Utilization of char from biomass gasification for tar reduction

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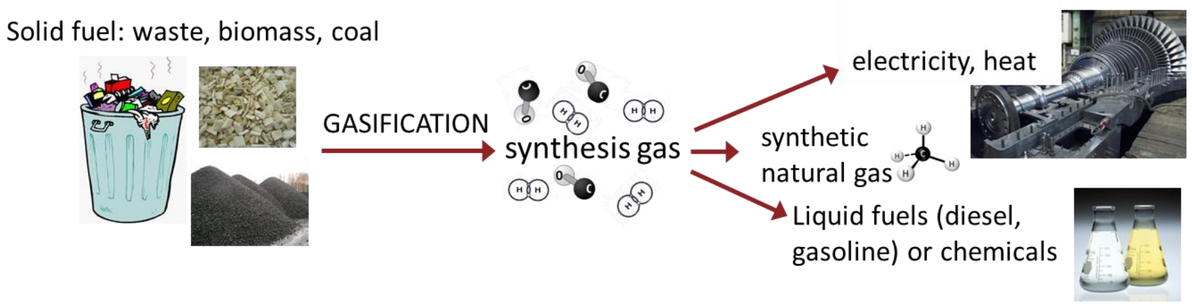
Motivation

Energy recovery from solid fuels via gasification:



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.

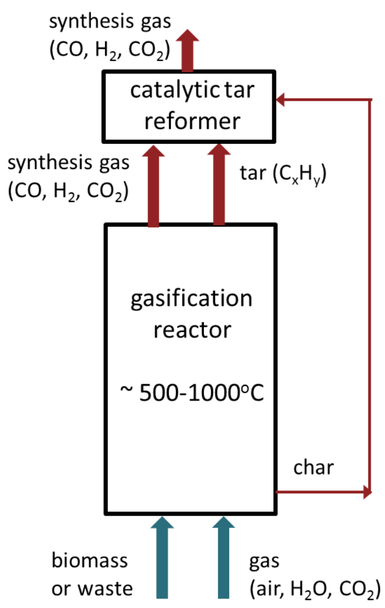


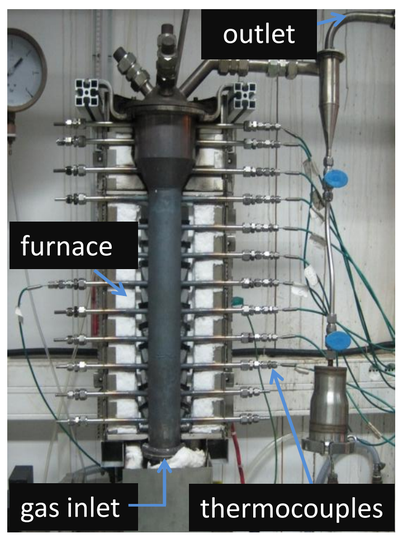
Diagram of process

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)

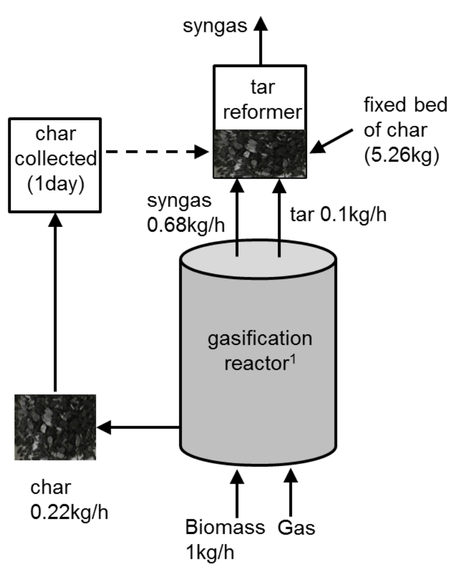
Catalytic Performance:
- Catalytic hydrocarbon cracking in a thermo gravimetric analyzer (TGA) or flow through reactor

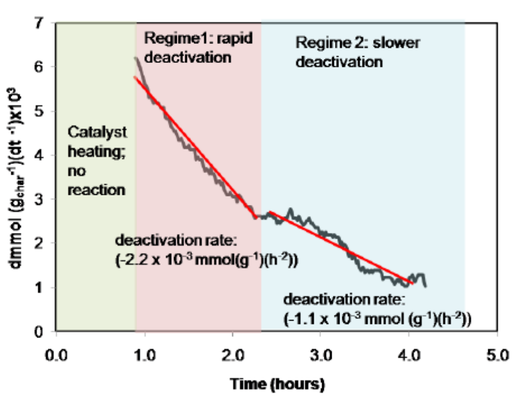


fluidized bed gasifier

Calculations

REACTOR MODEL USING CHAR CATALYTIC PERFORMANCE



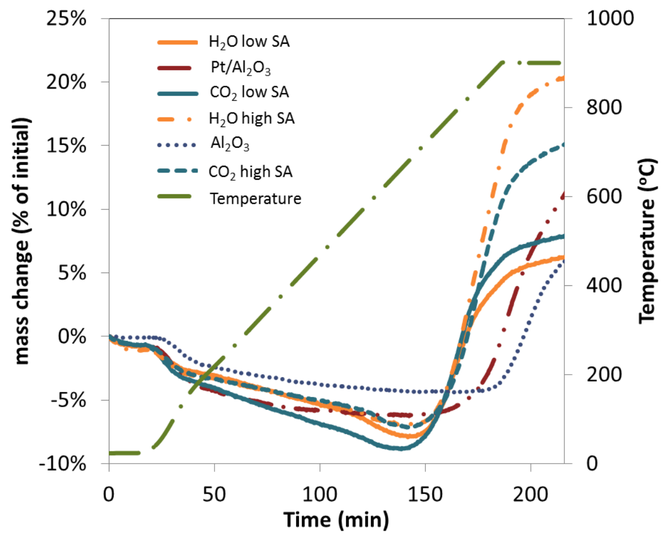


Results and Discussion

CATALYTIC PERFORMANCE OF CHAR

CH_4 decomposition in TGA (mass gain from carbon produced)

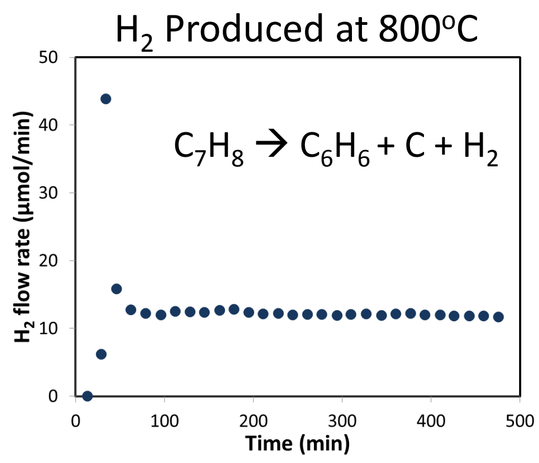
Reactions: $CH_4 \rightarrow C + 2H_2$



-performance increases with SA for each char type (CO_2, H_2O)
-diffusion limitations in micro pores of CO_2 char may reduce performance

Catalyst	Surface Area (m^2g^{-1})
Alumina catalyst carrier (γ- Al_2O_3)	101
Commercial catalyst – 0.5% Pt on γ- Al_2O_3	130
Char made by gasification with H_2O at 700°C for 30 min (H_2O low SA)	429
Char made by gasification with H_2O at 700°C for 1 h (H_2O high SA)	621
Char made by gasification with CO_2 at 700°C for 30 min (CO_2 low SA)	435
Char made by gasification with CO_2 at 920°C for 30 min (CO_2 high SA)	687

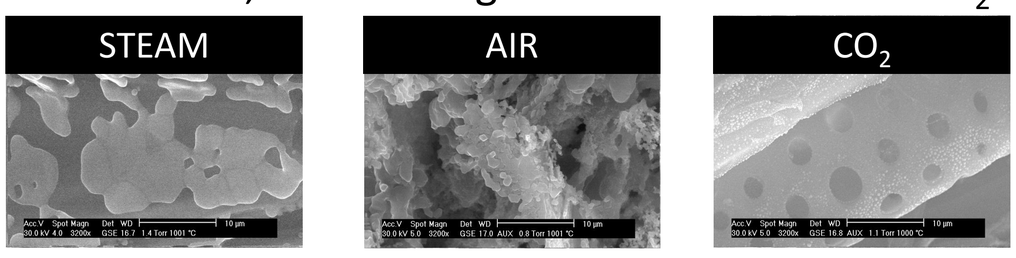
Toluene decomposition in flow through reactor:



- 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 CO_2



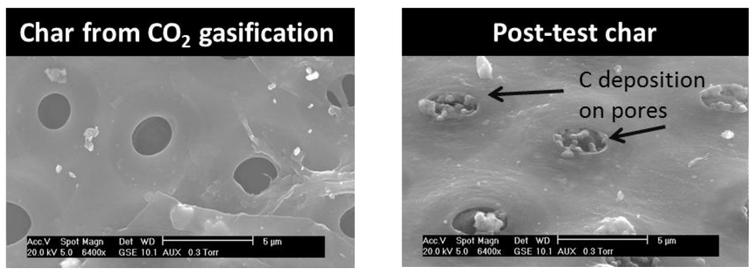
Char gasification conditions	Pore volume < 0.8 nm (cm^3g^{-1})
H_2O at 700°C for 30 min	0
CO_2 at 700°C for 30 min	0.18
CO_2 at 920°C for 30 min	0.30

Micro pores present in char made with CO_2 but not H_2O; higher T gives more micro pores

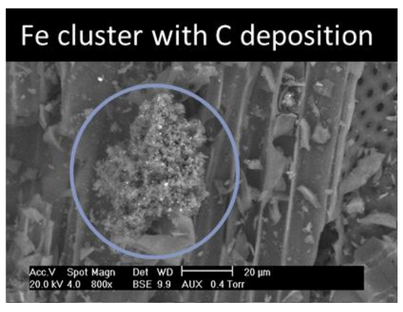
EDX analysis showed that char contains Ca, Fe, Mg, K, Na

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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