Utilization of char from biomass gasification for tar reduction

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Motivation

Energy recovery from solid fuels via gasification:
Solid fuel: waste, biomass, coal

electricity, heat

GASIFICATION
synthesis gas

synthetic natural gas

LPG

Liquid fuels (diesel, gasoline) or chemicals

By-products of gasification:
- Tar must be decomposed but is aggressive towards catalysts.
- Char or ash is considered a low-value product; often landfilled.

Process Concept:
Use residual char from gasification to catalyze tar decomposition.

Research Goal:
To investigate the catalytic properties of char and its activity for catalytic hydrocarbon decomposition.

Experimental Methods

Gasification
- Char recovered from poplar wood gasification in a fluidized bed reactor
- 550, 750, or 920°C for 30 or 60 min

Char characterization:
- BET surface area, composition (EDX), structure (ESEM)

Catalytic Performance:
- Catalytic hydrocarbon cracking in a thermo gravimetric analyzer (TGA) or flow through reactor

Calculations

REACTOR MODEL USING CHAR CATALYTIC PERFORMANCE

Results and Discussion

CATALYTIC PERFORMANCE OF CHAR

CH₄ decomposition in TGA (mass gain from carbon produced)

Reactions: CH₄ → C + 2H₂

- performance increases with SA for each char type (CO₂, H₂O)
- diffusion limitations in micro pores of CO₂ char may reduce performance

Toluene decomposition in flow through reactor:

- Toluene flow rate = 12.7 μmol/min
- MS analysis of condensate showed presence of benzene and ethylbenzene
- Tar is a main component of tar decomposition of toluene suggests char may also decompose other tars

CHAR CHARACTERIZATION

Char Sintering: at 1000°C, sintering for char made with air and steam; no sintering for char made under CO₂

Micro pores present in char made with CO₂ but not H₂O; higher T gives more micro pores

EDX analysis showed that char contains Ca, Fe, Mg, K, Na

Properties impacting catalytic performance:

Char pores: after catalytic reaction C deposition on char pores

Metal sites: after catalytic reaction C deposition on iron

Conclusions & Future Work

- Char from biomass gasification demonstrated catalytic performance for decomposition of methane and toluene.
- Higher surface area increases catalytic performance of char but pore diffusion limitations may exist in microporous char.
- Future work will further understanding of how char properties impact its performance

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