

Carbon and Sulfur Conversion of High-sulfur Organic Waste in the Enhanced Chemical Looping Gasification

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ABSTRACT

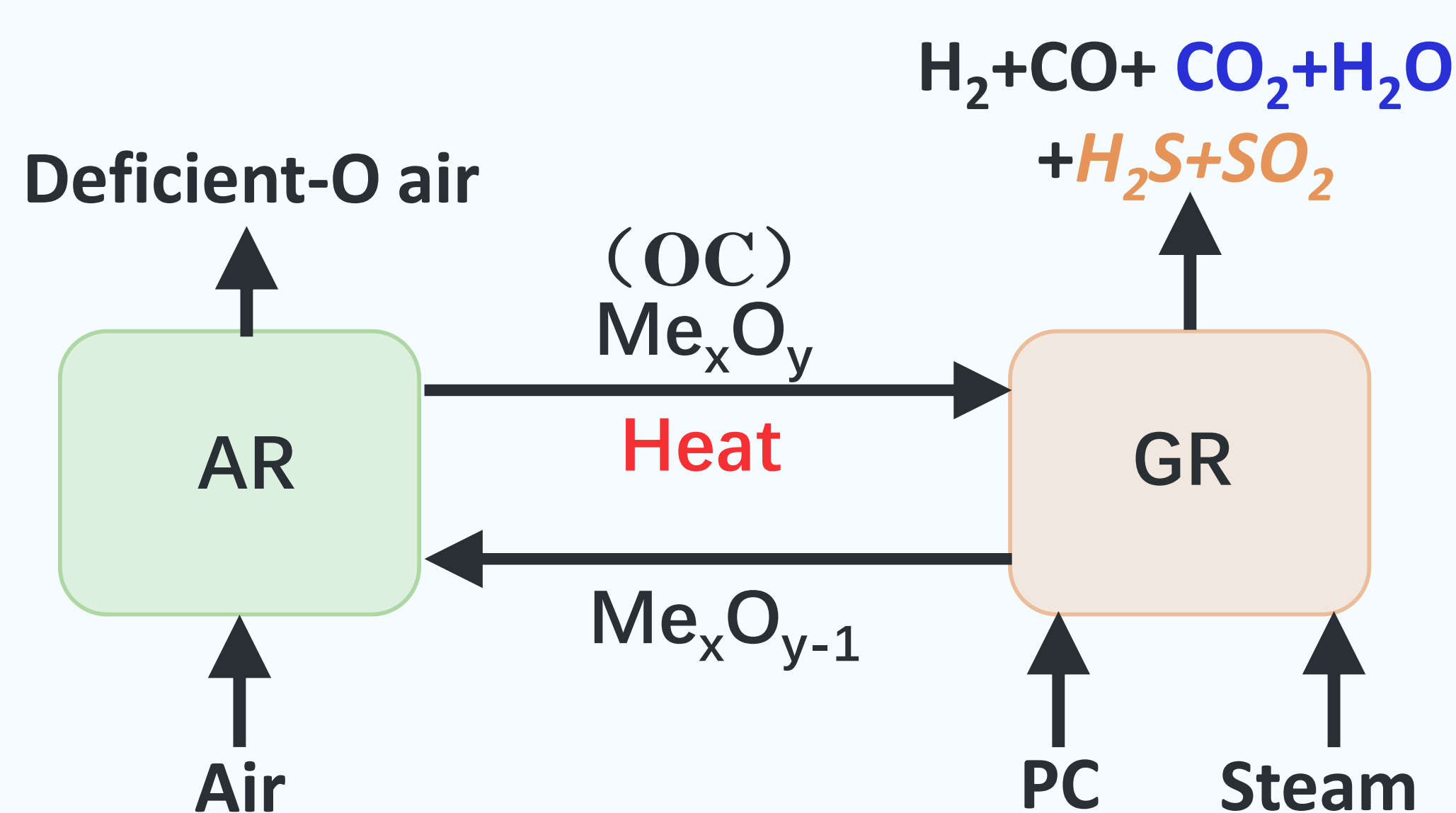


Fig 1: Chemical looping gasification.

When sulfur in petroleum coke (PC) converts to H_2S instead of SO_2 , it is the resource which can be recovered by Claus process. Chemical looping gasification (CLG) is capable of achieving PC conversion and sulfur recovery. To simultaneously overcome the obstacles of low gasification reactivity and improve H_2 and H_2S production, hematite modified by K as oxygen carrier (OC) was involved in the high-sulfur system to investigate the effect on sulfur conversion via batch fluidized bed in PC CLG process. K enhanced H_2 generation beyond expectation because K not only improved the PC gasification but also enhanced the steam oxidation of deep reductive OC. Especially when using 10% KNO_3 -hematite, H_2 yield increased by 3.9 times as compared to 0%K, with the carbon conversion efficiency of 99.92% in the 22nd minute. The sulfur fate had been originally studied using K-modified hematite OC. H_2S was the main phase of sulfur release and the high H_2 yield also assisted H_2S production. Introducing K contributed to in-situ sulfur capture forming K-Fe-S compounds in the OCs due to the deep reduction of Fe. 10% KNO_3 -hematite exhibited excellent cyclic stability with a H_2 volume fraction more than 65% in 21 cycles.

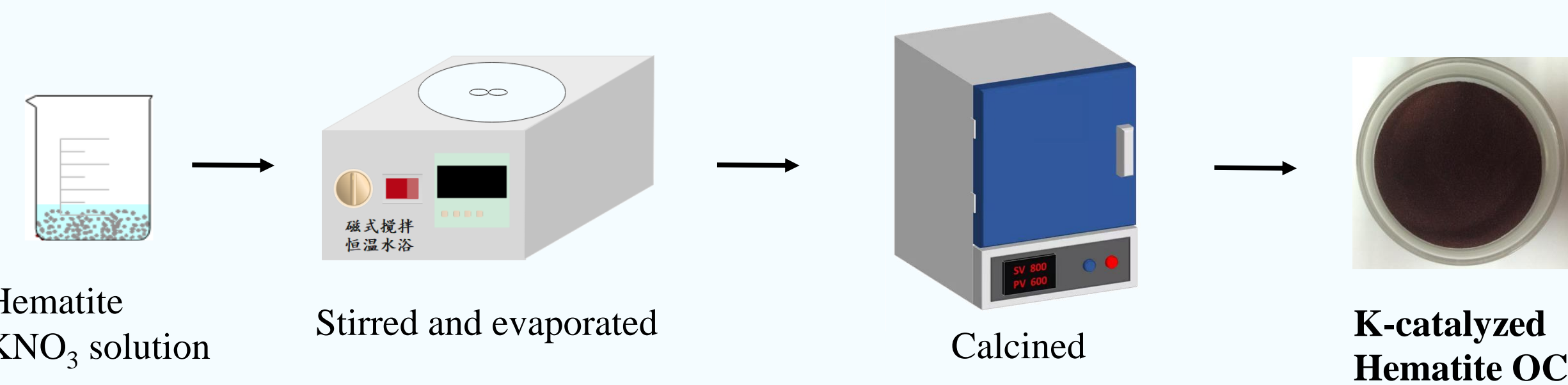
Materials & Methods

- Industrial high-sulfur PC (China Yangzi Petrochemical Co., Ltd)**
The lumps of PC were crushed to the particles of 0.1-0.3 mm.

Table 1 : Proximate and ultimate analyses of PC

Sample	Proximate analysis (wt.%, ad)				Ultimate analysis (wt.%, ad)				
	M	V	FC	A	C	H	O	N	S
PC	0.76	12.98	85.87	0.39	85.24	3.82	2.44	1.29	6.06

- K-catalyzed OC (Wet-impregnation)**



- Experimental setup**

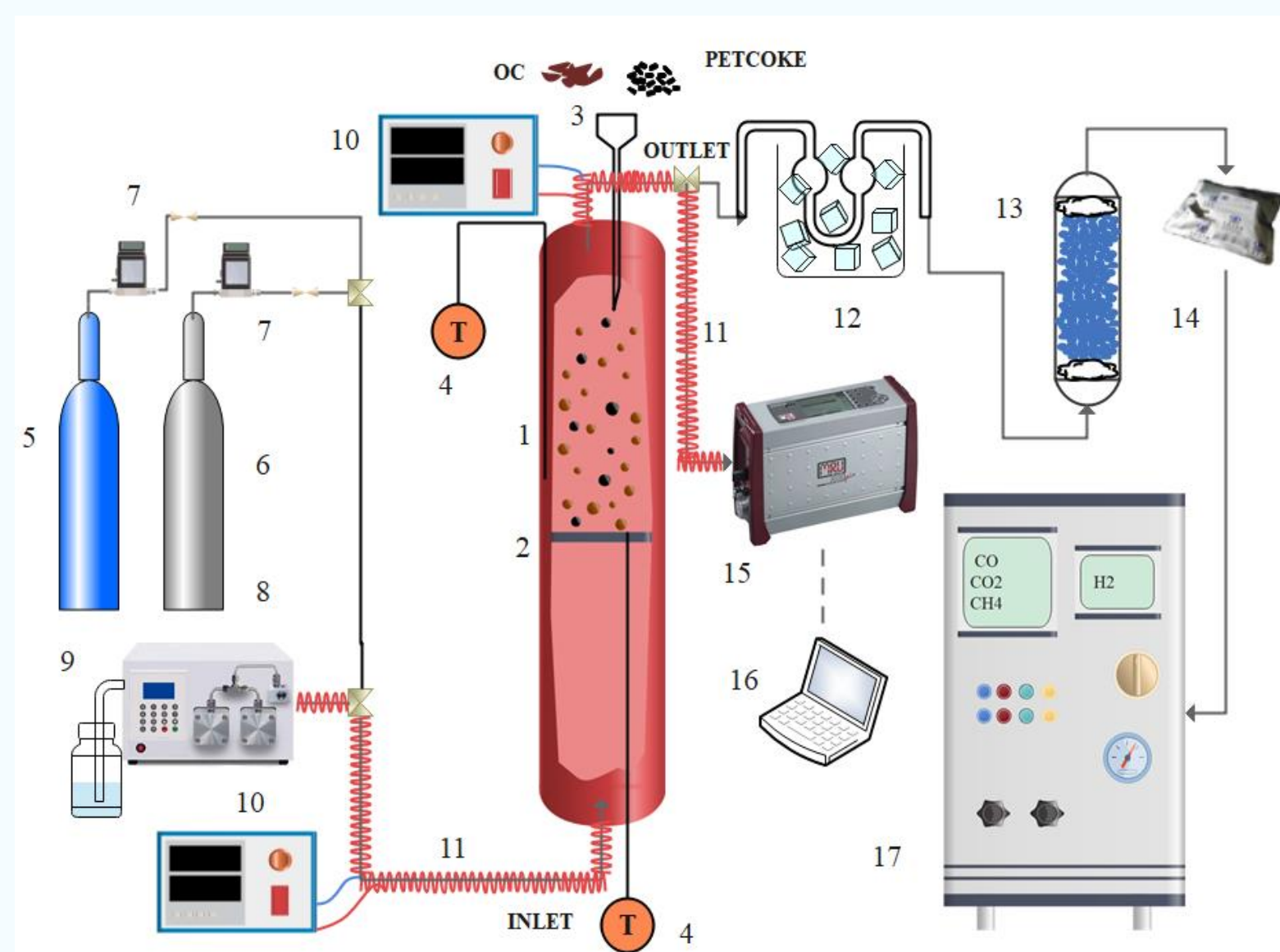


Fig 2: Quartz batched fluidized bed reactor.

1	Inert atmosphere	N_2
2	Oxidation	O_2 (100 ml/min STP) + N_2 (2 L/min STP)
3	Inert atmosphere	N_2
4	Reduction	N_2 (1 L/min STP) + steam (1 ml/min)

Effect of K on sulfur conversion

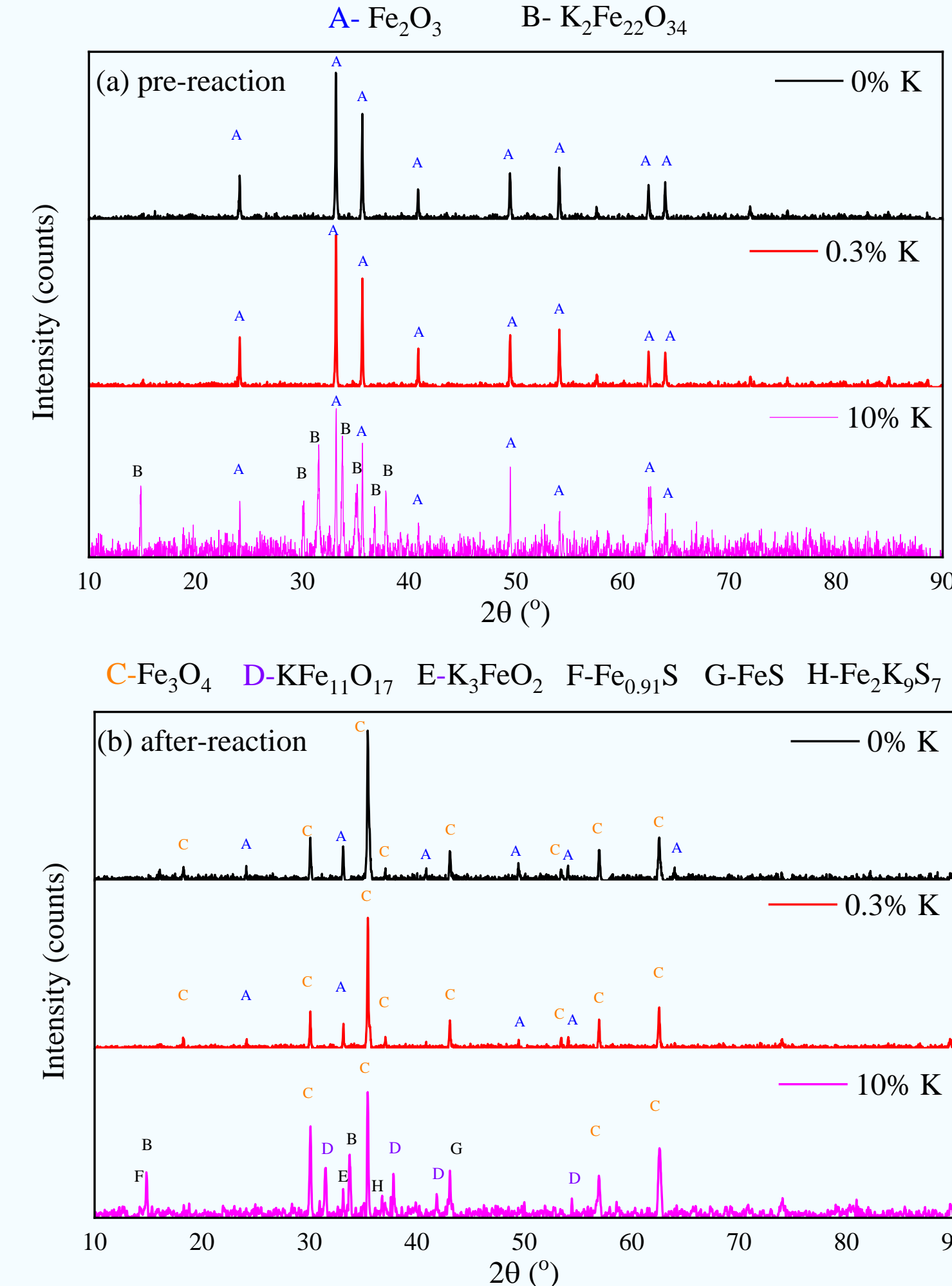
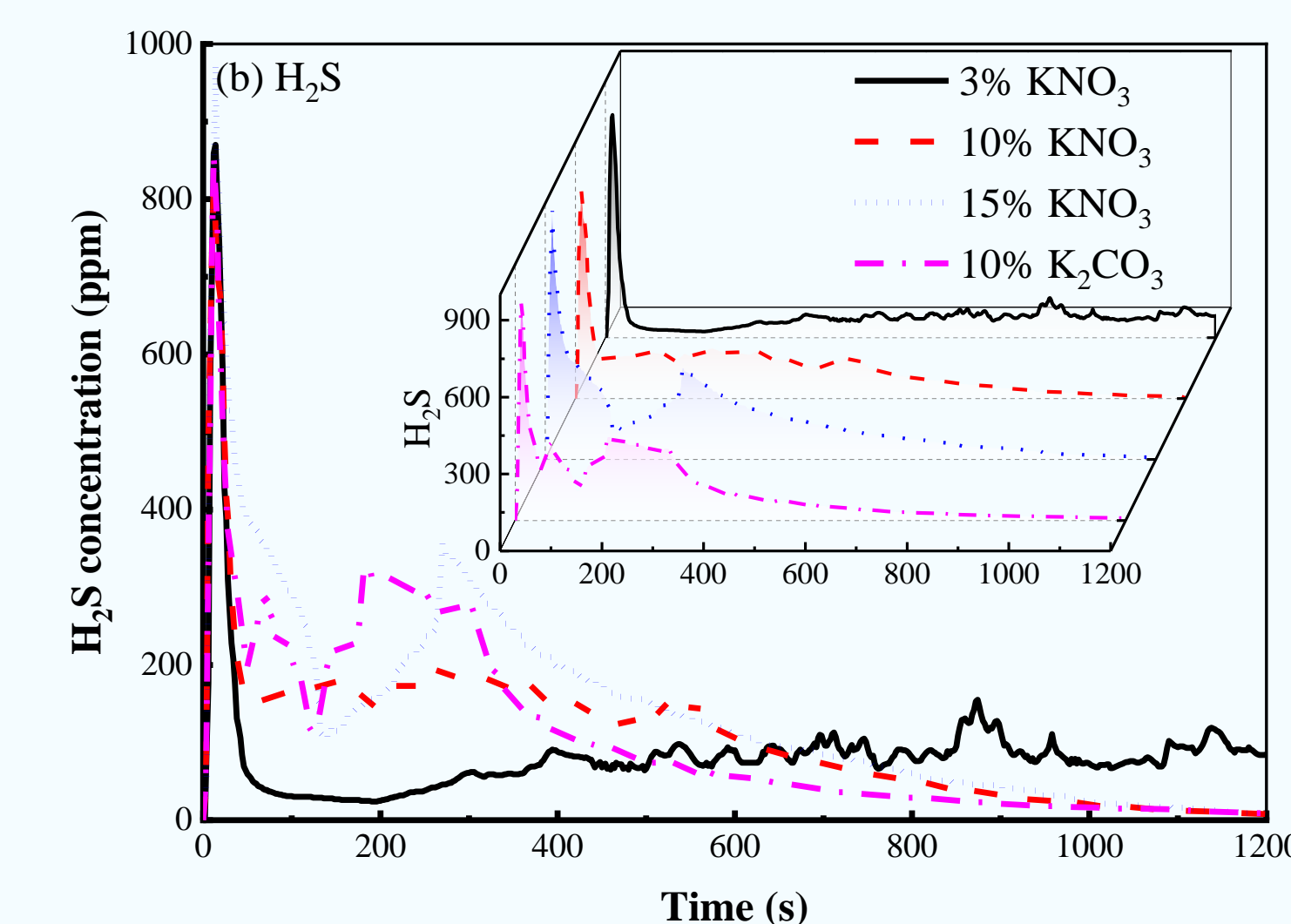
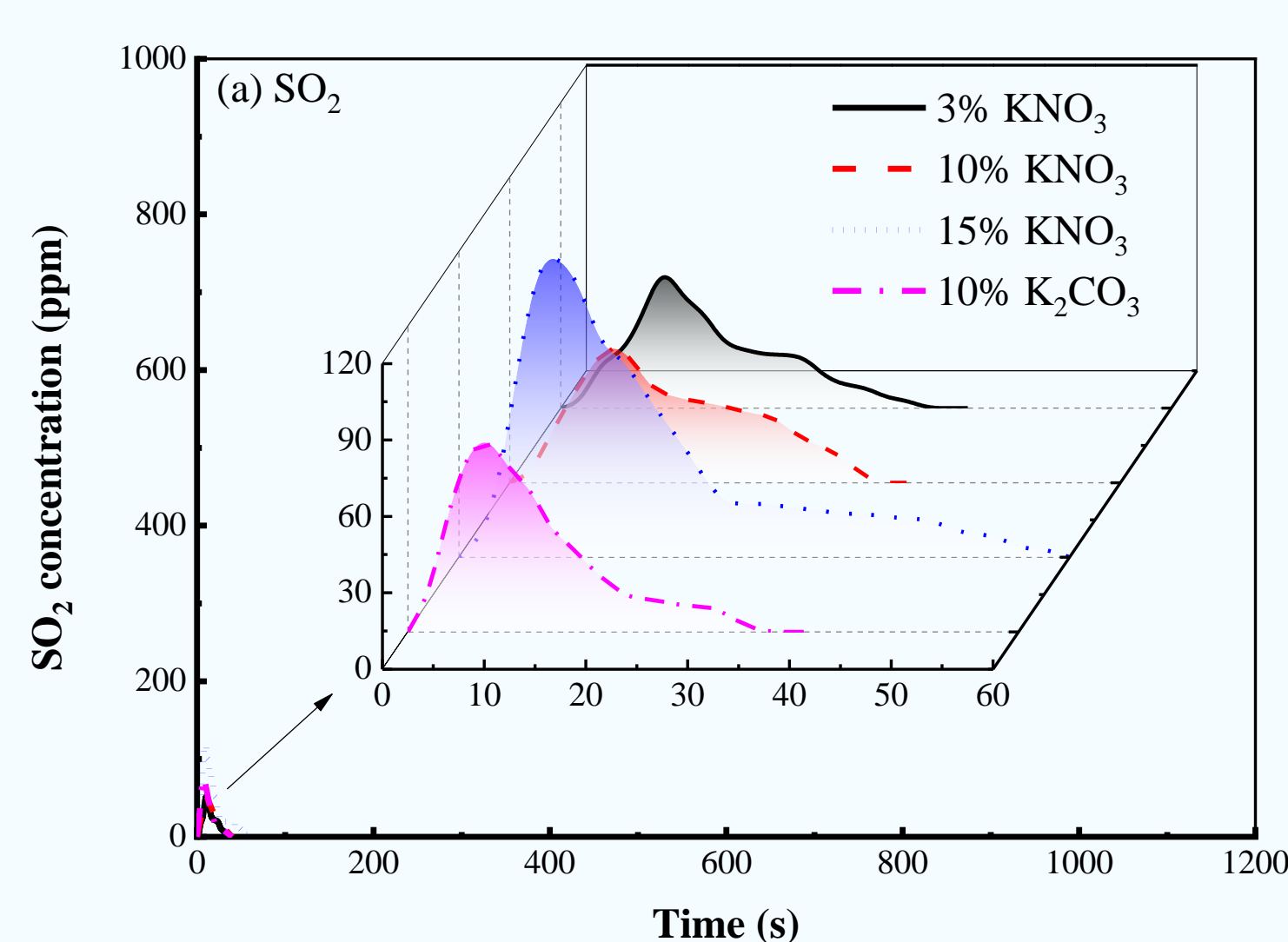
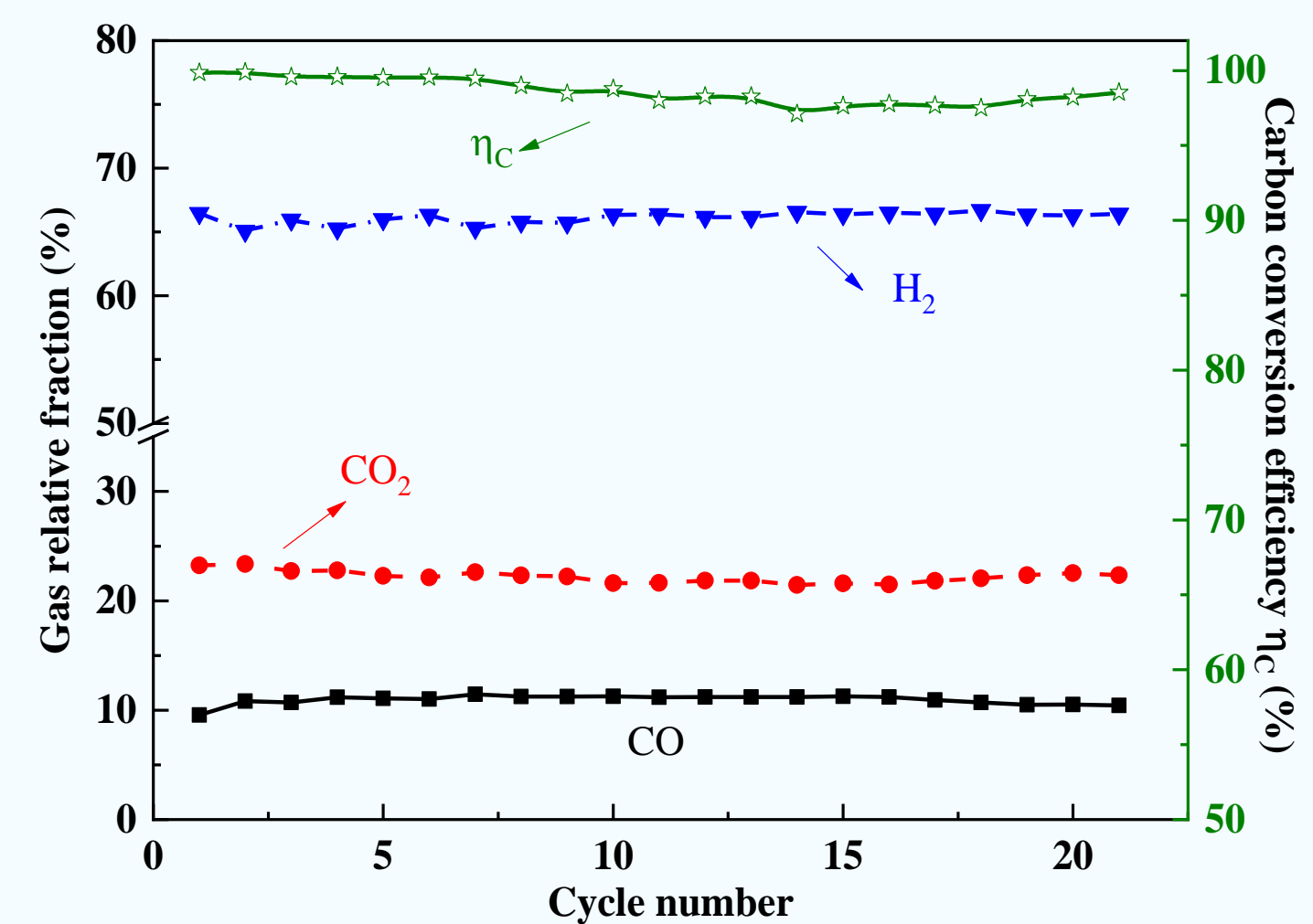


Table 2 : Sulfur composition in reacted OC

	Major phase	Minor/Trace phase
0K	-	Fe_3S_4 , FeS
0.3% K	-	FeS , FeS_2
10% K	$Fe_{0.91}S$, FeS , KFe_2S_3	$Fe_2K_9S_7$, FeS_2 , $K_3Fe_2S_4$, $KFe(SO_4)_2$, K_2S_5 , $K_2S_4O_6$
R-10% K	$KFe(SO_4)_2$, $Fe_{0.91}S$	$K_2S_4O_6$, $K_2S_3O_{10}$, $K_3Fe_2S_4$, FeS_2 , $Fe_2K_9S_7$

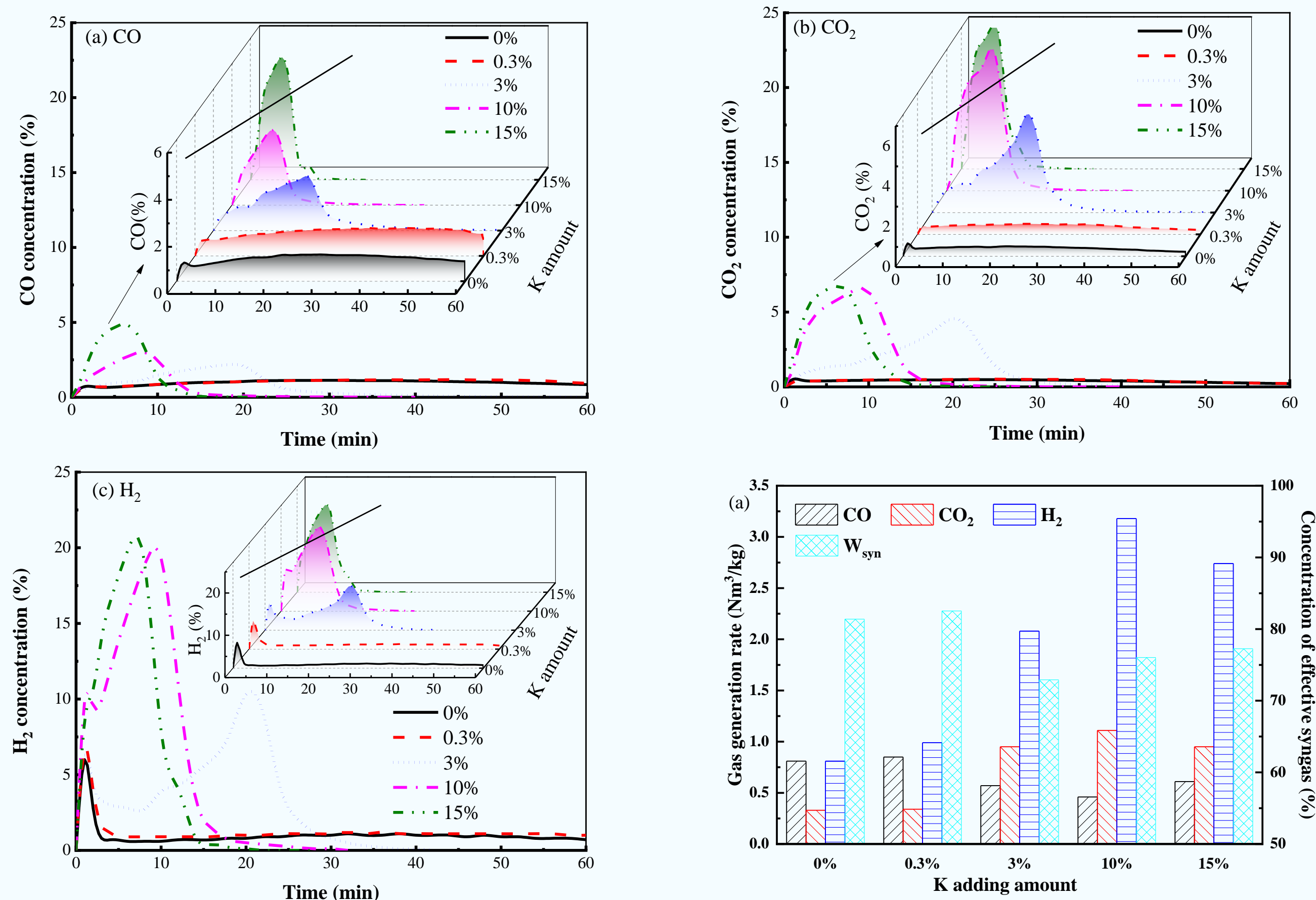
Stability of K-catalyzed OC



- H_2S is the major component of sulfur release in K enhanced CLG.
- K enhanced in-situ sulfur capture through K-Fe-S compounds in OCs.
- 10% KNO_3 -hematite had excellent stability.

Results

Effect of K on carbon and hydrogen conversion



- Break through the barriers between volatile release and char gasification.
- K-catalyzed OC improved H_2 yields -3.9 times.

Conclusions

- Introducing K had an evident enhancement on H_2 generation from improving PC gasification and partial oxidation of deepened reductive Fe by steam.
- K accelerated the S conversion via char-S gasification, and in-situ S capture through K-Fe-S compounds in OCs.
- The mechanism of K-modified hematite to catalyze CLG was established.

