Capturing and Conversion of CO_2 with Chemical-Looping Technology

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Methodology

Chemical-looping Technology

- Power production and CO_2 capture are intrinsically combined by the use of an oxygen carrier (OC) that transfers oxygen from the air to the fuel preventing direct contact between them.

Hydrothermal Conversion of CO_2 to HCOOH

- Very effective method as the high temperature properties of water are different from the water at ambient conditions

Hydrothermal Conversion of HCOOH to CH_3OH

- Formic acid can be converted to methanol (CH_3OH) in a packed bed reactor, by using high temperature water as a source of H_2.

Reactions

- Chemical Looping Combustion.

  $C_nH_{2n} + MeO \rightarrow Me + CO_2 + H_2O$

  $Me + O_2 \rightarrow MeO$

- Hydrothermal Conversion of Carbon dioxide to Formic Acid.

  $M^0 + CO_2 + H_2O \rightarrow MO_x + HCOOH$

  $MO_x + C_aH_bO_c \rightarrow M^0 + C_aH_{b-2c}O_c + xH_2O$

- Hydrothermal Conversion of Formic Acid to Methanol.

  $HCOOH + H_2 \rightarrow CH_3OH + H_2O$

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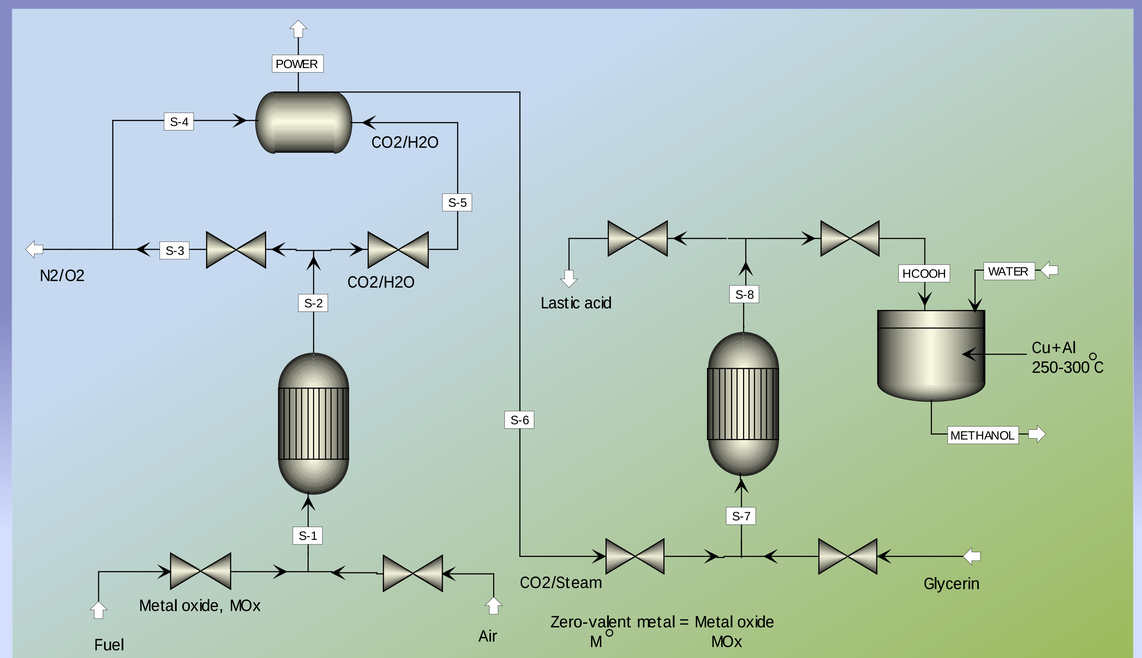
Objectives

Using the packed bad chemical-looping technology operated at hydrothermal conditions CO_2 can be converted to formic acid or directly to methanol using various metals with:

- The lowest possible energy and economic costs for the fuel/biomass conversion systems without adverse environmental/societal consequences,
- A reduction of carbon intensity from energy conversion and use,
- Interactions of systems and patterns at the local/regional scale with systems/patterns at the global scale.



Chemical-looping processes combining combustion of a fuel at the first stage and hydrothermal process of converting CO_2 to methanol at the second stage.

Process Description

Under hydrothermal conditions, using Cu (12 mmol) as catalyst in the presence of Al (4.4 mmol) was about 30.4%. The reaction takes place at 300 °C with a reaction time of 9 hours. Methanol may be formed by the synthesis of CO_2 and H_2 from the decomposition of formic acid. This shows that there is possibility of converting CO_2 to methanol directly starting with CO_2 in a packed bed chemical-looping system. By combining the chemical-looping combustion of a fuel and the hydrothermal process of converting CO_2 to formic acid, we will have a process converting a fuel to methanol

Advantages

- Over 90% CO_2 captures at lowest cost
- Separation of water is based on cooling/ compression of the product gas containing mainly CO_2 and water at process pressure
- No or very little thermal NO_x production because of low temperature
- Compatible with sulfur and mercury capture technologies
- Heavy metals may stay with the ash
- Higher thermodynamic efficiency
- No hot spots under fluidized bed technology

Disadvantages

- Dual reactors operation
- Oxygen carrier circulation between the reactors
- Solids handling

Conclusion

- Chemical-looping technology may help improve combustion, reforming, and gasification of various fuels with the ability of capturing and converting CO_2 to valuable chemicals and fuels.
- At hydrothermal conditions CO_2 can be converted to formic acid or directly to methanol using various metals.
- It is possible to convert CO_2 to formic acid by using zero-valent metals in the first process, while the methanol is synthesized from formic acid in the second stage using various metals.

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