

Chemical-Looping on solid fuels in a laboratory fluidized –bed reactor

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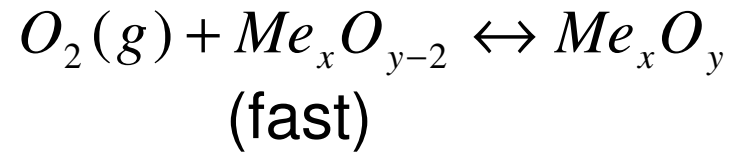
Göteborg, Sweden

Presentation at the 1st International Conference on Chemical Looping

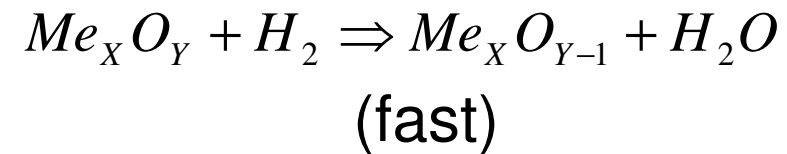
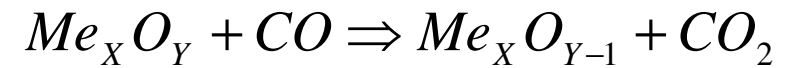
March 17-19, 2010, Lyon, France

Oxidation

CLC

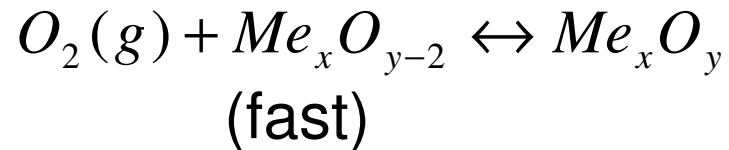


Reduction

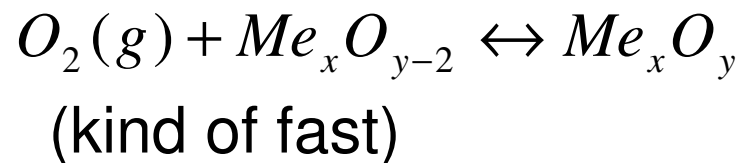


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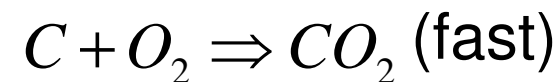
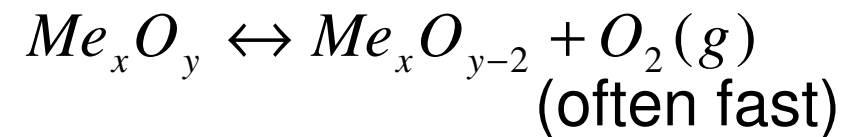
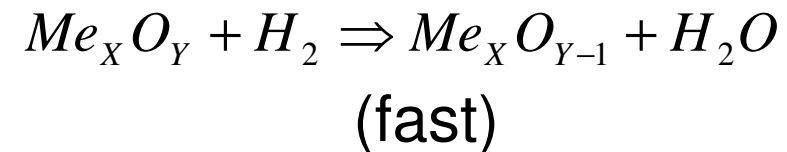
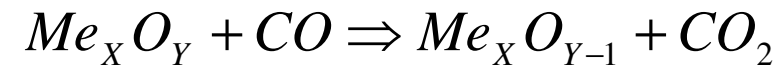
CLC



CLOU

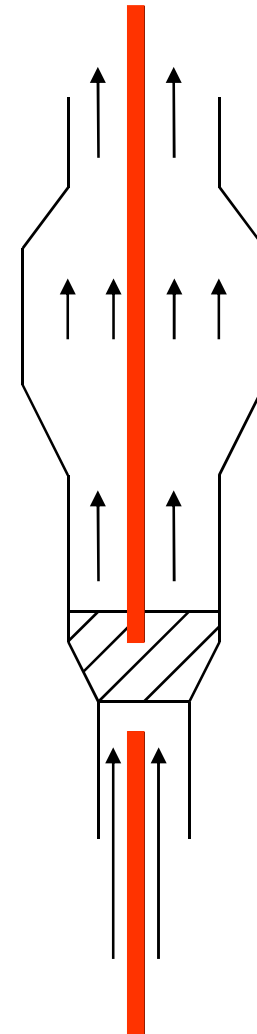


Reduction



Experimental parameters

- 15-40 g of bed material
- Temperature of 800-1100°C in the bed
- 0.05-0.5 g of fuel for every cycle
- Flow 600 -1000 ml/min
 - oxidation 5-21% O₂
 - inert 100% N₂
 - reduction H₂O/N₂/CO₂/SO₂
 - inert 100% N₂





Solid fuel used:

Fuel	H _i MJ/kg	Proximate analysis (wt% as received)			Ultimate analysis (wt% as received)				
		Volatiles	Moisture	Ash	C	H	S	N	O
Mexican Petroleum coke	31.7	10	8	0.5	81.3	2.9	6	0.9	0.5
South African coal	29.9	21.6	8.3	15.9	62.5	3.5	0.7	1.4	7.7
Chinese coal	26.6	8.8	1	21	70.3	2.8	0.6	1.1	3.1
Indonesian coal	26.4	45.3	8.5	1.4	66.1	4.7	0.1	0.7	18.5
Taiwanese coal	27.9	31.5	2.5	12.3	70.6	4.5	0.5	1.7	7.9
French coal (raw)	24.9	25	1.5	21.8	63.9	3.6	0.8	0.8	7.7
French coal (sieved)	24.9	25	1.5	21.8	63.9	3.6	0.8	0.8	7.7
Colombian coal	29.1	37	3.3	5.2	74	5	0.6	1.4	10.6
German lignite	20.9	50.5	10	5	69.9	5.4	1	0.6	23.1
Swedish wood char	-	11	3	3	83	-	-	-	-

Oxygen carriers used in CLC:

Name	Type of material	Origin of Material
$\text{Fe}_2\text{O}_3/\text{MgAl}_2\text{O}_4$	Synthetic particles	Sweden, Chalmers
Imenite	Ilmenite mineral	Norway, Titania A/S
$\text{NiO}/\text{NiAl}_2\text{O}_4$	Synthetic particles	France, IFP
Mt Wright	Iron ore	Australia via Studiengesellschaft für Eisenerzaufbereitung
Glödskal A	Residue product from rolling of steel sheets	Sweden, SSAB

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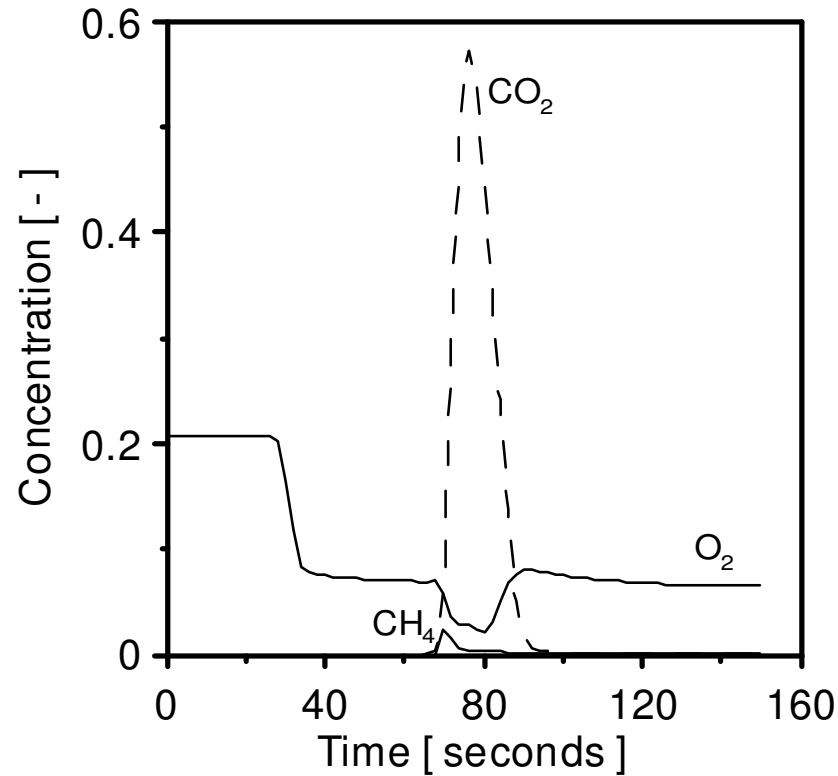
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Oxygen carriers used in CLOU:

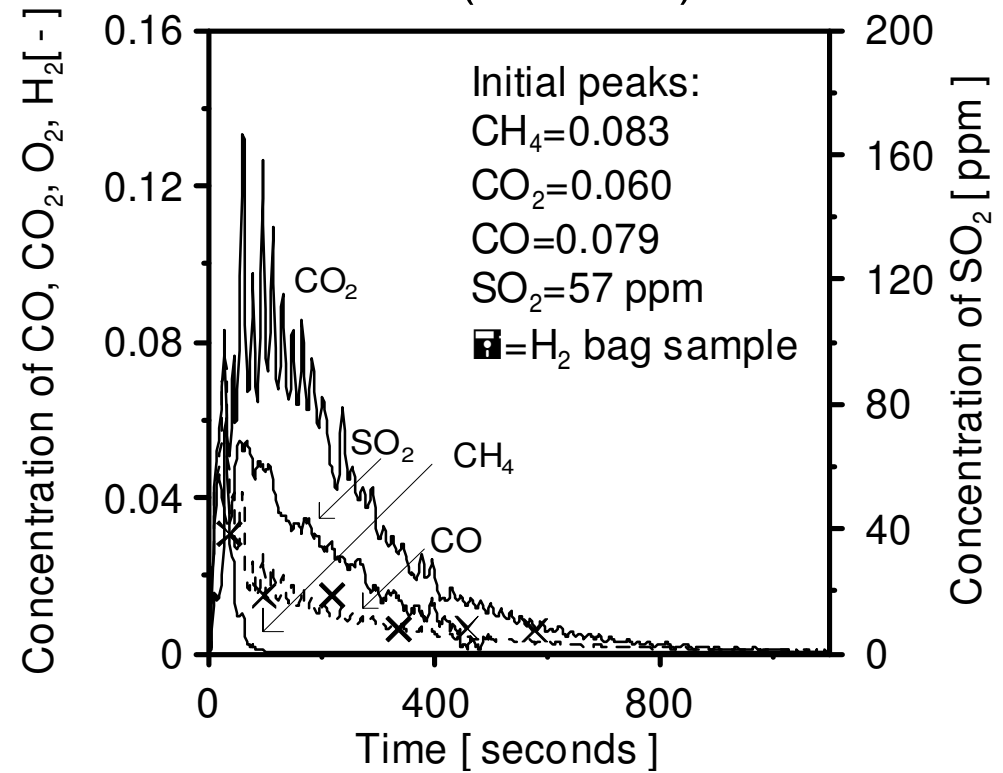
Name	Type of material	Origin of Material
CuO/ZrO_2	Synthetic particles	Sweden, Chalmers
$\text{CaMn}_{0.875}\text{Ti}_{0.125}\text{O}_3$	Synthetic particles	Norway, SINTEF

Solid fuel conversion:

Petroleum coke in
CLOU(CuO on ZrO₂)

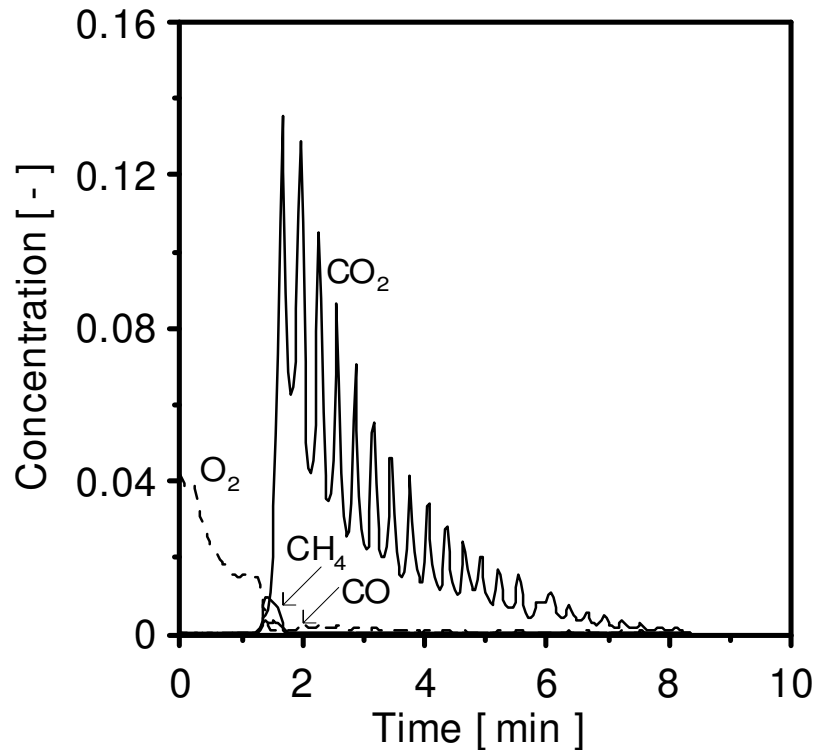


Petroleum coke in
CLC(ilmenite)



Conversion of petroleum coke in $\text{CaMn}_{0.875}\text{Ti}_{0.125}\text{O}_3$

Conversion times at 900°C

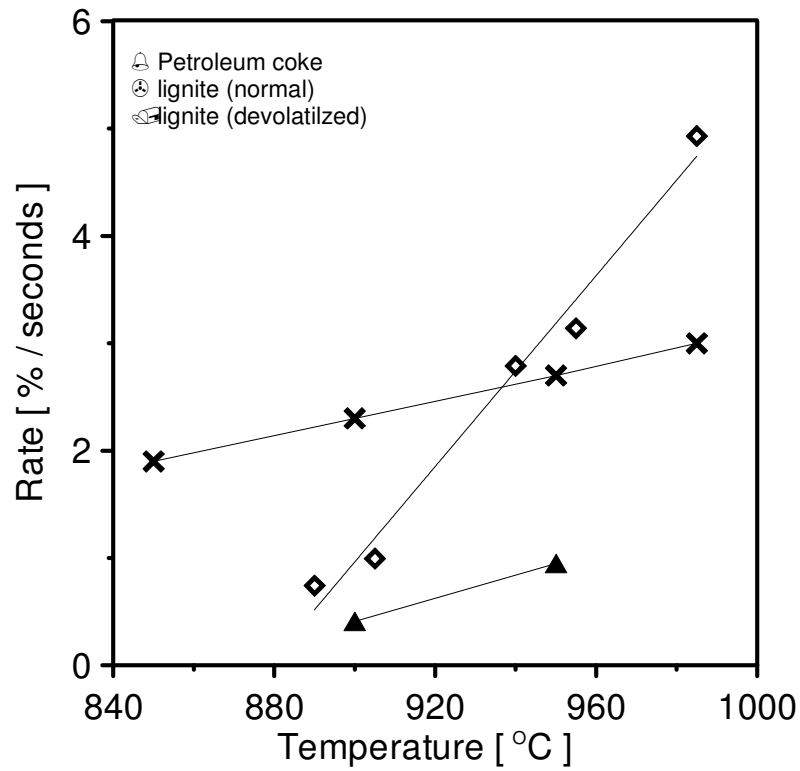


<u>Time for 95% conversion (s)</u>	<u>Mexican petroleum coke</u>
CLC(ilmenite)	1000
CLOU ($\text{CaMn}_{0.875}\text{Ti}_{0.125}\text{O}_3$)	750
CLOU (CuO on ZrO_2)	100

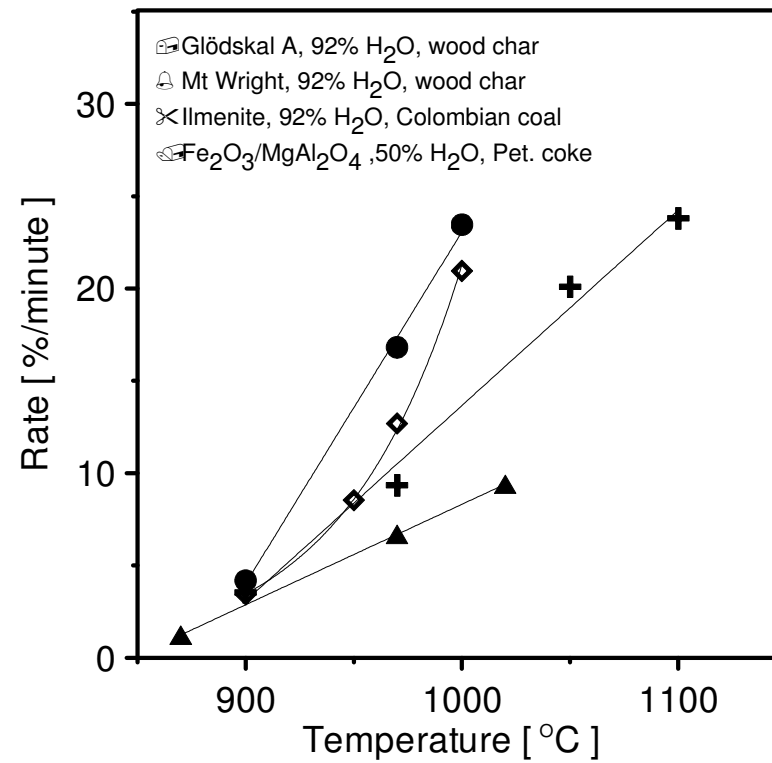
This material is developed by:
SINTEF, Norway

Rate of fuel conversion:

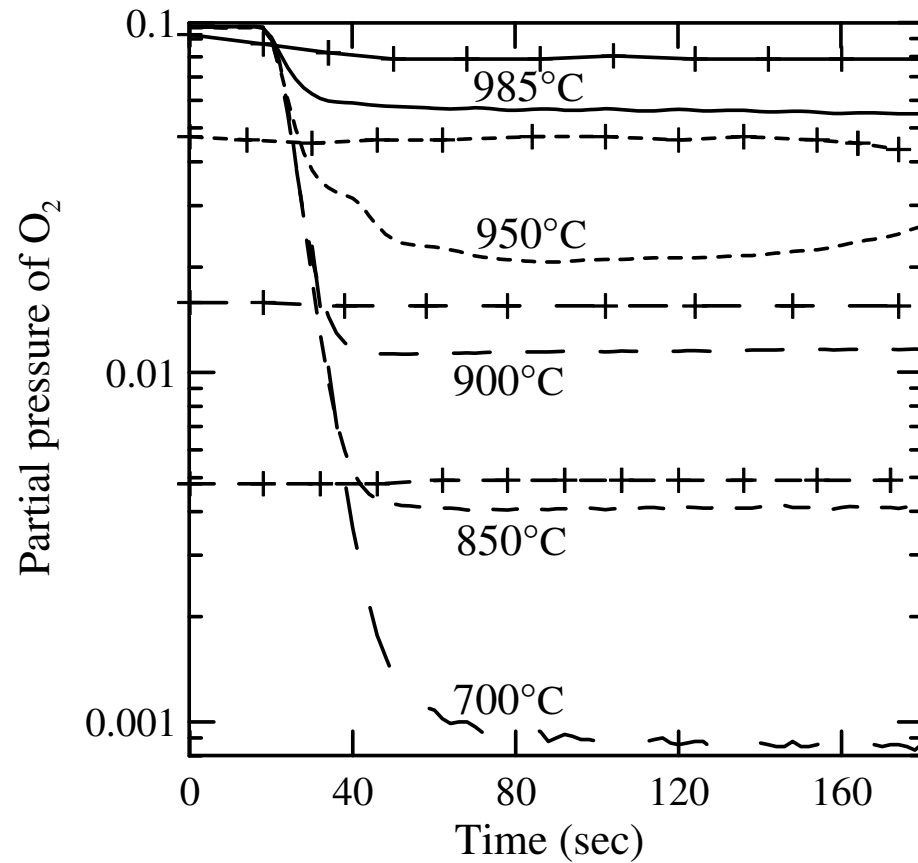
CLOU(CuO on ZrO₂)



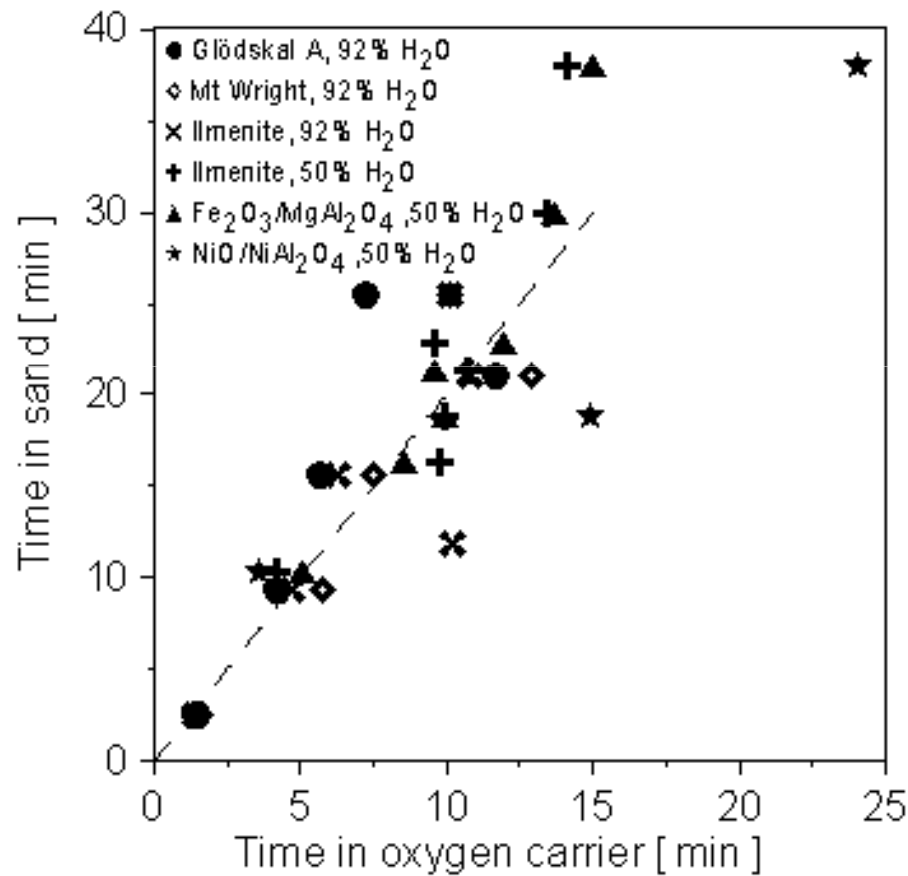
CLC



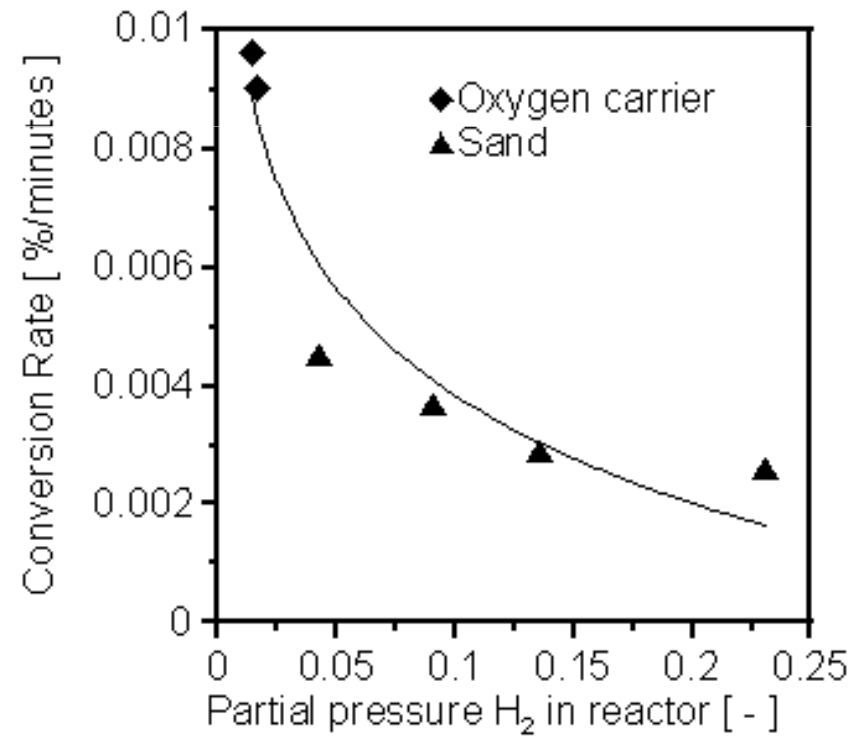
Measured and theoretical partial pressure of oxygen over CuO/Cu₂O for different temperatures



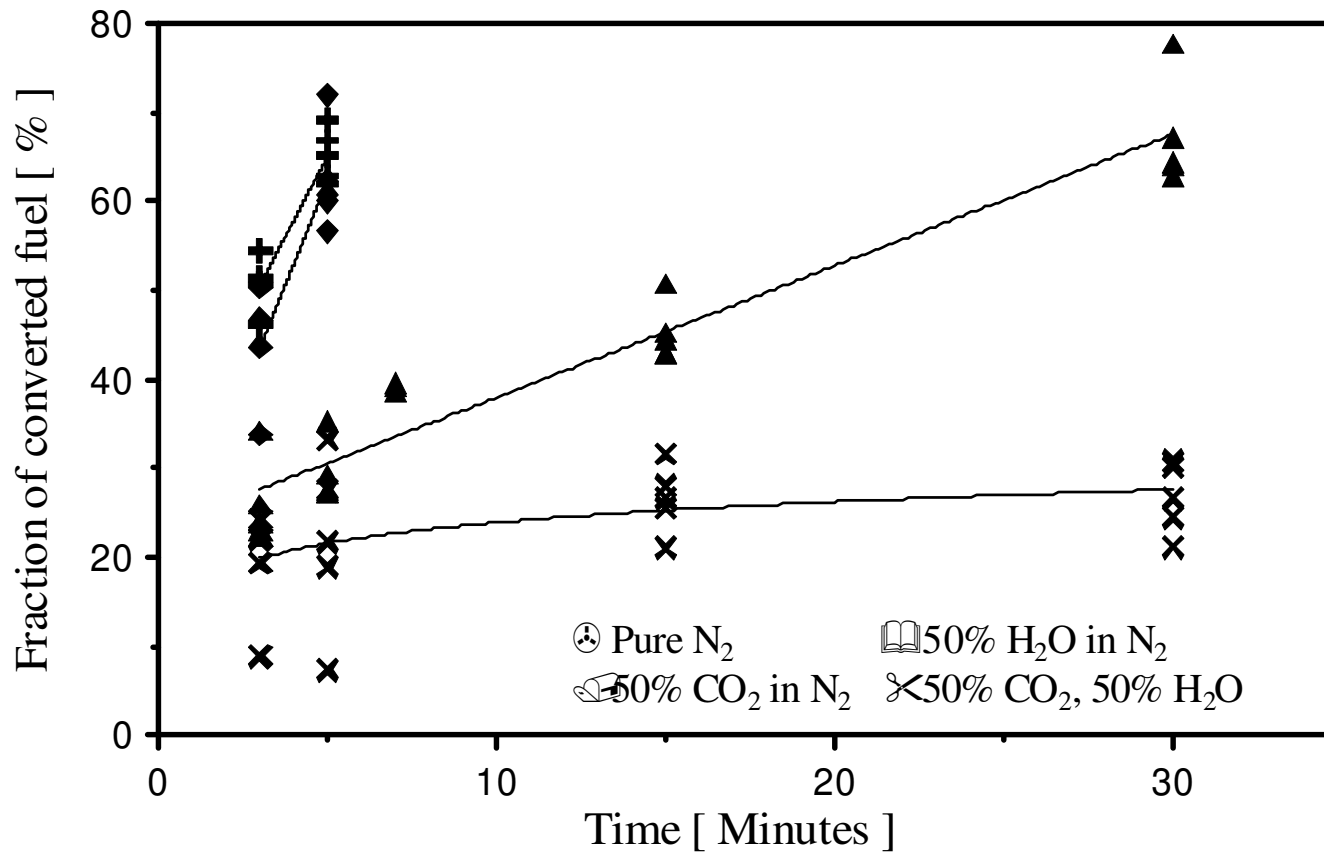
Fuel gasification



and hydrogen inhibition

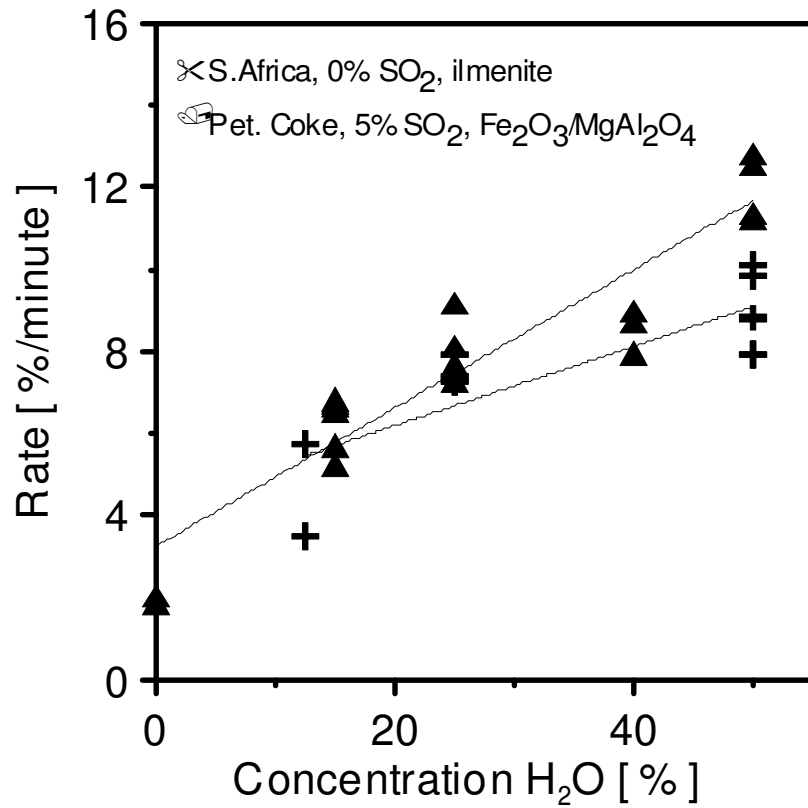


Conversion of bituminous Colombian coal in CO₂/Steam

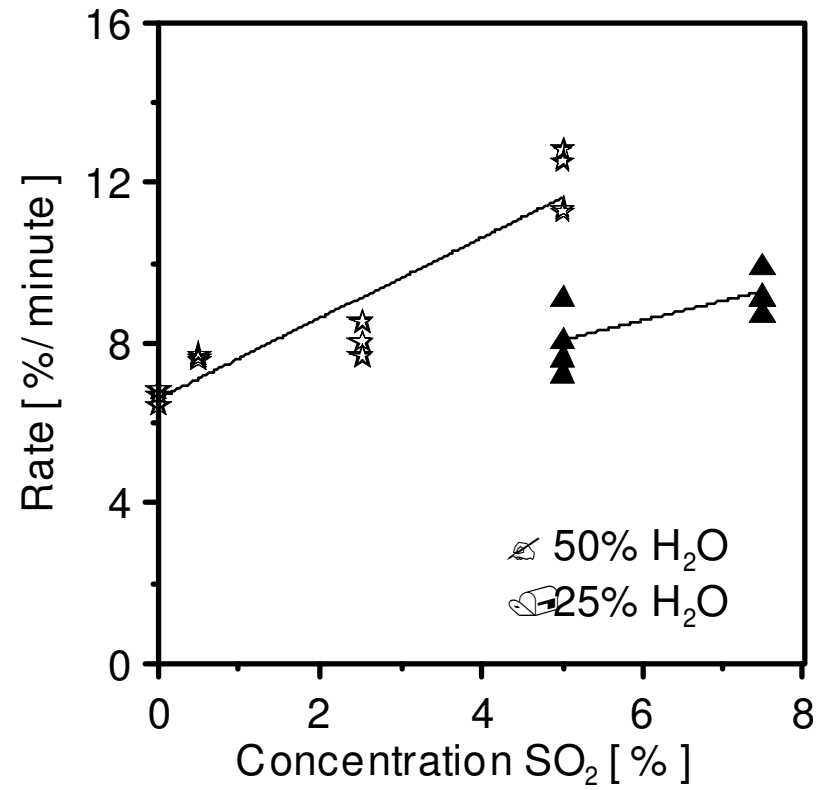


Effects in CLC of:

Steam

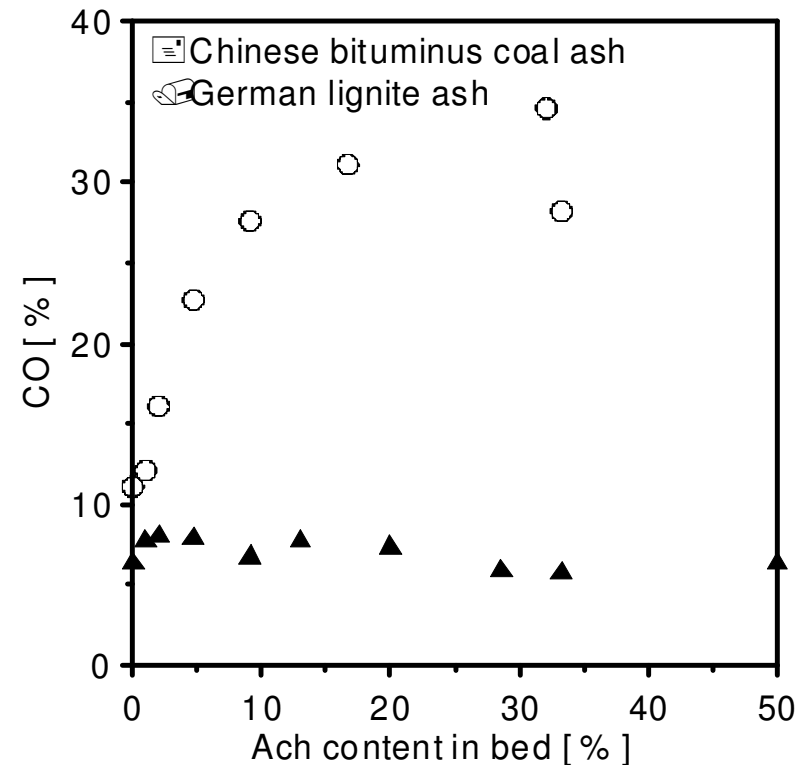


SO₂



Deactivation of oxygen carrier

- Ash can influence fuel conversion
- SO_2 deactivate Ni-particles (possibly also CaMn-particles)
- Successive alterations of oxygen carriers
 - separation of Fe and Ti in ilmenite



Conclusions

- Solid fuel conversion is faster in CLOU as compared to CLC
- Each CLOU material has an upper temperature limit below which the oxidation in air is practically feasible
- H_2 has an inhibiting effect on fuel conversion
- The gasification rate in CLC is strongly influenced by parameters such as the temperature, steam and SO_2 fraction in the surrounding
- SO_2 can deactivate Ni-based materials and ash can affect oxygen carrier reactivity

Thank you for your attention!