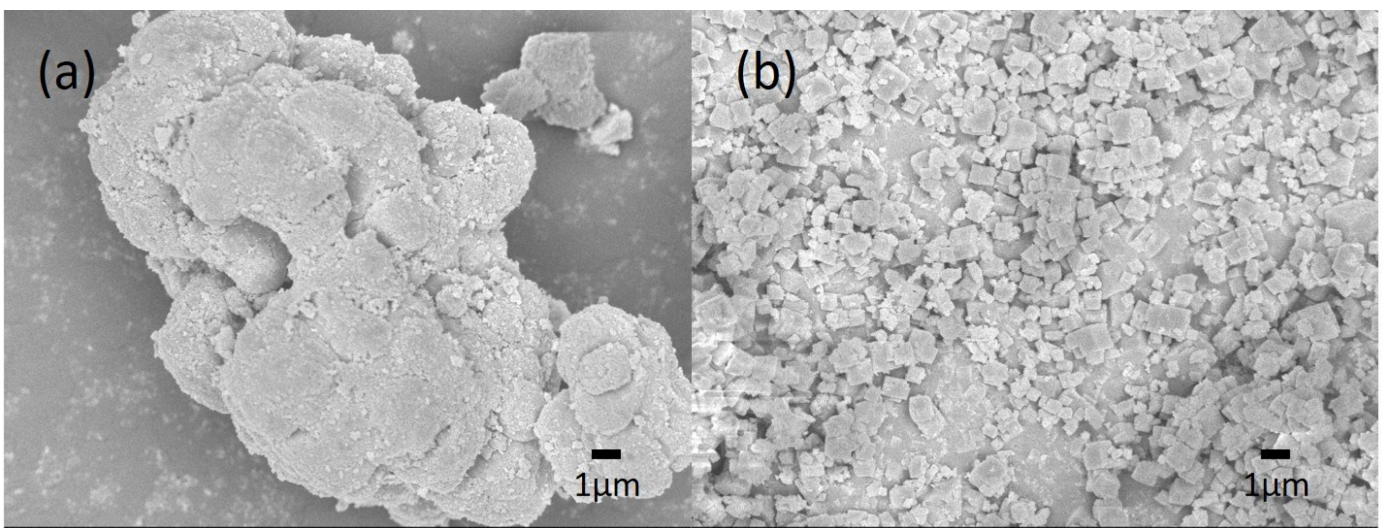

Figure S2. SEM images of (a) In_2O_3/ZrO_2 (In_2O_3: 10 wt%) catalyst and (b) SAPO-34 zeolite.

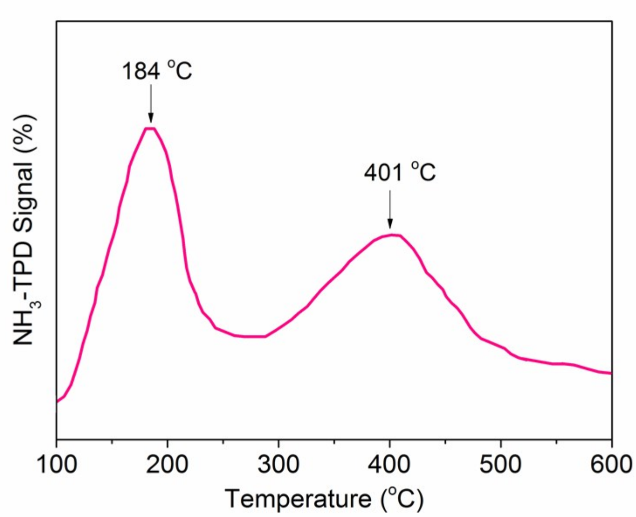

Figure S3. NH_3-TPD curve of the synthetic SAPO-34 zeolite.

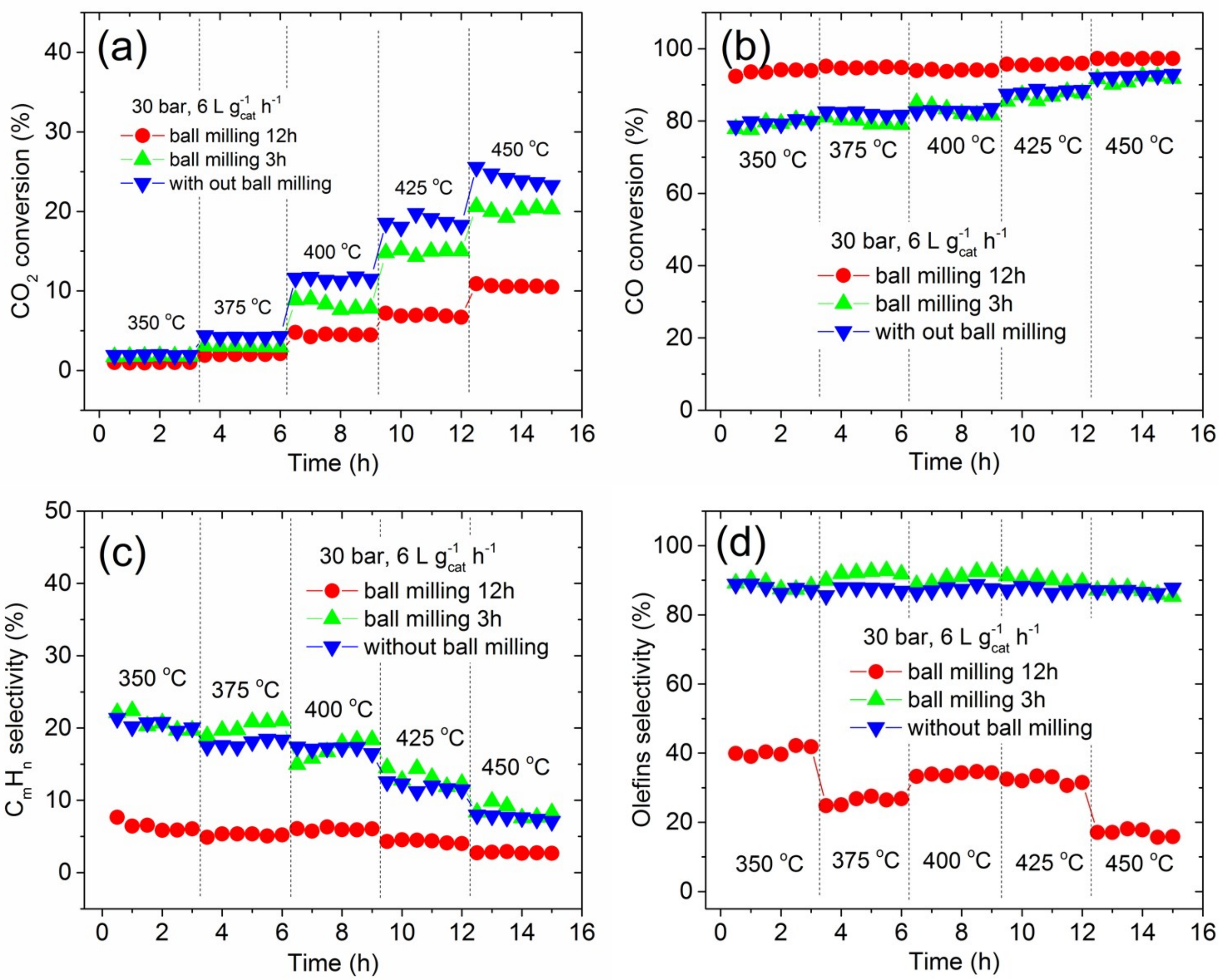

Figure S4. Effect of ball milling of the 1InZr-1SAPO catalysts on the catalytic performance.

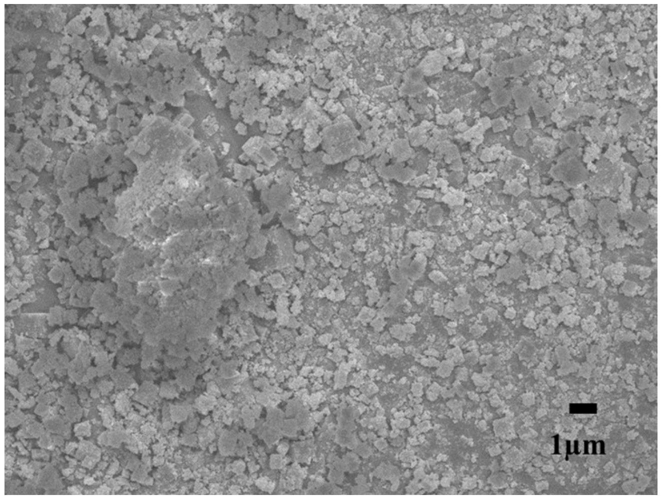

Figure S5. SEM image of 1InZr-1SAPO after ball milling for 12 h.

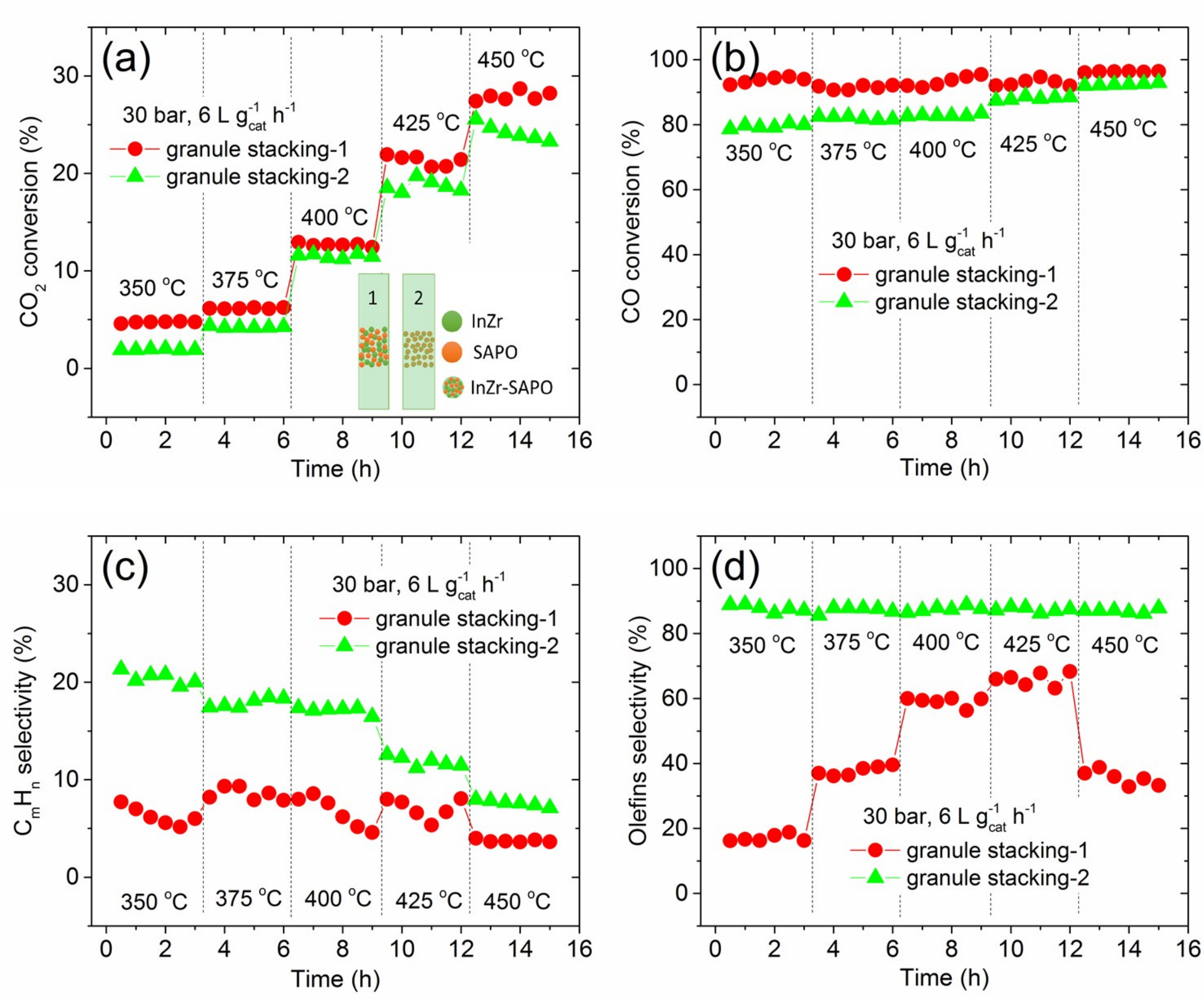

Figure S6. Effect of different granule stacking styles on the catalytic performance of 1InZr-1SAPO.

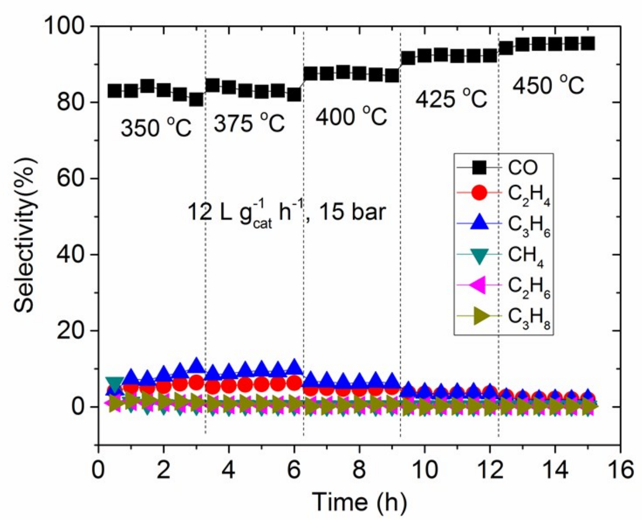

Figure S7. The selectivity of all products (including CO) over the 1InZr-1SAPO catalyst.

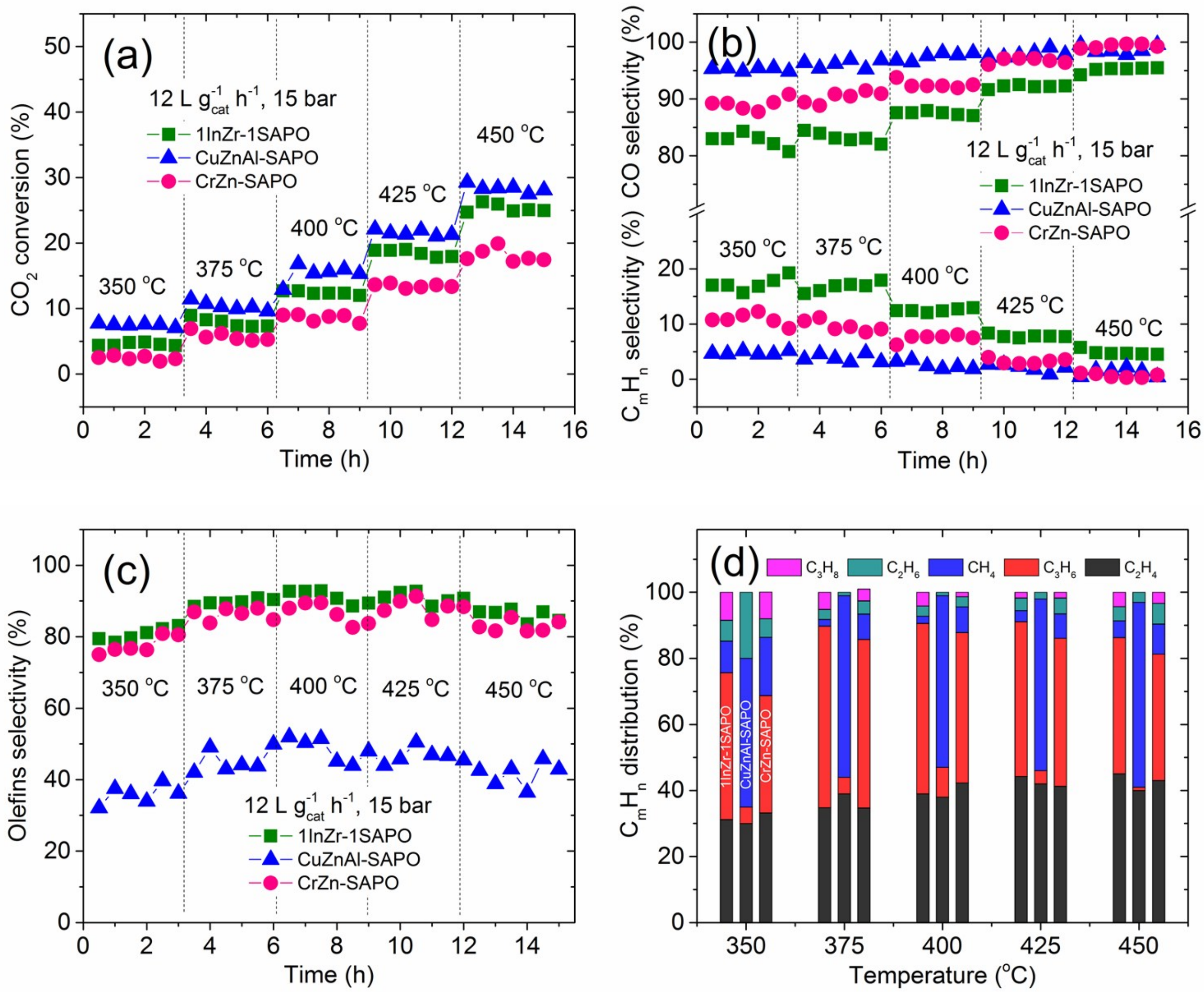

Figure S8. The catalytic performance of different combination of metal oxides and SAPO-34 zeolite (1InZr-1SAPO, CuZnAl-SAPO, and CrZn-SAPO).

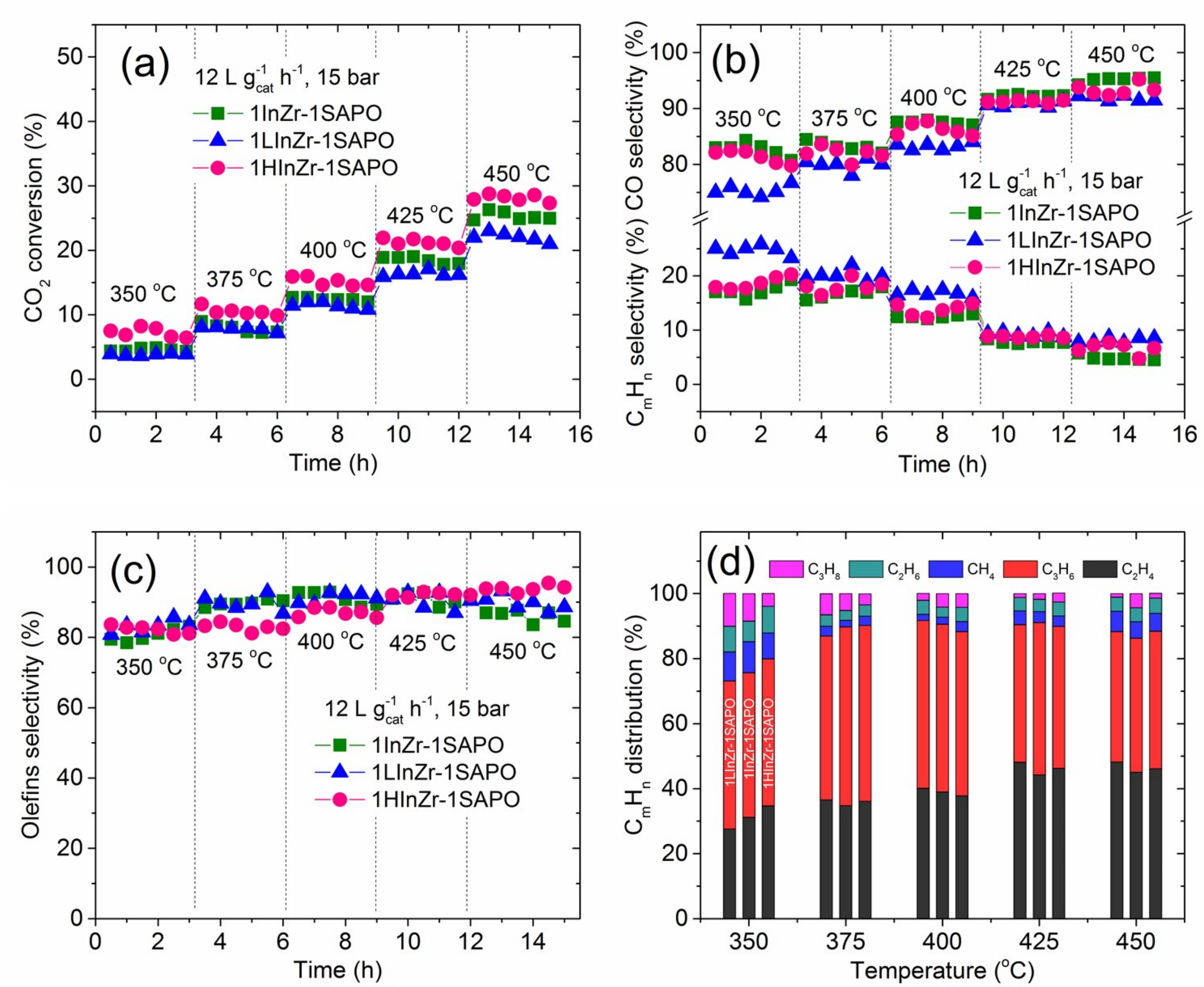

Figure S9. The catalytic performance of In_2O_3/ZrO_2-SAPO-34 catalysts with different loading amounts of In_2O_3 on ZrO_2 (1LInZr-1SAPO for 5 wt%, 1InZr-1SAPO for 10 wt%, and 1HInZr-1SAPO for 20 wt%).

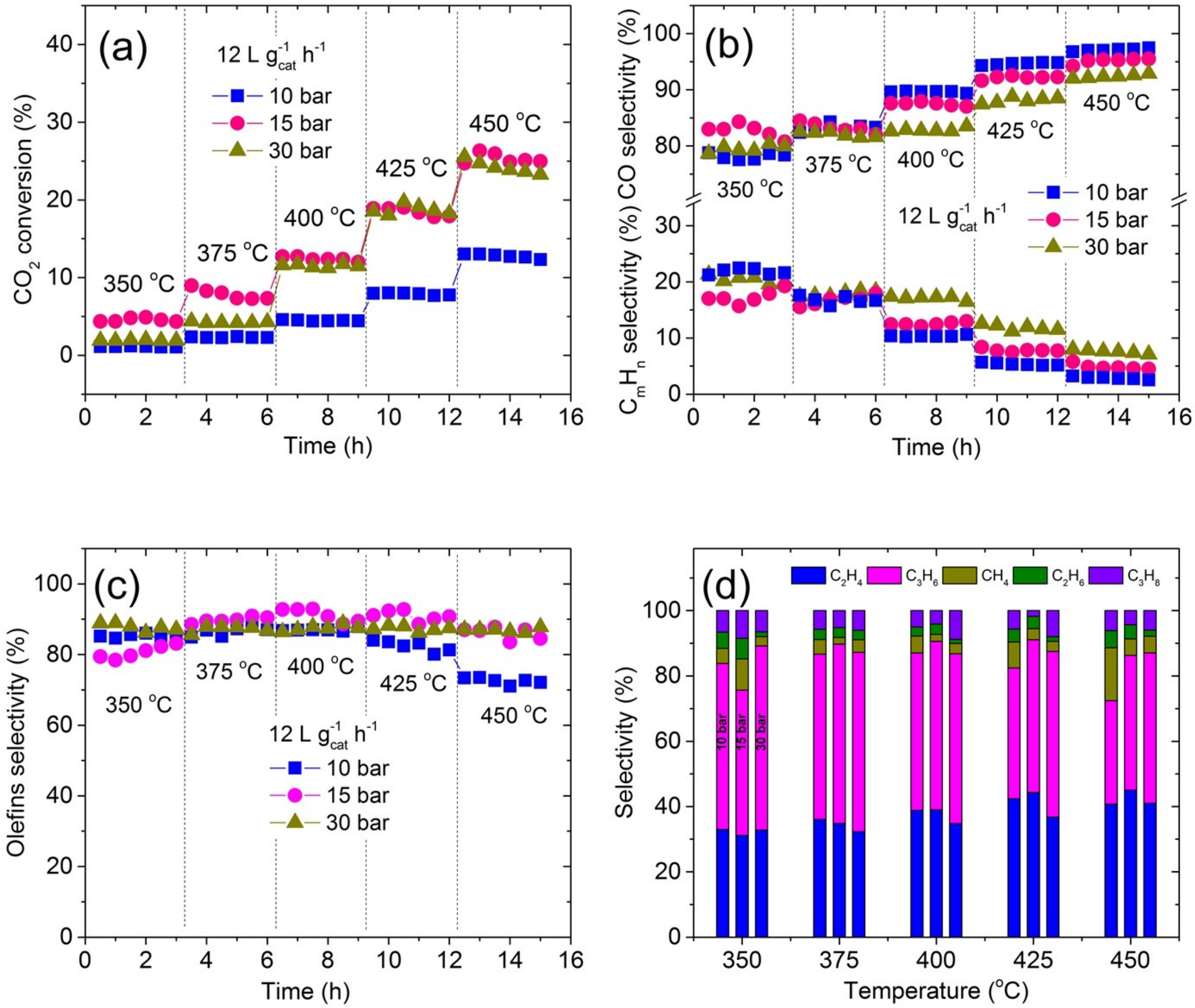

Figure S10. The influence of pressure on the catalytic performance of 1InZr-1SAPO catalyst.

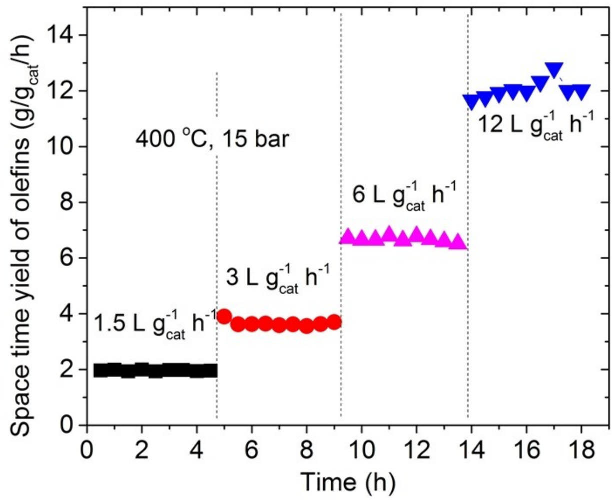

Figure S11. The effect of space velocity on the space time yield of olefins at 400 ^oC and 15 bar.

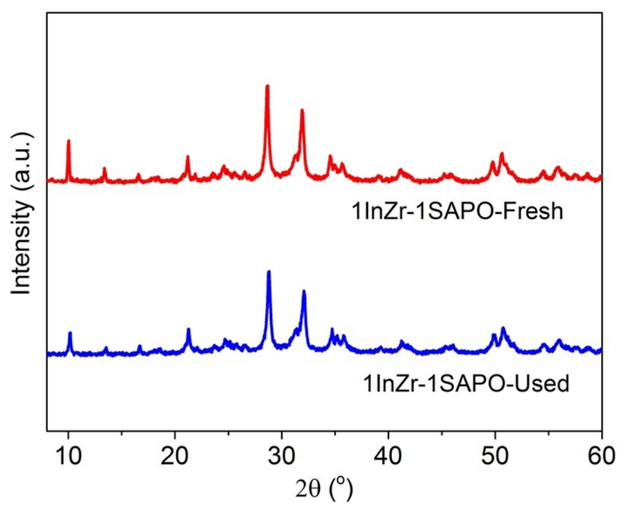

Figure S12. XRD patterns of 1$InZrO_2$-1SAPO before and after the stability test.

Table S1. Control experimental results over single and mixed catalysts under typical reaction conditions.

Catalysts (0.5 g)	Reactants (20mL/min, STP)	Reaction conditions	CO_2 or Methanol Conversions	Products detected
In_2O_3/ZrO_2	20%CO_2, 60%H_2, N_2 balance	400 °C, 15 bar	17.6 %	CH_3OH, CO, H_2O
In_2O_3/ZrO_2	2%Methanol, N_2 balance	400 °C, 1 bar	21.5 %	CO_2, H_2, CO, CH_4, H_2O
SAPO-34	20%CO_2, 60%H_2, N_2 balance	400 °C, 15 bar	1.2 %	CO, H_2O
SAPO-34	2%Methanol, N_2 balance	400 °C, 1 bar	99 %	CH_4, C_2H_4, C_2H_6, C_3H_6, C_3H_8, CO, H_2O
In_2O_3/ZrO_2+ SAPO-34	20%CO_2, 60%H_2, N_2 balance	400 °C, 15 bar	21.5%	CH_4, C_2H_4, C_2H_6, C_3H_6, C_3H_8, CO, H_2O

Table S2. A comparison of reported works on CO_2 hydrogenation to light olefins.

Catalysts	Reaction condition	CO_2 conversion	Olefins selectivity	Reference
In_2O_3/ZrO_2+ SAPO-34	CO_2/H_2=1/3, 400 ^oC, 15 bar, 12 $L\,g_{cat}^{-1}\,h^{-1}$	~20 %	80-90%	This work
Na-Fe@CNT	CO_2/H_2=1/3, 370 ^oC, 7.5 bar, 1 $L\,g_{cat}^{-1}\,h^{-1}$	~23 %	40-50%	[1]
K-Fe@CNT	CO_2/H_2=1/3, 370 ^oC, 1 bar, 1 $L\,g_{cat}^{-1}\,h^{-1}$	14.5%	84.6 %	[1]
Na-Fe_2O_3	CO_2/H_2=1/3, 320 ^oC, 30 bar, 2 $L\,g_{cat}^{-1}\,h^{-1}$	40.5%	46.6 %	[2]
N-K-600-0 (contains K, Fe_3O_4, and χ-Fe_5C_2)	CO_2/H_2=1/3, 400 ^oC, 30 bar, 3.6 $L\,g_{cat}^{-1}\,h^{-1}$	43.1%	27.3%	[3]
K-promoted FeO_x	CO_2/H_2=1/3, 300 ^oC, 5 bar, 2.7 $L\,g_{cat}^{-1}\,h^{-1}$	~40%	~60%	[4]
Fe–Zn–K	CO_2/H_2=1/3, 320 ^oC, 5 bar, 1000 h^{-1}	51.0 %	53.6%	[5]
K-promoted Fe–Co/Al2O3	CO_2/H_2=1/3, 300 ^oC, 11 bar, 1.01 g s mL^{-1}	~50%	25%	[6]
$CuZnOZrO_2$+ HZSM-5	CO_2/H_2=1/3, 400 ^oC, 28 bar, W/F: 20 g_{cat} h/mol	38.4%	No report. (The selectivity of hydrocarbons in all products is 7 %)	[7]
$CuZnOZrO_2$+ SAPO-34	CO_2/H_2=1/3, 400 ^oC, 28 bar, W/F: 20 g_{cat} h/mol	33.9%	No report. (The selectivity of hydrocarbons in all products is 36 %)	[7]

Reference

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