Catalytic conversion of ethylene from gasification producer gas into bio-aromatics

B.J. Vreugdenhil (ECN)[1]
Y.-T. Kuo (ITRI)
G. Aranda Almansa (ECN)
C.M. Lok (Catalok)

[1] Corresponding author: vreugdenhil@ecn.nl

www.ecn.nl
P.O. Box 1
1755 ZG Petten
The Netherlands

www.itri.org.tw
Bldg. 64, 195 Sec.
4, Chung Hsing Rd.,
Chutung, Hsinchu
31040
Taiwan

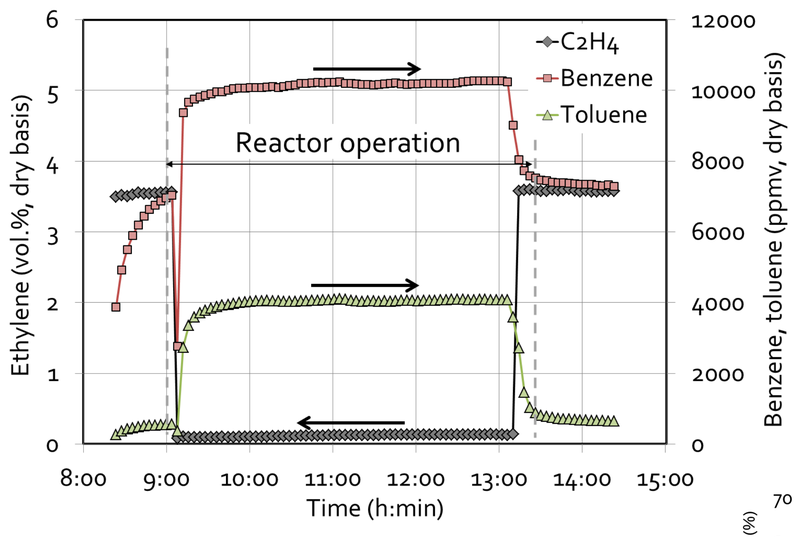
Co-production: 1 + 1 = 3

- Objective: production of fuels and chemicals from biomas/waste.
- Ethylene, BTX: harmful in synthesis processes, but also high economic value.
- Recovery of valuable compounds better than (costly) conversion to syngas.
- Improved business case of biofuel production.

How to recover bio-ethylene?

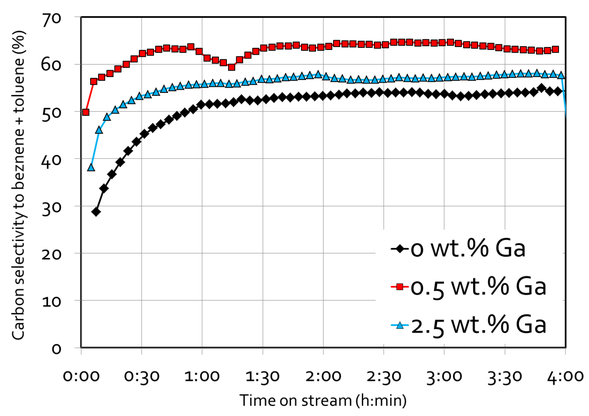
- High value (~ 17 €/GJ) but challenging separation.
- Options:
  - ⊘ Conventional cryogenic technology: energy-intensive, not economical in biomass gasification applications.
  - ? Membranes/ adsorption: under development.
  - **Reactive separation → (catalytic) conversion into other high-value compounds which can be more easily harvested from the gas.**

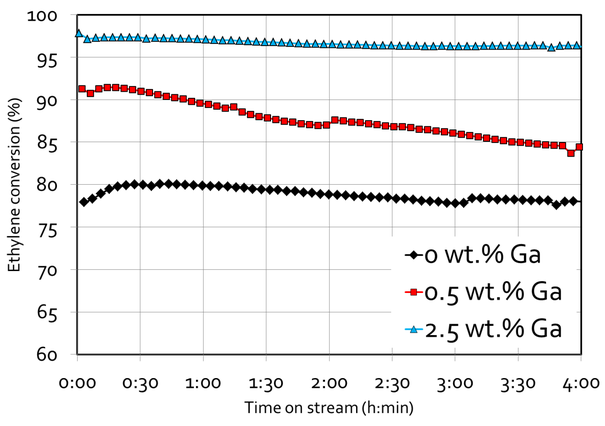
Ethylene aromatization with bifunctional Ga-ZSM-5 catalysts



2.5 wt.% Ga-ZSM-5

Ethylene:
3.5 vol.% → < 0.1 vol.%
(> 97% conversion)
Benzene:
7000 ppmv → 10000 ppmv
(x 1.4)
Toluene:
500 ppmv → 4000 ppmv
(x 8)



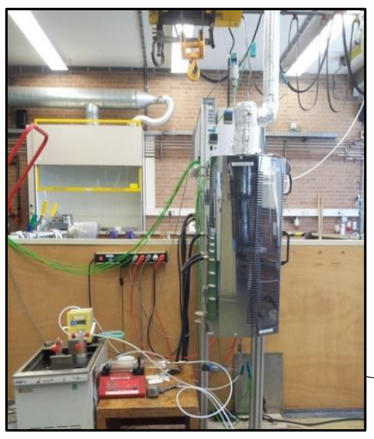


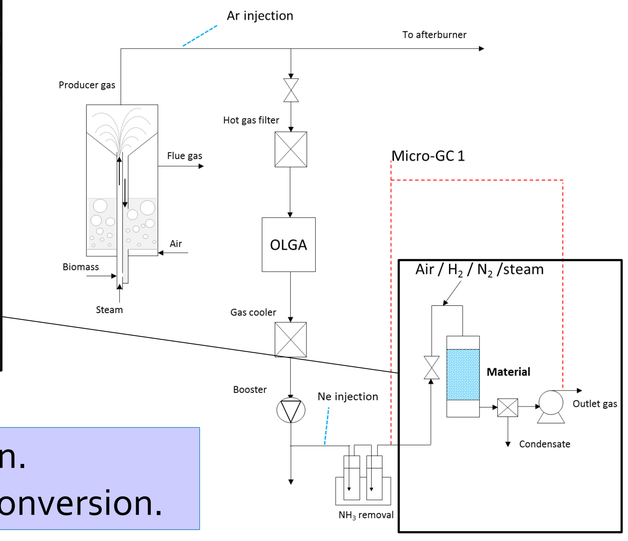
↑Ga loading → ↑ C selectivity to benzene,
↓ C selectivity to toluene.
0.5 wt.% Ga: max. selectivity to benz + tol (~ 65%).

Test	C_2H_4 conversion (%)	Carbon selectivity (%)					
		Benzene	Toluene	Xylenes	Ethylbenzene	C10	Total aromatics
ZSM-5	78.9± 0.8	7.5±1.4	43.9±3.2	8.7	1.3	5.6	66.9
0.5 wt.% Ga-ZSM-5	87.6 ±2.2	31.4±0.8	31.5±1.3	4.1	0.7	5.5	73.2
2.5 wt.% Ga-ZSM-5	96.7±0.4	24.4± 1.1	31.8±1.3	3.6	0.2	7.0	67.1

Experimental setup

Ga-zeolite catalysts tested under realistic gasification conditions (MILENA producer gas as feed).
Effect of operating conditions: temperature, **promoter loading**, zeolite acidity, GHSV, catalyst preparation.





80-97% ethylene conversion.
↑Ga loading → ↑ethylene conversion.

Afterwards: recovery of bio-BTX

Bio-BTX scrubber unit (1 Nm³/h feed)

Bio-BTX product from beech wood gas, > 95% recovery.

Conclusions

- Ethylene aromatization: novel approach for upgrading of producer gas from biomass/waste gasification in co-production schemes.
- Simultaneous upgrading of gas + recovery of valuable aromatic fraction → better business case.
- Ga increases ethylene conversion and promotes benzene formation.
- The composition of the bio-BTX product can be steered with the temperature and/or the Ga loading of the catalyst.

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