Integrated tar-free thermochemical air/steam fixed-bed updraft gasification of TCR®-biochar

Graz

Thursday 23 Jan 2020

Stefan Eder

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Our Vision
Availability of biomass waste as feedstock

Limited sustainable use

Discussion plate-Tank

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Source: [1] UBA, 2011 [2]Destatis 2010 [3]Zeller et al., 2011; [4]Simon et al., 2008; [5]UBA, 2012

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Our Vision

Availability of biomass waste as feedstock

Limited sustainable use

Discussion plate-Tank

Biogenic residues

Biowaste[1]
4 Mio. Mg/a

Garden- und parkwaste[2]
4,5 Mio. Mg/a

Straw[3]
8 - 13 Mio. Mg/a

Hay[4]
0,6 - 0,9 Mio. Mg/a

Sewage sludge[5]
1,9 Mio. Mg/a (TS)

... ...

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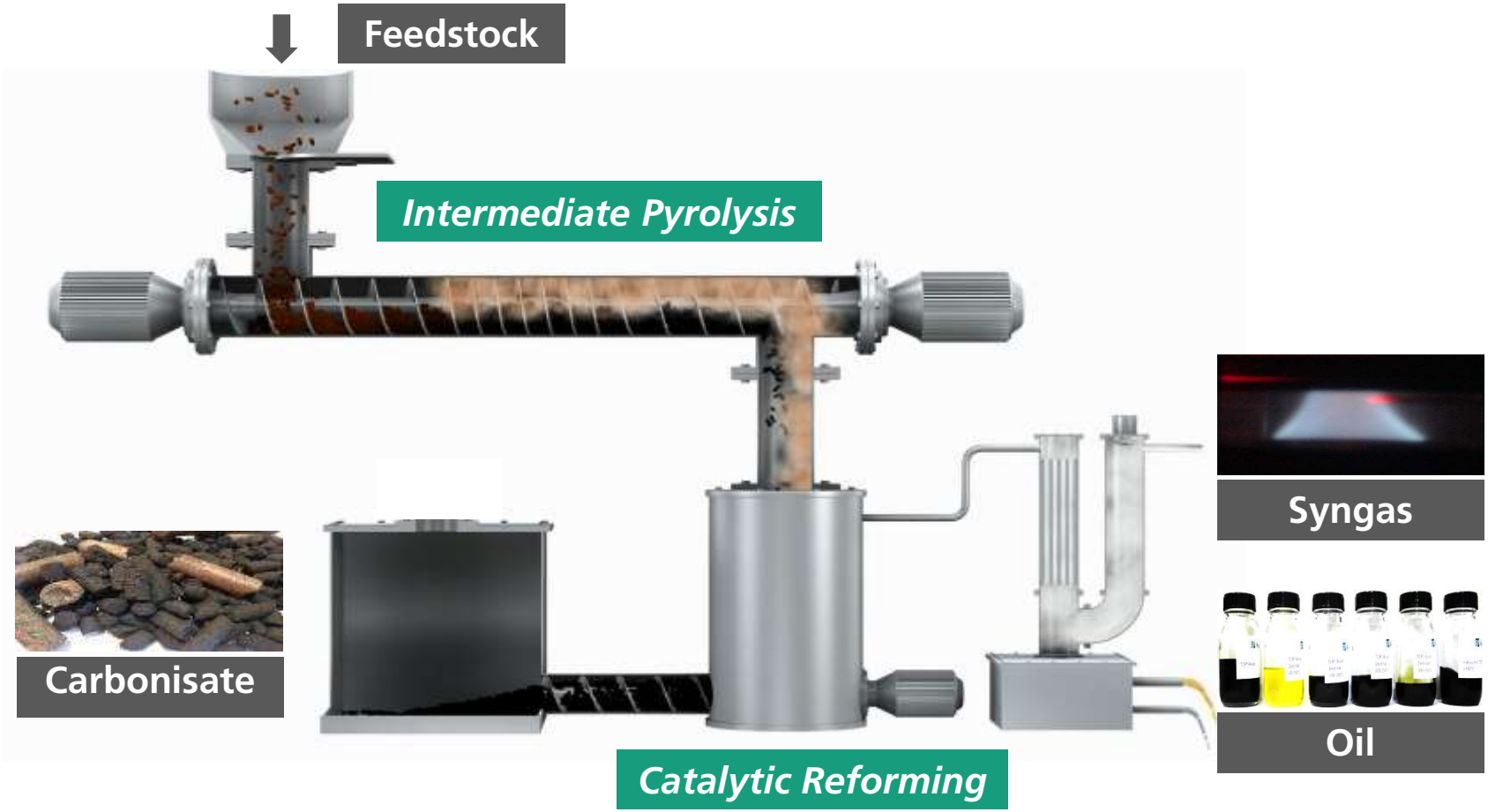
Production of TCR®-biochar feedstocks

Thermochemical gasification integration to biomass conversion processes like TCR®-technology



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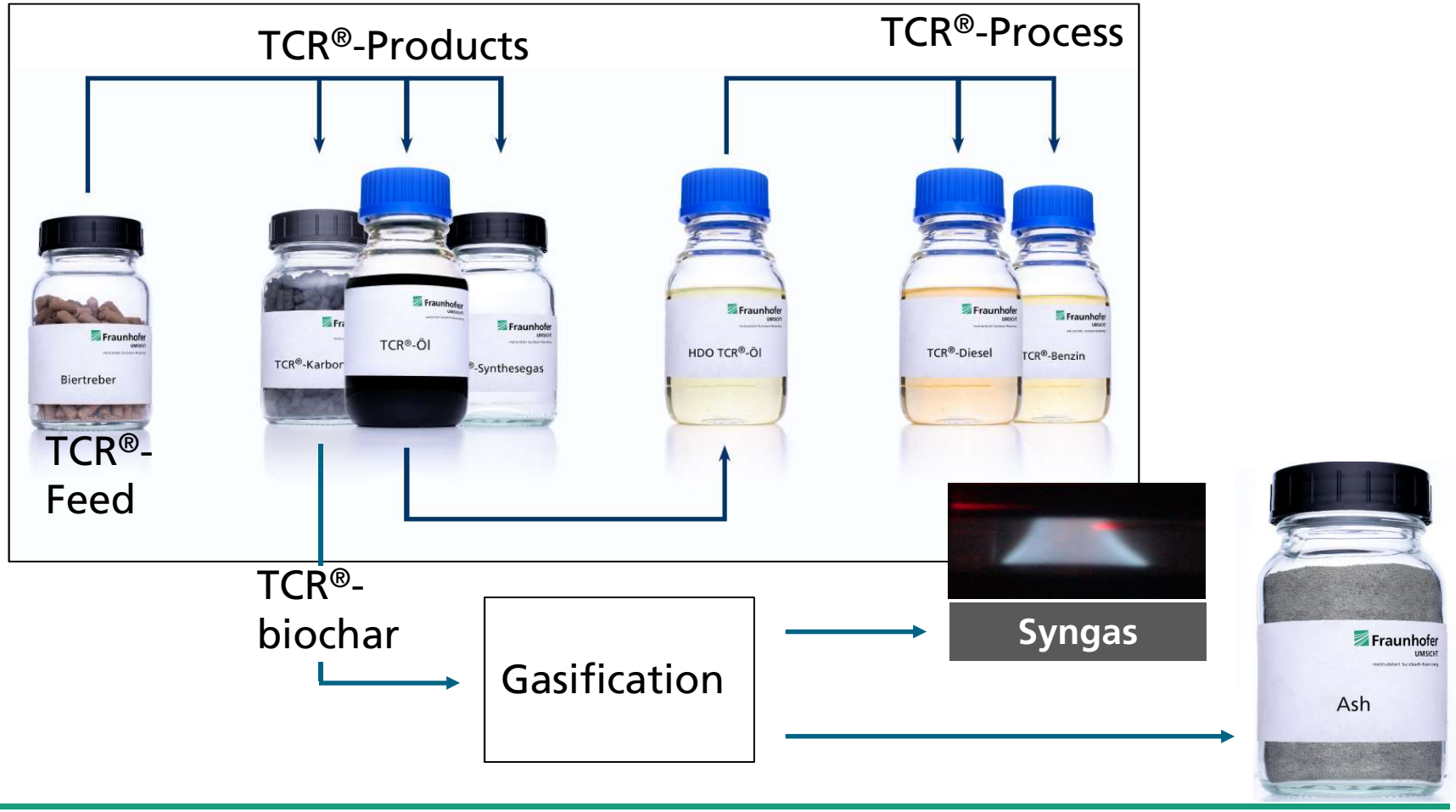
Overview

Thermochemical gasification integration to biomass conversion processes like TCR®-technology



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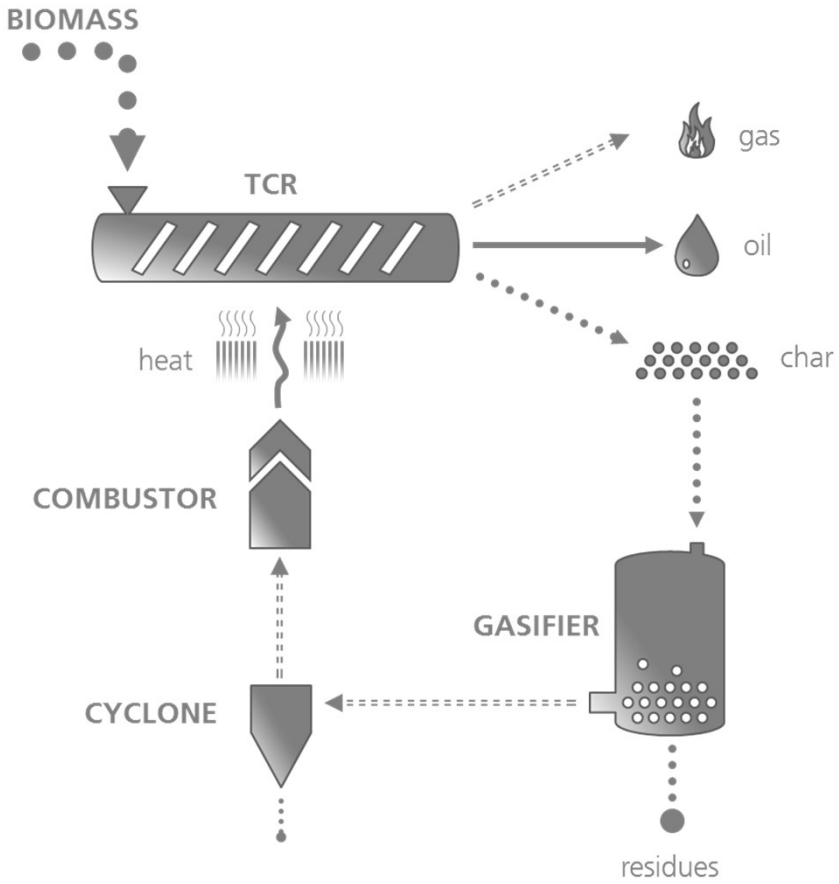
Overview

Thermochemical gasification integration to biomass conversion processes like TCR®-technology

- On-site use
  - Producer gas usable in combustion chamber
  - safes natural gas
  - Use for HDO
  - Easy to integrate into TCR® process
- Off-site use
  - Existing infrastructure
  - Gasification process can be scaled up
  - Centralized hydrogen generation



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Gasifier Test Bench ALPHA-SuRo

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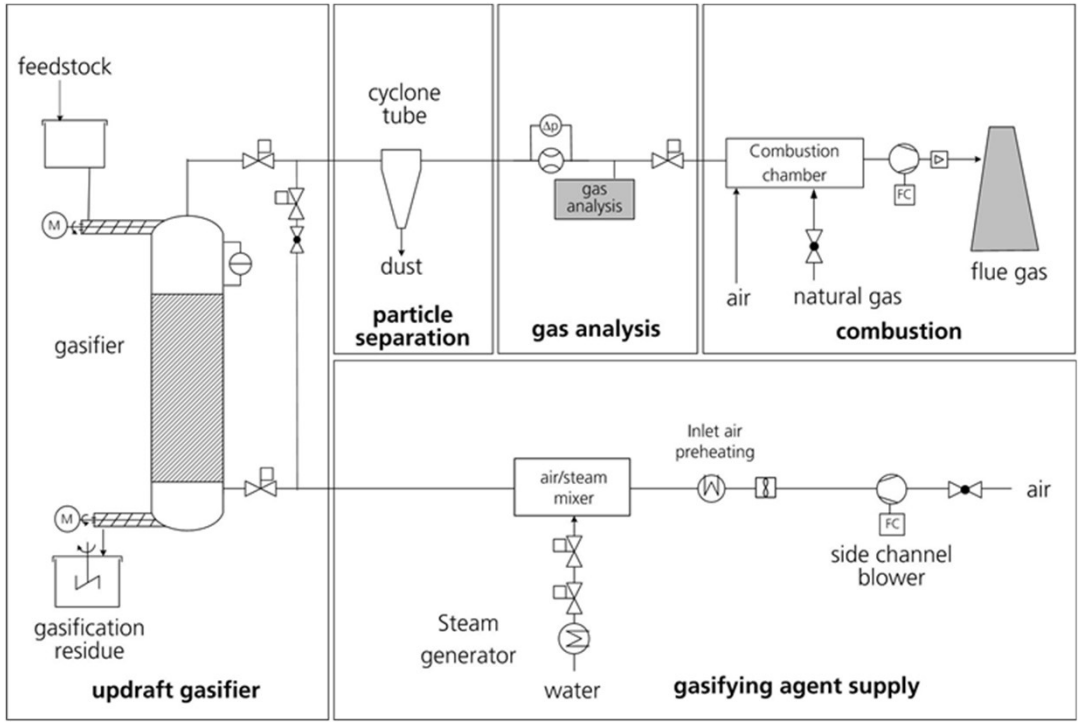
Gasifier Test Bench ALPHA-SuRo

Specifications

- Gasification process
  - updraft, fixed-bed reactor
  - auto thermal, atmospheric
  - steam/air mixture
  - preheated inlet air
- Gasifier with
  - refractory lined reactor
  - automatic loading and ash removal system
  - filling level detection

  → continuous operation



- Feedstock (size: 4 … 40 mm)
  - TCR®-biochar pellets (sewage sludge, digestate)
  - wood chips
  - mixed biomass pellets
- Online gas monitoring

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Gasifier Test Bench ALPHA-SuRo

Feedstock

Parameter	Unit	feedstock		
		TCR®-biochar from digestate	TCR®-biochar from sewage sludge	Wood Chips (for reference)

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Source: Reil, S.; Beer, S.; Ultsch, C.; Meiler, M., Hornung, A.: Thermochemical gasification of char from biomass with subsequent combustion for heat supply in endothermal biomass conversion processes. 24th European Biomass Conference, 06.-09.06.2016 in Amsterdam

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Gasifier Test Bench ALPHA-SuRo

Feedstock

Parameter	Unit	feedstock		
		TCR®-biochar from digestate	TCR®-biochar from sewage sludge	Wood Chips (for reference)
bulk density	kg/m³	583	624	310
ash content	wt.-%	**44.9**	**65.3**	**0.4**
volatile matter	wt.-%	6.7	9.5	85.3
total carbon	wt.-%	50.1	30.3	49.3
higher heating value (HHV)	kJ/kg	17,925	11,190	19,146
upper heating value (LHV)	kJ/kg	17,804	10,906	17,925
chlorine	mg/kg	14,200	658	-
ash melting behaviour				
sintering temperature	°C	**900**	**900**	**1,130**
softening temperature	°C	1,050	1,040	1,530
flow temperature	°C	1,120	1,160	1,575

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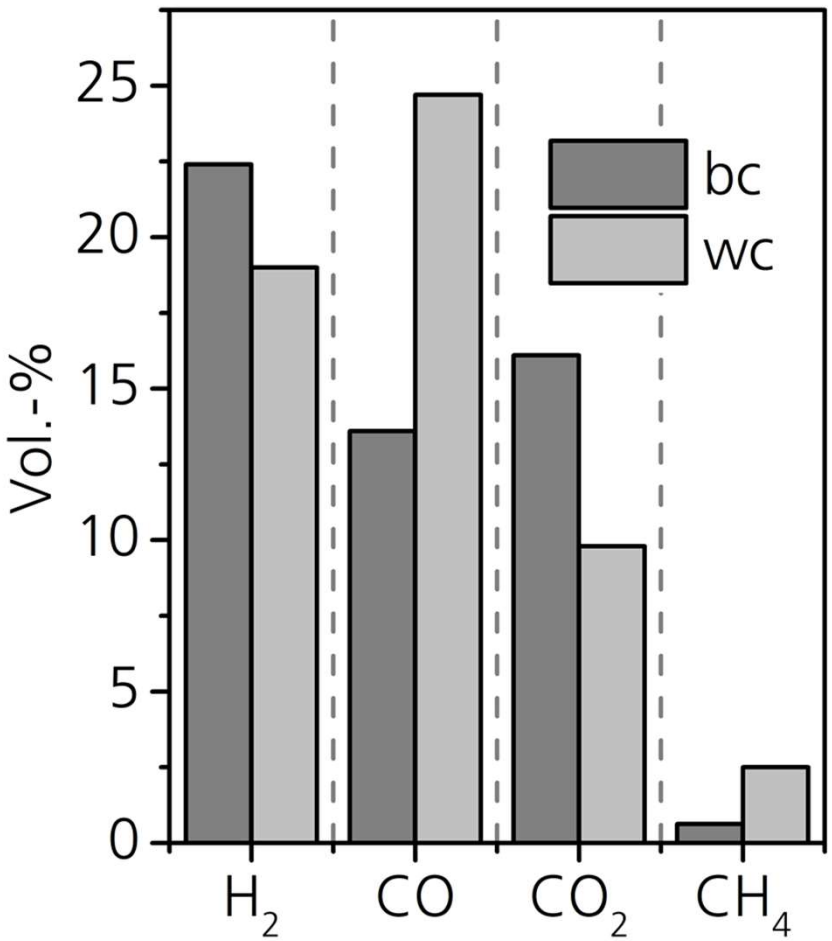
Gasifier Test Bench ALPHA-SuRo
comparison of producer gas composition

- biochar (bc)
  - air/steam gasification
  - higher H_2 content due to steam content in gasifying agent
  - Higher CO_2 & lower CO & CH_4 content due to Boudouard shift at lower reaction temperatures
- wood chips (wc)
  - air gasification



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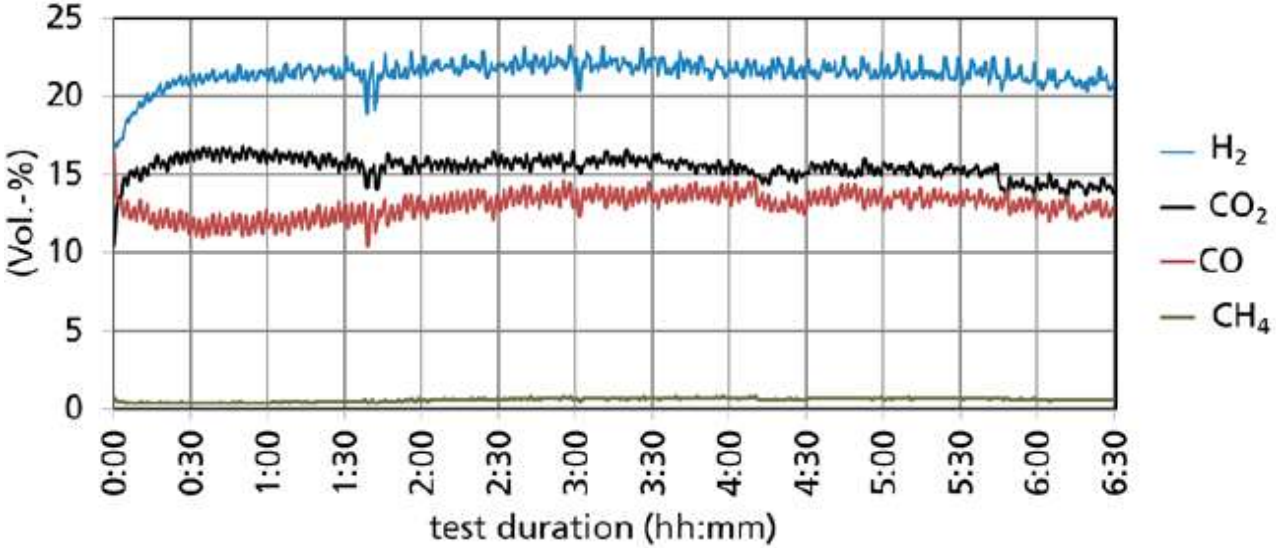
Gasifier Test Bench ALPHA-SuRo

Producer gas composition in an optimum operation point



- Constant producer gas composition
- Stationary during the whole operation
  - Good temperature control within the fixed-bed
  - No sintering and melting of ash

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Solid Phase Adsorption (SPA)
Tar measurement method

- Sorbent phase
  - CHROMABOND® C18ec, 3 mL
  - Very nonpolar sorbent with octadecyl phases on base material silica
  - Adsorbs all hydrocarbons in the gas
- Sampling
  - Insert needle through septum
  - Sucking a defined volume (100 mL) per minute
  - Freeze to at least -20 °C (immediately)
  - Analytics of samples with GC for 25 substances
- Comparison of SPA with DIN CEN/TS 15439
  - Results are in good agreement
  - SPA is an appropriate method for tar analysis

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Source: The SPA-Methode has been compared with DIN CEN/TS 15439 by Michael Neubert et. al. at "Biomass and Bioenergy" Journal number 105 on pages 443 – 452 in 2017

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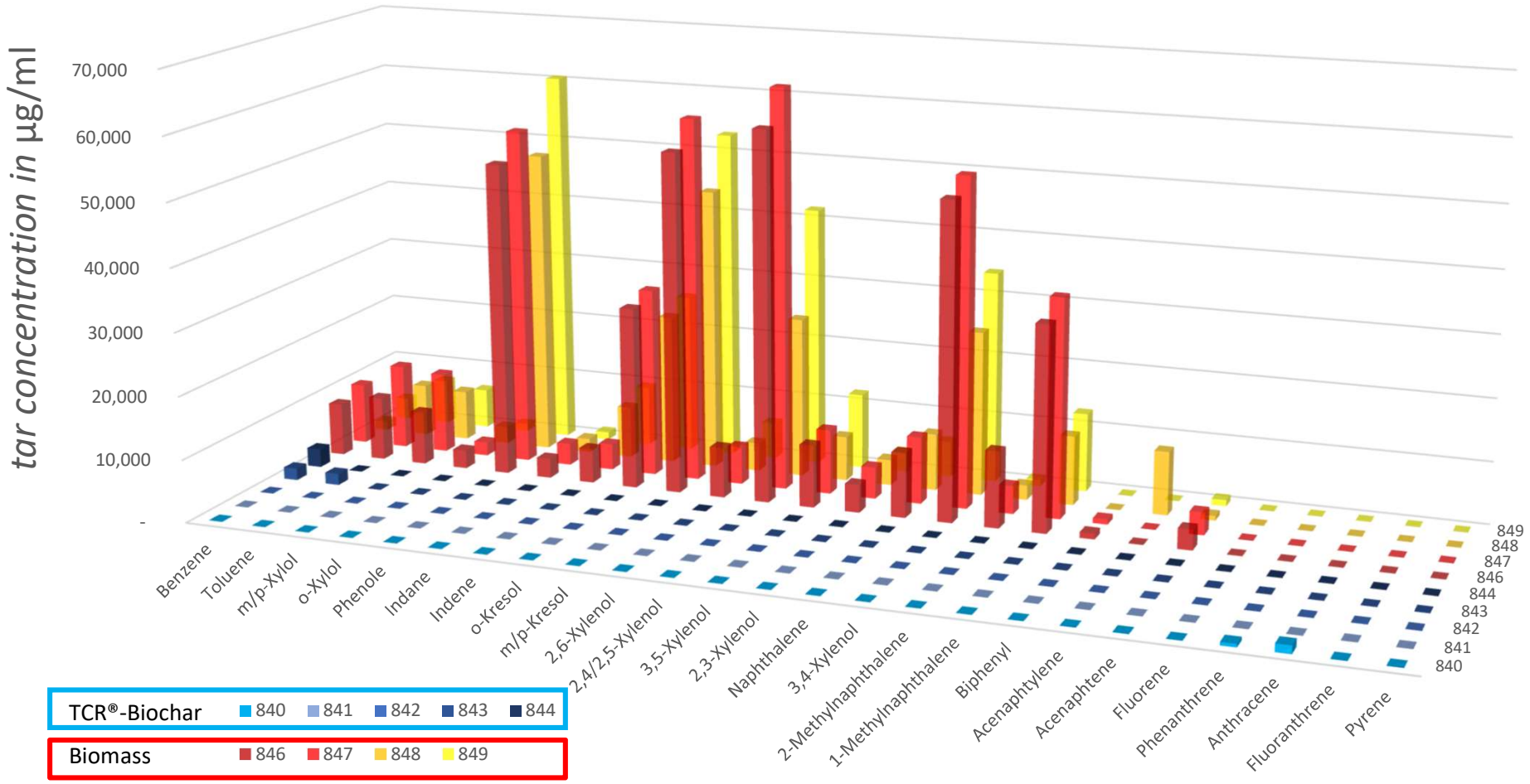
Tar measurement

SPA – Results of comparison of biochar and biomass



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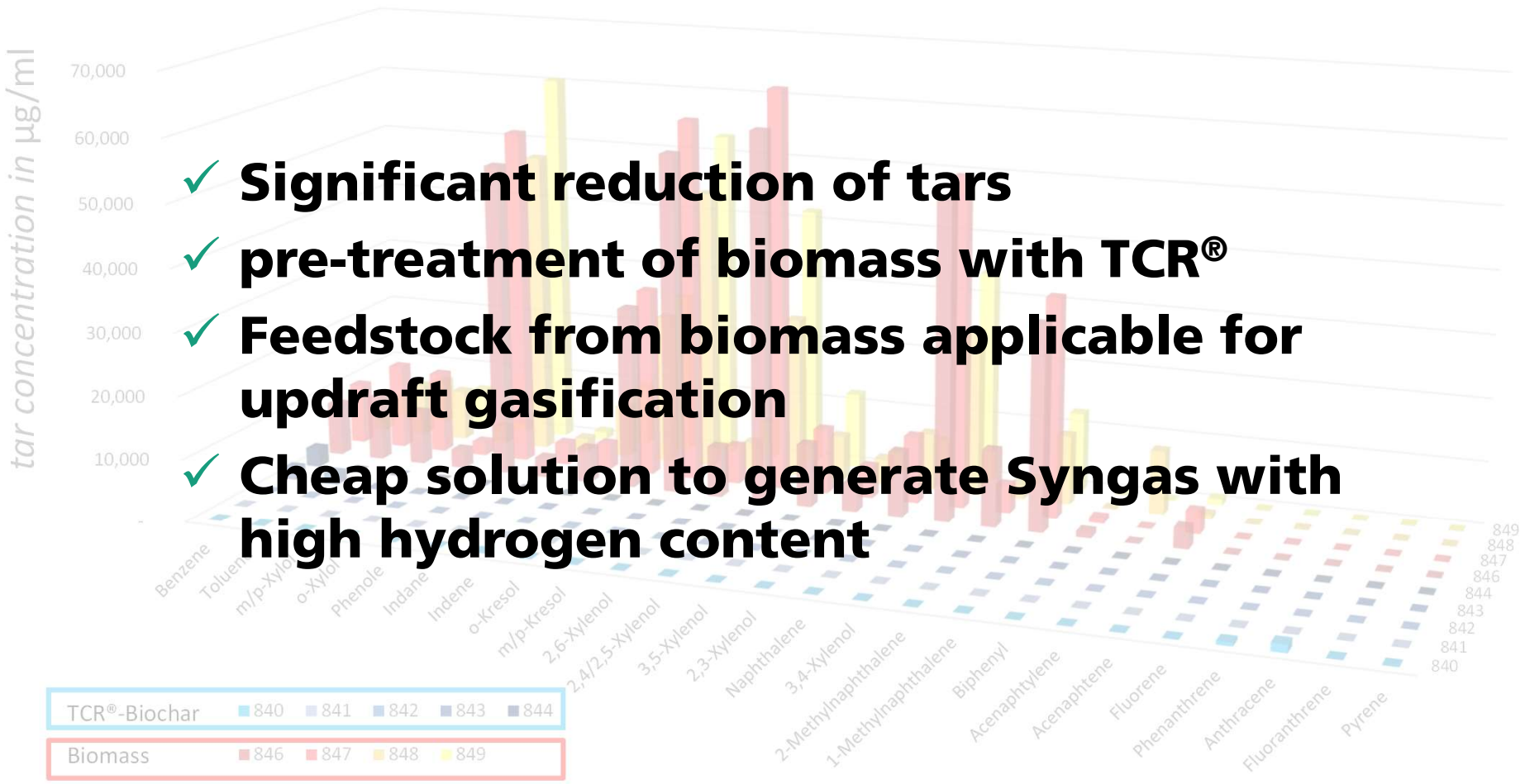
Tar measurement

SPA – Results of comparison of biochar and biomass



- ✓ **Significant reduction of tars**
- ✓ **pre-treatment of biomass with TCR®**
- ✓ **Feedstock from biomass applicable for updraft gasification**
- ✓ **Cheap solution to generate Syngas with high hydrogen content**

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DEPARTMENT RENEWABLE ENERGY

THERMOCHEMICAL PROCESSES

Thank you for your kind attention

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