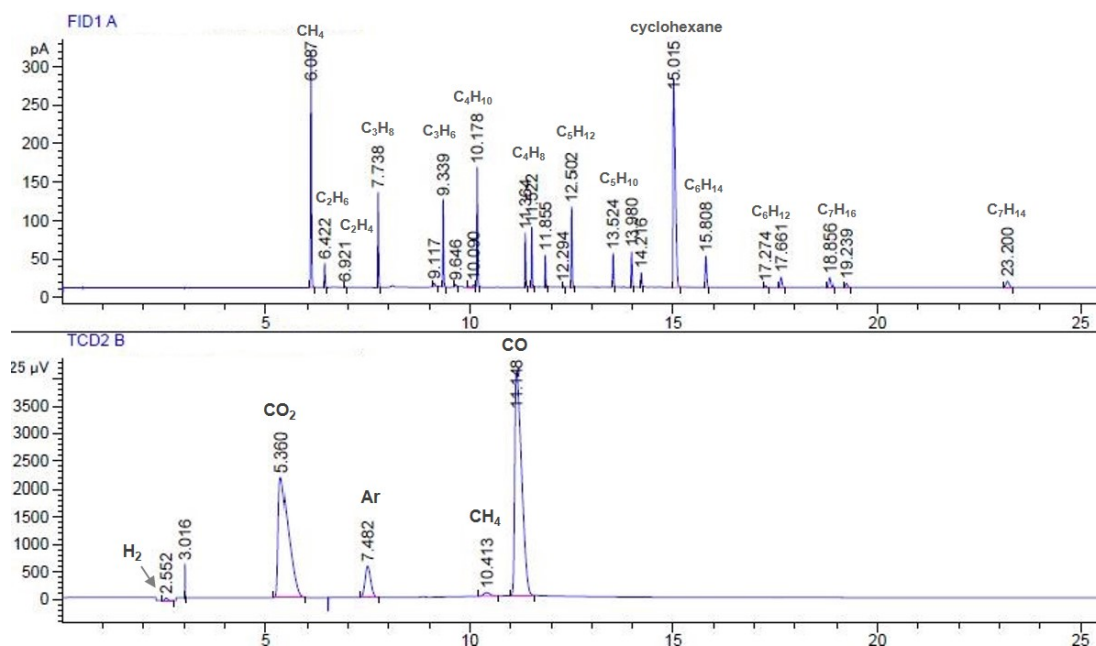
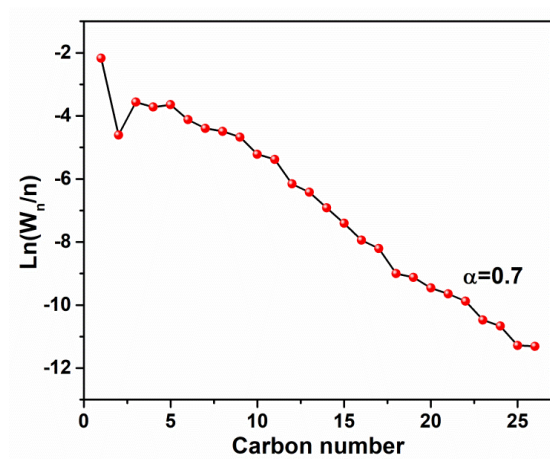


Direct conversion of CO and H₂O into liquid fuels under mild conditions

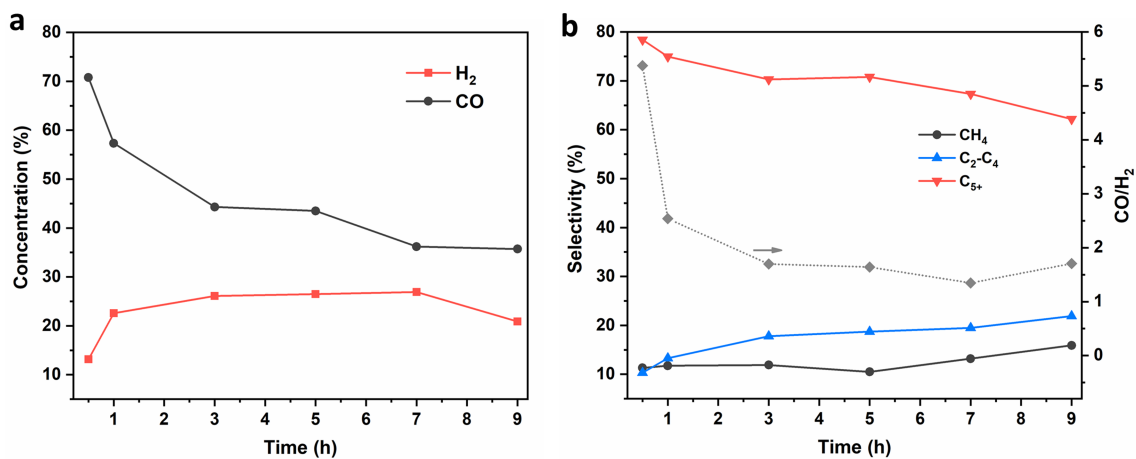
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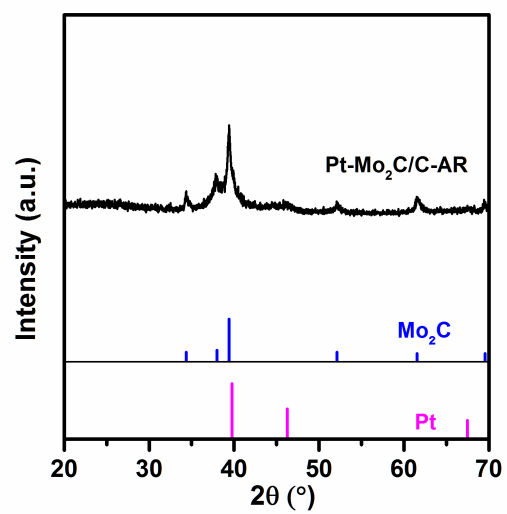
Supplementary Figure 1 | GC spectrum of the gas phase products. The product was obtained on Pt-Mo₂C/C+ Ru/C catalysts for pure CO and H₂O conversion at 200°C. The Permanent gases were detected by TCD detector, and hydrocarbons were detected by FID detector.



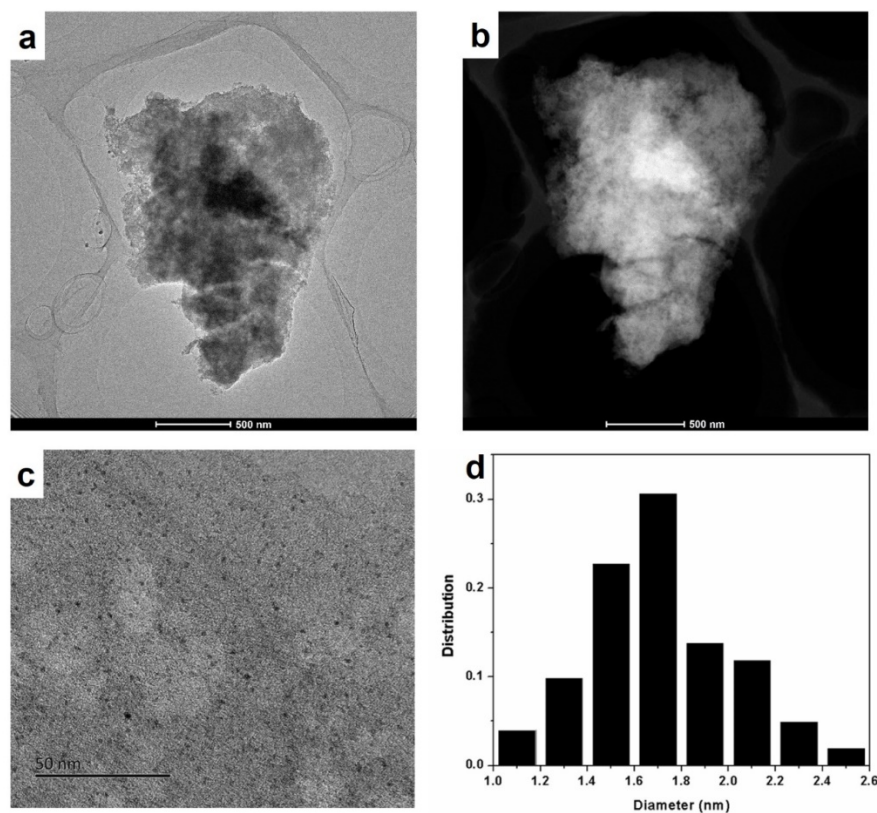
Supplementary Figure 2 | ASF distribution of Pt-Mo₂C/C+ Ru/C catalysts. The calculated α factor was 0.7.



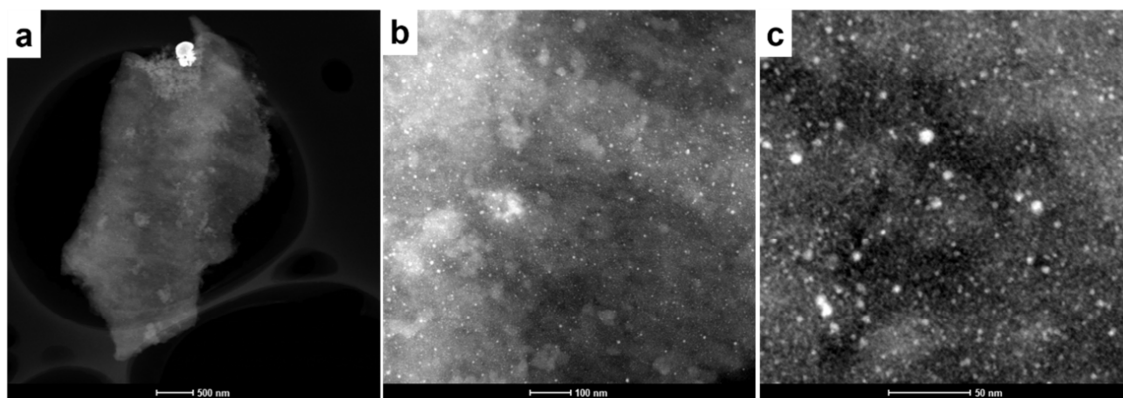
Supplementary Figure 3 | Reaction results of different reaction times. Reaction condition: Pt-Mo₂C/C+ Ru/C catalysts, 60 ml water, 3.0 MPa CO, 200°C, the reaction time was 0.5h, 1h, 3h, 5h, 7h and 9h, respectively. **(a)** The concentration of CO and H₂ with time, **(b)** The distribution of hydrocarbon and the ratio of CO/H₂ at different reaction times.



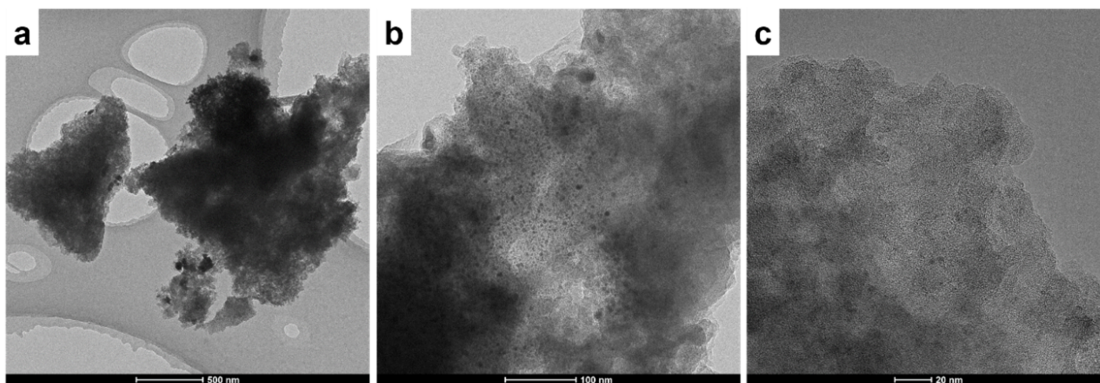
Supplementary Figure 4 | XRD pattern of Pt-Mo₂C/C after reaction. Reaction condition: 3 MPa CO, 60 mL water, 250°C, react for 2h.



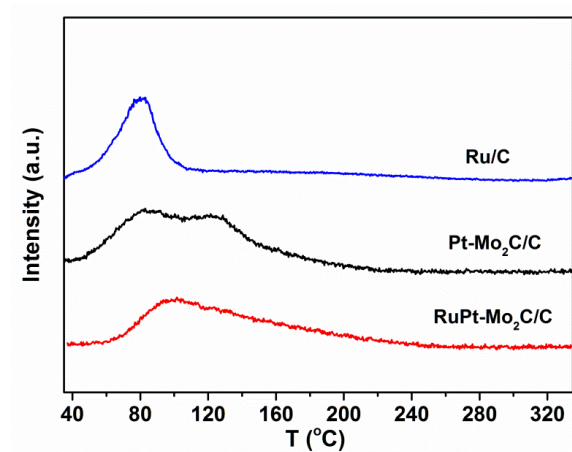
Supplementary Figure 5 | Structure characterization of Ru/C. TEM images and corresponding particle size distribution of Ru/C.



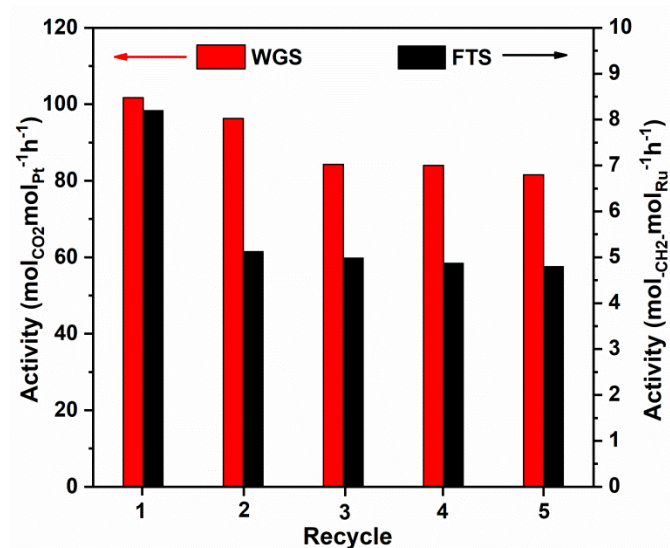
Supplementary Figure 6 | Structure characterization of Pt-Mo₂C/C. HAADF-STEM images of Pt-Mo₂C/C.



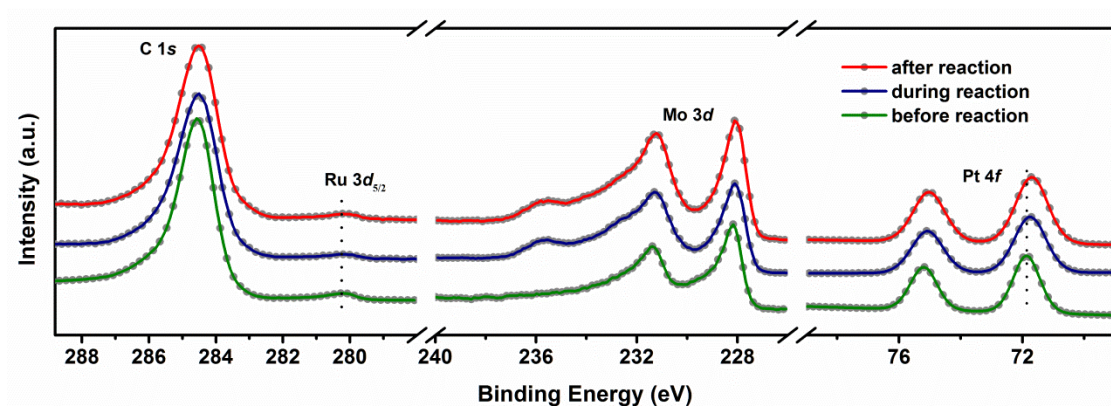
Supplementary Figure 7 | Structure characterization of RuPt-Mo₂C/C. TEM images of RuPt-Mo₂C/C.



Supplementary Figure 8 | CO-TPD profiles of different catalysts. All catalysts were reduced before tests.



Supplementary Figure 9 | Recycle experiments on Pt-Mo₂C/C+ Ru/C catalysts. Reaction condition: 60 ml water, 3.0 MPa CO, 200°C, react for 7h in each cycle.



Supplementary Figure 10 | XPS spectrum of Pt-Mo₂C/C+ Ru/C catalysts. The XPS spectrum before, during and after reaction, the reaction time was 0h, 3h and 7h, respectively. Reaction condition: 60 ml water, 3.0 MPa CO, 200°C.

Supplementary Table 1 | Aqueous-phase FTS activity over different Ru-based catalysts.

Catalyst	Reaction Atmosphere	Solvent	T(K)	Activity (mol _{CH₂} -mol _{metal} ⁻¹ h ⁻¹)	Ref.
Pt-Mo ₂ C/C+Ru/C	Pure CO	Water	473	8.7	This paper
Ru NPs	Syngas	Water	423	6.9	1
fcc Ru	Syngas	Water	423	15.9	2
Ru NPs/CNF	Syngas	Water	503	1.5	3
Ru/C	Syngas	Water/Decalin	493	40 ^a	4
Ru/NaY	Syngas	Water	438	5.9	5
Ru@SiO ₂	Syngas	Water	423	6.70	6

^a Initial reaction rate

Supplementary Table 2 | Aqueous-phase FTS activity and hydrocarbons distribution over the catalysts with different mole ratio of Ru/Pt ^a.

Entry	Catalyst	Reaction atmosphere	WGS activity ^b /		FT activity ^c /		Hydrocarbon selectivity/ %		
			mol _{CO2} / mol _{metal} h ⁻¹	mol _{metal} ⁻¹	mol _{CH2} / mol _{metal} h ⁻¹	mol _{metal} ⁻¹	CH ₄	C ₂ -C ₄	C ₅₊
1	Pt-Mo ₂ C/C+Ru/C (Ru/Pt=1.5,Ru/Mo=0.3)	CO	45.7		3.1		20.1	7.8	72.1
2	Pt-Mo ₂ C/C+Ru/C (Ru/Pt=4.6,Ru/Mo=0.3)	CO	118.4		2.4		17.2	22.7	60.1
3	Pt-Mo ₂ C/C+Ru/C (Ru/Pt=9.9,Ru/Mo=0.9)	CO:H ₂ =1:1	124.5		8.6		9.4	20.2	70.4

^a Typical reaction conditions: 60 ml water, 200°C, 3.0 MPa feed gas, The reaction time for the reactions was 7 h. The metal ratios in the catalysts were calculated based on the metal mole numbers.

^b The WGS activity over Pt-contained catalysts was calculated based on Pt dosage.

^c The FTS activity was calculated based on the Ru dosage.

Supplementary Table 3 | EXAFS fit results of different catalysts.

Catalyst	Shell	Bond Length	CN	σ^2 (nm ²)	E ₀ shift (eV)	R factor
Pt-Mo ₂ C/C	Pt-Mo	2.746±0.028	2.6±0.2	0.002±0.002	5.5	0.014
	Pt-Pt	2.750±0.024	6.3±1.2	0.005±0.001		
RuPt-Mo ₂ C/C	Pt-Ru	2.678±0.096	2.2±0.3	0.004±0.001	1.1	2E-3
	Pt-Pt	2.693±0.081	5.8±0.5	0.006±0.001		

Supplementary References

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