Catalytic PRB Coal-CO_2 Gasification for Fuels and Chemicals with Two Different Types of Syngas (1st- CO + zero CH_4; 2nd- H_2:CO:CH_4 = 2:1:near-zero) and Negative or Low CO_2 Emissions

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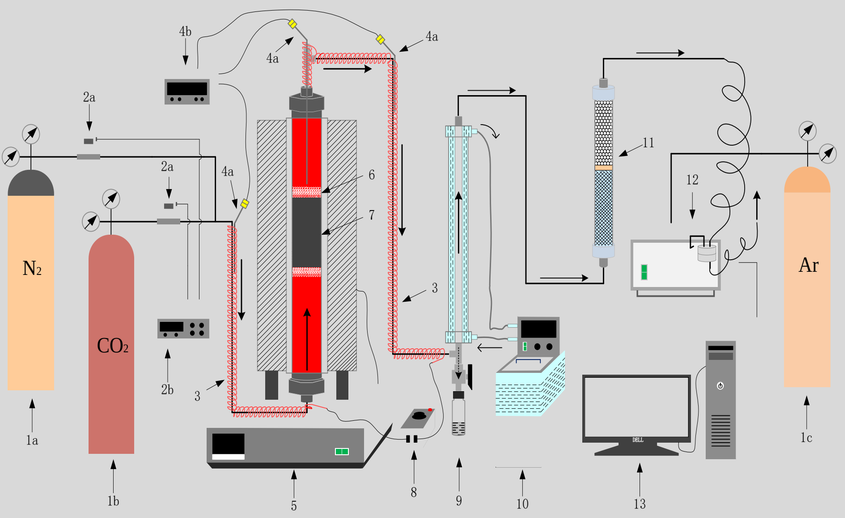
Objective

Development of a catalytic gasification technology with the characteristics of zero CH_4 and negative/low CO_2 generations

Specific Goals

- Reduce CH_4 and CO_2 by 30% and 50%, respectively
- Increase H_2 in the gas from pyrolysis at least 20%
- Generate CO with near 0 CH_4 in CO_2-char gasification
- Produce syngas with H_2: CO = 2:1 and < 0.5% CH_4
- Reduce activation energies by 30-50%

Experiments



Schematic diagram of catalytic coal gasification with CO_2 [(1a) N_2, (1b) CO_2, (1c) Ar; (2) mass flow controller; (3) heating tapes; (4) thermocouples and temperature scanner; (5) tube furnace; (6) ceramic wools; (7) coal sample; (8) temperature controller for heating tapes; (9) tar collector; (10) water-cooled condenser; (11) water-trap; (12) micro GC; and (13) data acquisition system].

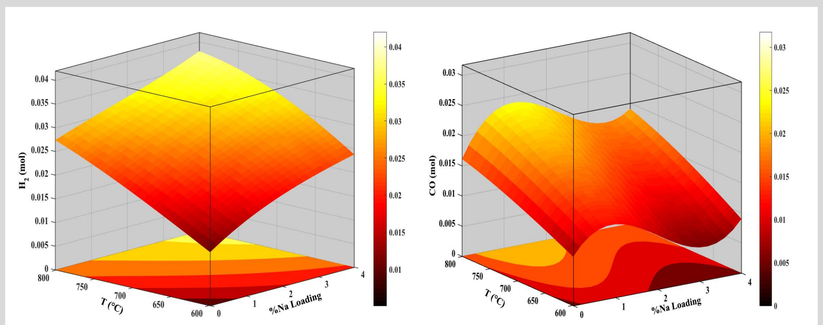
Photo of one experimental set-up

Operating conditions

- Temperature range: 600 to 900°C
- Pressure range: Atmosphere to 10.0 bar
- Catalysts: Na-based, Fe-based, and Na-Fe based
- Sample: Dry and ash free (DAF) - 5.0 g
- N_2 flow rate: 15 ml/min

Results

Pyrolysis



a b

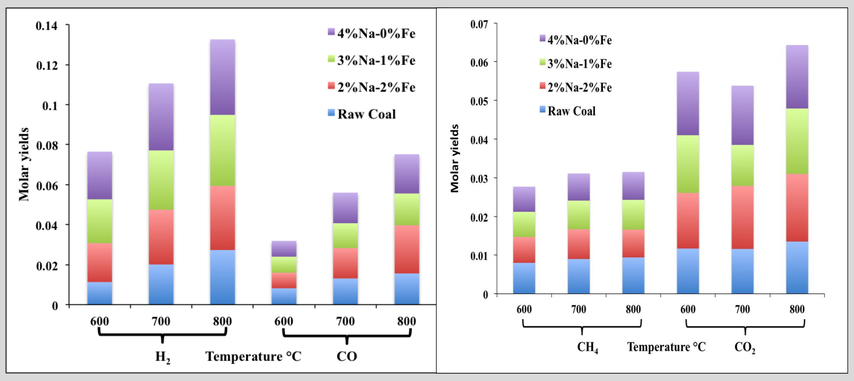
(a) Molar yields of H_2 vs loadings of Na and pyrolysis temperature; (b) Molar yields of CO vs loadings of Na and pyrolysis temperature.

Yields of H_2

- Increases by 66.70 % with 4% Na catalyst at 700 °C
- Increases by 38.10 % with 4% Na catalyst at 800 °C
- H_2 increases with the decrease in pyrolysis temperature

Yields of CO

- Increases by 16.79 % with 4% Na catalyst at 700 °C
- Increases by 54.49 % with 2% Na–2 % Fe catalyst at 800 °C
- CO increases with the temperature



a b

(a) Molar yields H_2 and CO generated from coal pyrolysis at temperature 600, 700 and 800°C, respectively; (b) Molar yields CH_4 and CO_2 generated from coal pyrolysis at temperature 600, 700 and 800°C, respectively

Yields of CH_4

- Decreases by 22.22 % with 4 % Na catalyst at 700 °C
- Decreases by 23.40 % with 2 %Na-2 %Fe catalyst at 800 °C
- Slightly increases with temperature

Yields of CO_2

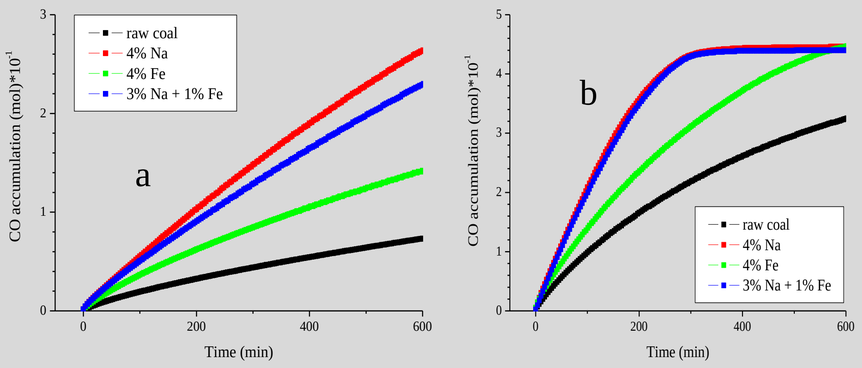
- Decreases by 8.62 % with 3% Na – 1%Fe catalyst at 700 °C
- Decreases by 22.22 % with 4 %Na catalyst at 700 °C

H_2: CO Ratio in the generated syngas

- 2.19 with 4 % Na catalyst at 700 °C
- 2.13 with 1 % Na-1 % Fe catalyst at 700 °C
- 1.93 with 4 % Fe catalyst at 700 °C
- 1.92 with 4 % Na catalyst at 800 °C
- 1.91 with 4 % Fe catalyst at 800 °C

Gasification

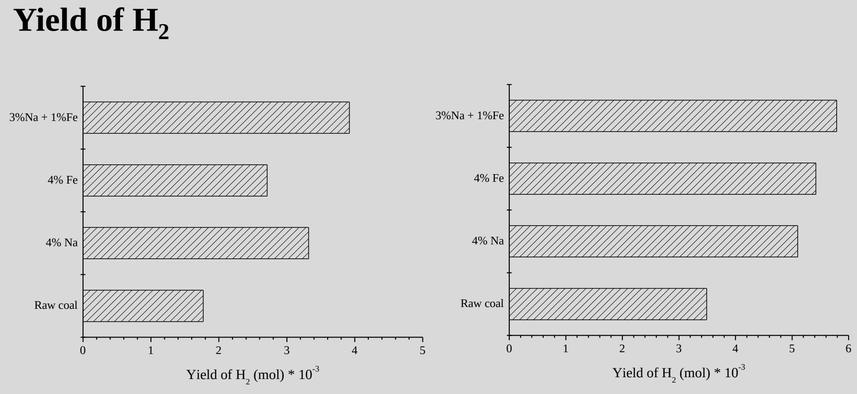
Yields of CO



(a) CO accumulation with reaction time during char gasification at 600 °C; (b) CO accumulation with reaction time during char gasification at 700 °C

- Increases by 39.06 % with 4% Na catalyst at 700 °C

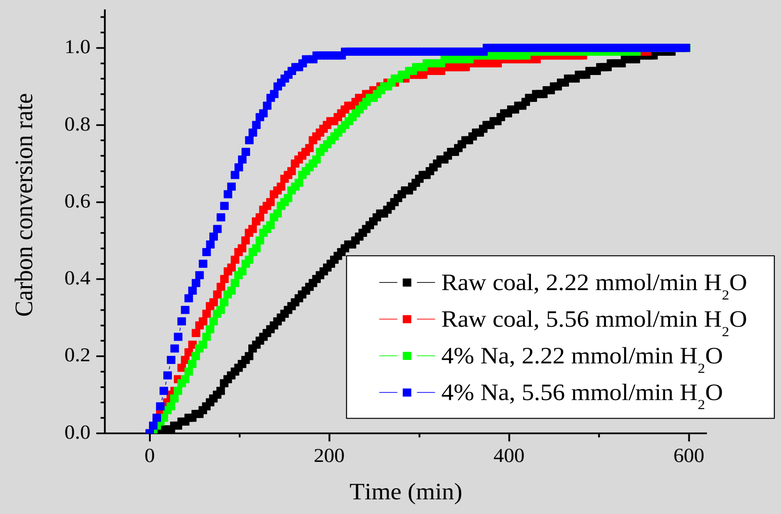
Yields of H_2



Yield of H_2 at 700 °C (a) at 800 °C (b)

- Increases by 121.47 % with 3% Na-1%Fe catalyst at 700 °C
- Increases by 65.90 % with 3% Na-1 % Fe catalyst at 800 °C
- Increases with the decrease in temperature

Conversion of carbon



Change of carbon conversion rates with time during char-H_2O gasification at 700°C

- Needs only 200 min for gasifying char with 4% Na and 5.56 mmol-H_2O/min, ~50% time needed for gasifying the same amount of char without use of catalyst
- Increases with the amount of H_2O used

Conclusion

Due to uses of the catalysts -

- **The total amount of CH_4 generated with both pyrolysis and gasification steps can be neglected**
- **The total amount of H_2 generated with both pyrolysis and gasification steps are significantly increased**
- **The total amount of CO generated with both pyrolysis and gasification steps are significantly increased**
- **The total amount of CO_2 generated with both pyrolysis and gasification steps are significantly decreased**
- **The ratio of H_2:CO in syngas generated with both pyrolysis and gasification steps are significantly increased**
- **Carbon conversion kinetics can be considerably improved.**

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