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A new inductively heated mini reactor for biomass pyrolysis and gasification tests

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A New Inductively Heated Mini Reactor for Biomass Pyrolysis and Gasification Tests

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Why a new test reactor?

- Many important catalytic reactions are endothermic e.g.:
  - Catalytic cracking
  - Gasification

- Issues with traditional test reactors:
  - Heat is transferred from the wall into reactor
    - Low heat transfer coefficient:
      → High temperature gradient
      → Parasitic thermal cracking reactions
  - Seals for agitator may leak

Solutions

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  → good control of residence time

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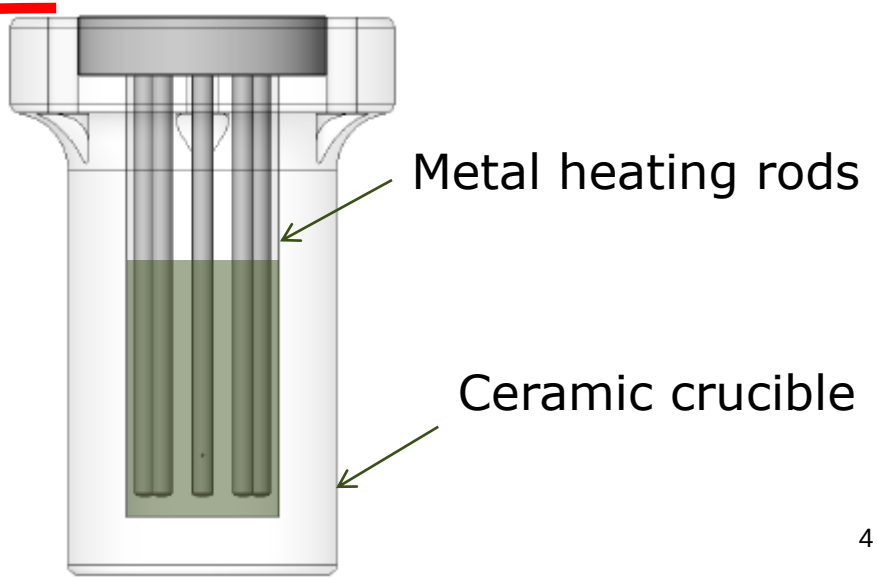
- **Low temperature difference between heating surface and catalyst bed:**
  → induction heating of rods within bed

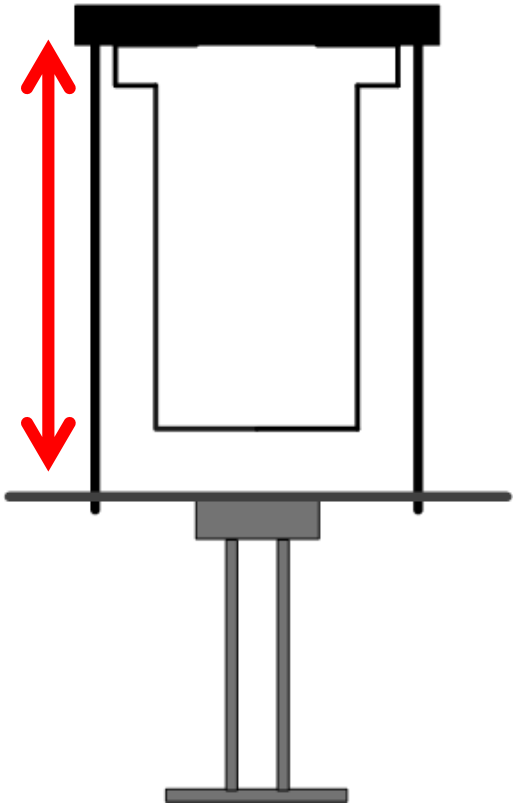


Solutions

- Batch reactor
  → good control of residence time

- Low temperature difference between heating surface and catalyst bed:
  → induction heating

- **No mechanical seal**
  → **jiggle bed**
  (up and down motion)



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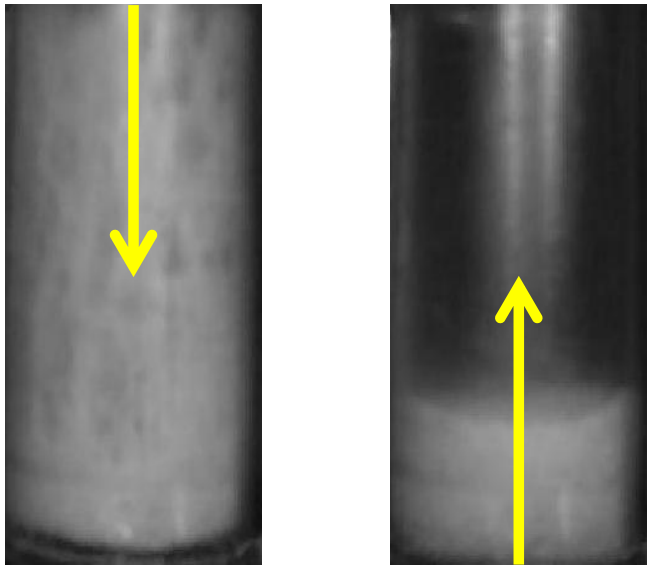
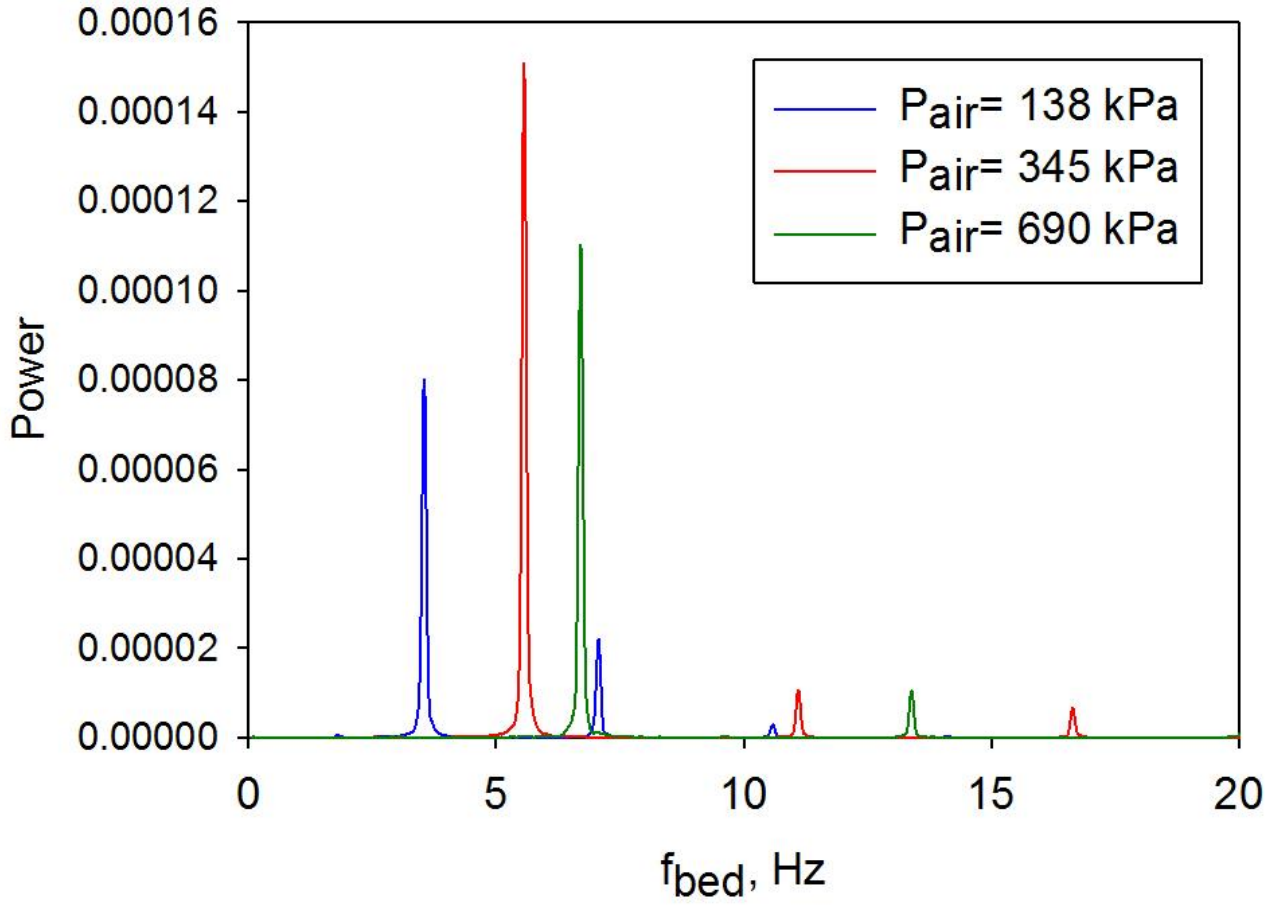


Optimum frequency and amplitude

- **Analysis of color variations**



Heat transfer performance

Heat transfer coefficient from metal rods to catalyst bed

For various conditions:

$h_w \left(\frac{W}{m^2.^\circ C}\right)$
45
80
220
493

→ similar to what can be obtained in a fluidized bed

Comparison with studies with pilot plant fluidized catalytic reactors

- Catalytic cracking of acetic acid

Molar steam to carbon ratio = 6				Molar steam to carbon ratio = 3			
	Catalysts tested by Medrano *et al.* (2009)		This study	Catalysts tested by Vagia and Lemonidou (2010)			This study
Catalyst	*Ni/Al,Ca0.5*	*Ni/Al,Mg0.2*	*X*	*5%Ni*	*10%Ni-1*	*10%Ni-2*	*X*
H_2	0.84	0.87	0.84	0.88	0.83	0.87	0.78
CO	0.18	0.14	0.17	0.27	0.30	0.31	0.27
CO_2	0.71	0.85	0.79	0.73	0.67	0.69	0.65
CH_4	0.00	0.00	0.04	0.00	0.03	0.00	0.06
C_2H_4+C_2H_6	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Conversion	0.90	0.99	1.00	1.00	1.00	1.00	1.00

→ excellent agreement between JBR results and pilot plant fluidized beds

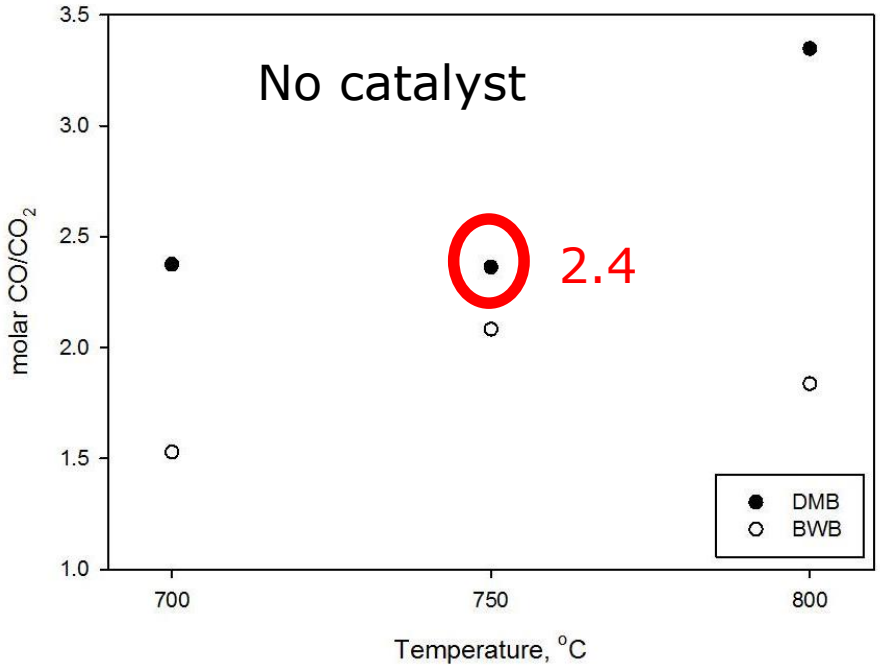
Gasification of bio-oil

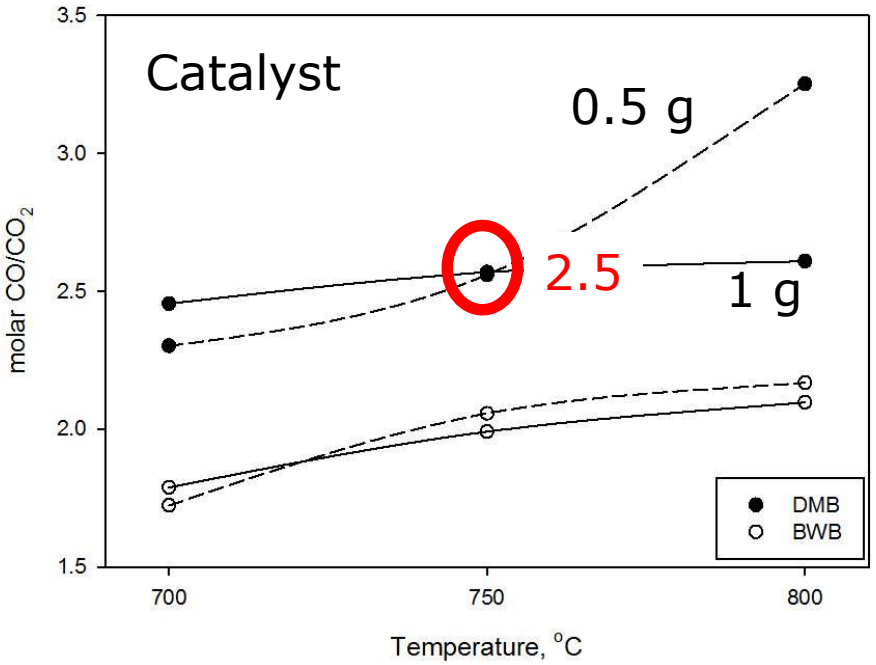
- Bed:
  - 10 g of sand (106-220 μm)
  - commercial catalyst (two catalysts were tested)

- Liquid feedstock:
  - 4 μl injected
  - Two types of bio-oils from wood pyrolysis:
    - Oak bio-oil produced by Dynamotive (DMB)
    - Birch wood bio-oil produced at 475 °C at ICFAR (BWB)

Gasification of bio-oil

30 s residence time





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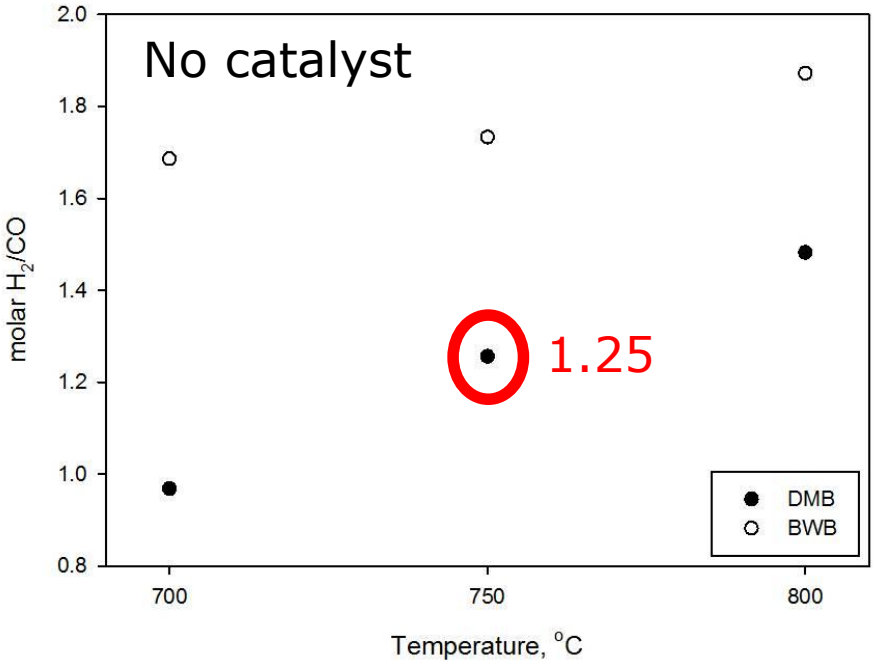
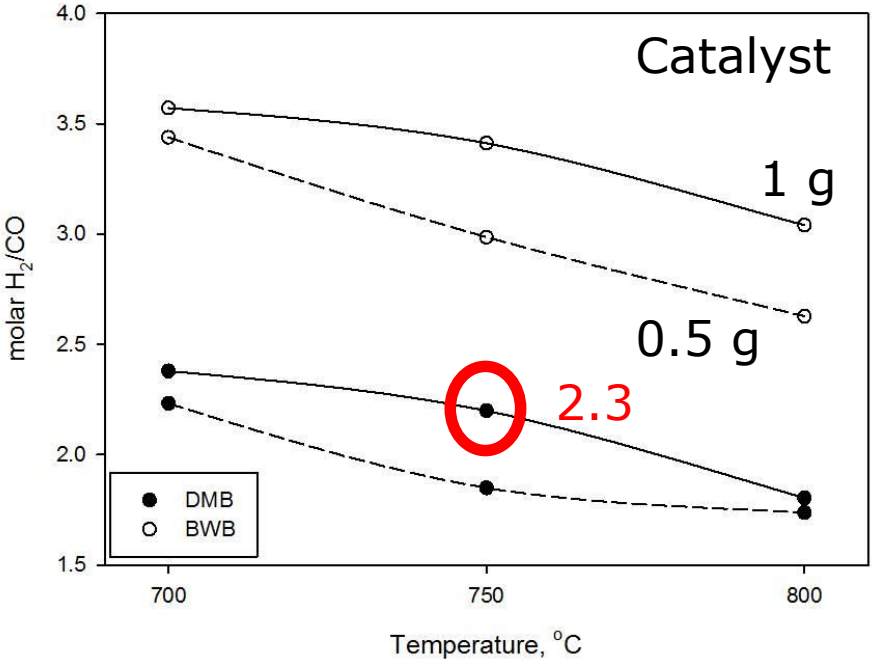
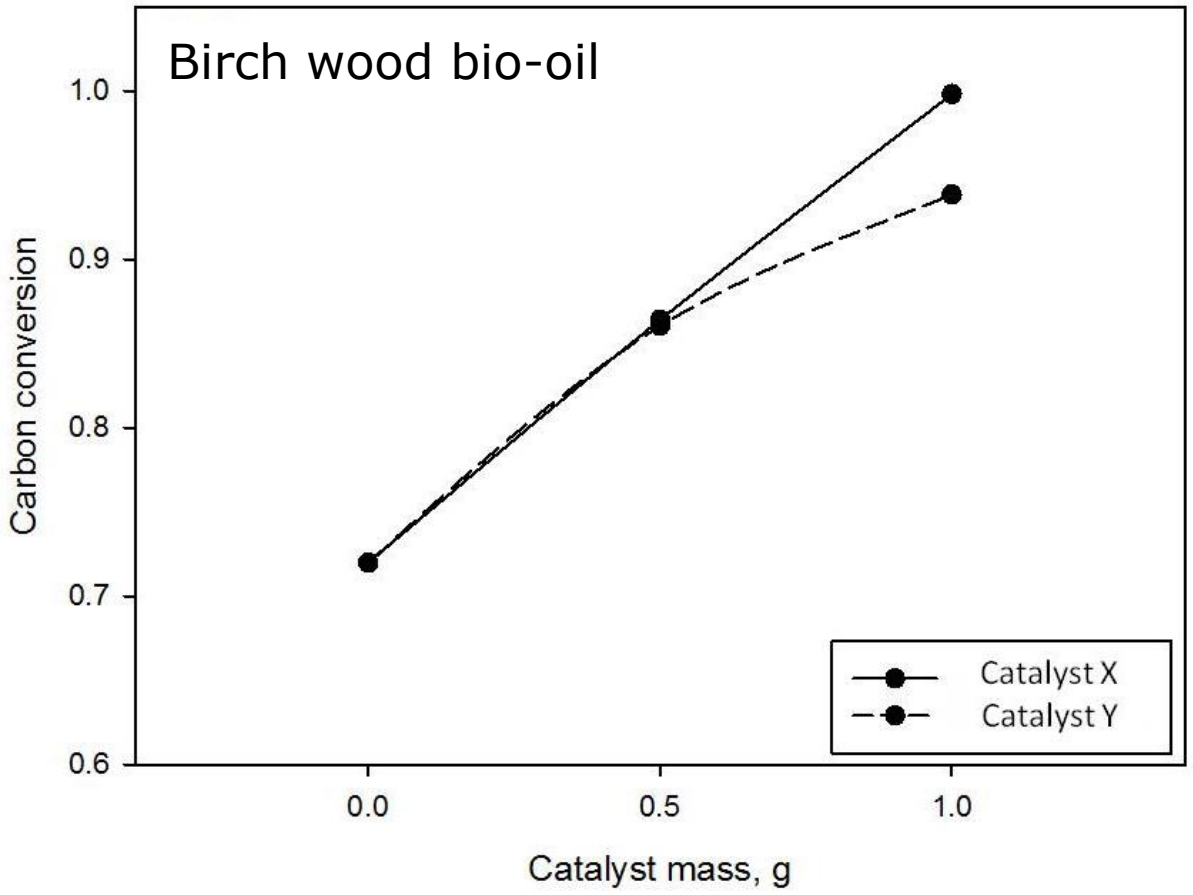




Gasification of bio-oil

800 ^{o}C , 30 s residence time



Conclusions

- The jiggle bed reactor:
  - effective batch micro reactor for catalyst testing
  - convenient
  - ideal for endothermic reactions
- Simulates typical fluidized bed reactors