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Online FTIR measurements of naphthalene

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Introduction

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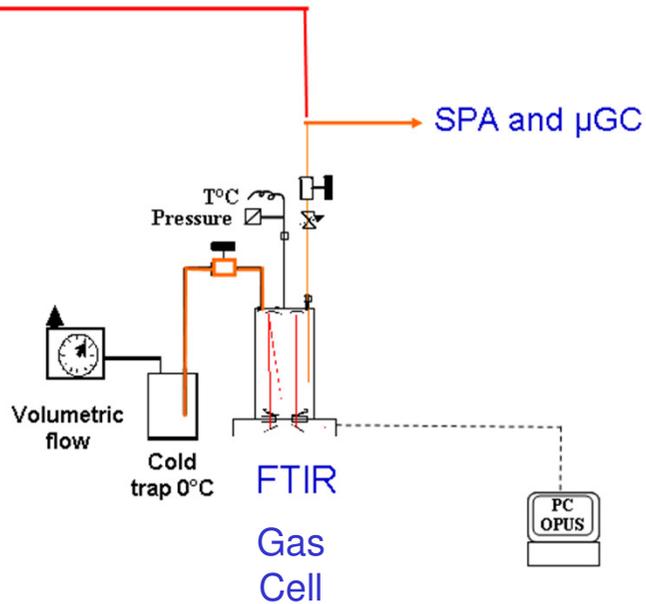
- w There is no “on line” method (from our knowledge) to measure Naphthalene the second major tar after benzene
- w Benzene, Toluene and Xylene on line by μ GC-TCD before tar gas cleaning
- w μ GC-TCD no available for naphthalene because needs cold dry gas
- w FTIR (Fourier Transformed Infra-Red):
 - is able to **sample hot wet gas (< 180°C)** suitable for condensable gas as naphthalene
 - is quasi “on line” (every minutes or less)
 - Is currently used in research set up
 - is rarely used at a pilot scale for steam gasification processes (TU Delft: H₂O, CO, CO₂, all C₂, and inorganics as NH₃, HCN, etc)
- w We performed some developments to adapt FTIR to naphthalene quantification with real gas
 - Find the best wavelength window without too much interferences
 - Check the subtracting procedures with model gas and real gas
 - Validate the methodology by comparison with other methods (Tar Protocol and SPA)



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FTIR sampling

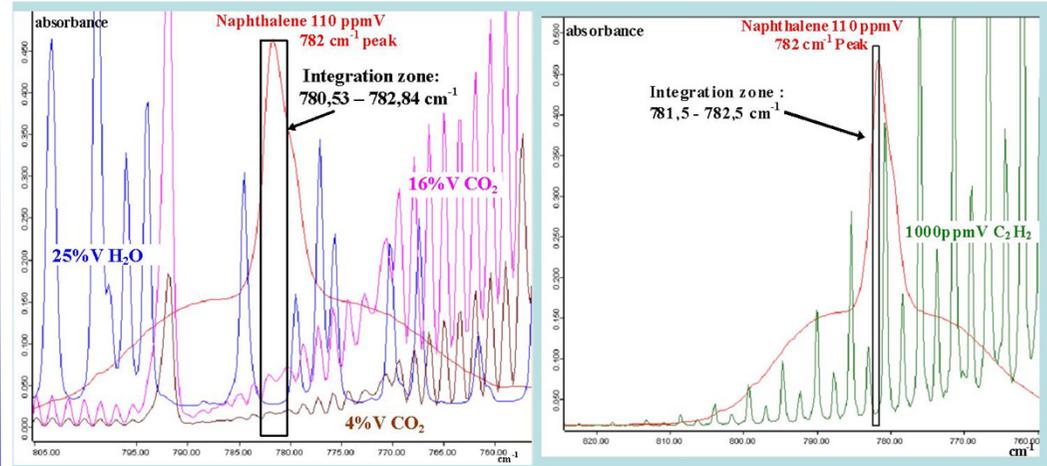
Gasifier



Gas cell	MARS Gemini 2 (Al + Ni coated) optical path length: 2 to 10 m Mirror: Gold coated heated to 150°C
Gas flowrate	50 to 200 NI/h

FTIR analysis

FTIR	Bruker Tensor 27
Software	OPUS (QUANT 1)
Resolution	0.5 cm ⁻¹
Acquisition frequency	1 minute
Detector	MCT (cooled by N ₂ liquid)

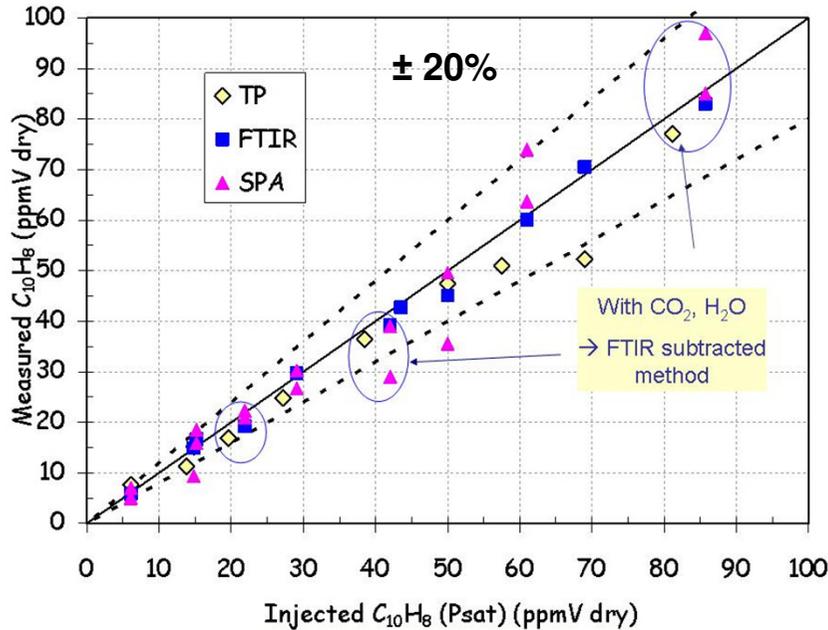


specie	Calibration	IR window (cm ⁻¹)
C ₁₀ H ₈	5 to 300 ppmV 30 mg/Nm ³ to 1,8 g/Nm ³	780,5 to 781,5 Subtraction if CO ₂ , NH ₃ , HCN, C ₂ H ₂

Measurement, Analysis and Monitoring of Condensable Gas Components (especially Tar) in Product-Gases from Biomass Gasification and Pyrolysis
International Workshop / June 8th 2011 at 19th EU Biomass Conference and Exhibition, ICC Berlin

Results and operational experience

Model gas



Real gas

Gasifier: 800 °C

Tar craker: 1100 °C

Biomass: Calys (5% ash)

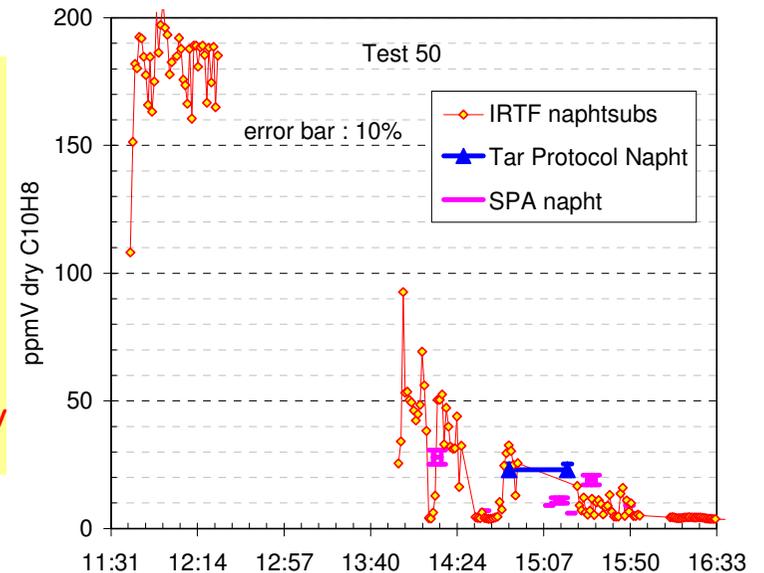
Residence time: 3 to 20s

High NH_3 and HCN content

High C_2H_2 content

Worst FTIR conditions for naphthalene:

H_2O : 25 to 33%V
 CO : 10 to 15%V
 CO_2 : 7 to 10%V
 H_2 : 20 to 30 %V
 CH_4 : 3 to 6%V
 C_2H_4 : 200 to 1200 ppmV
 C_6H_6 : 500 to 1400 ppmV
 C_2H_2 : 50 to 1000 ppmV
 NH_3 : 5000 to 8000 ppmV
 HCN : 300 to 1200 ppmV





Current status of system development

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w FTIR able to measure on line Naphthalene

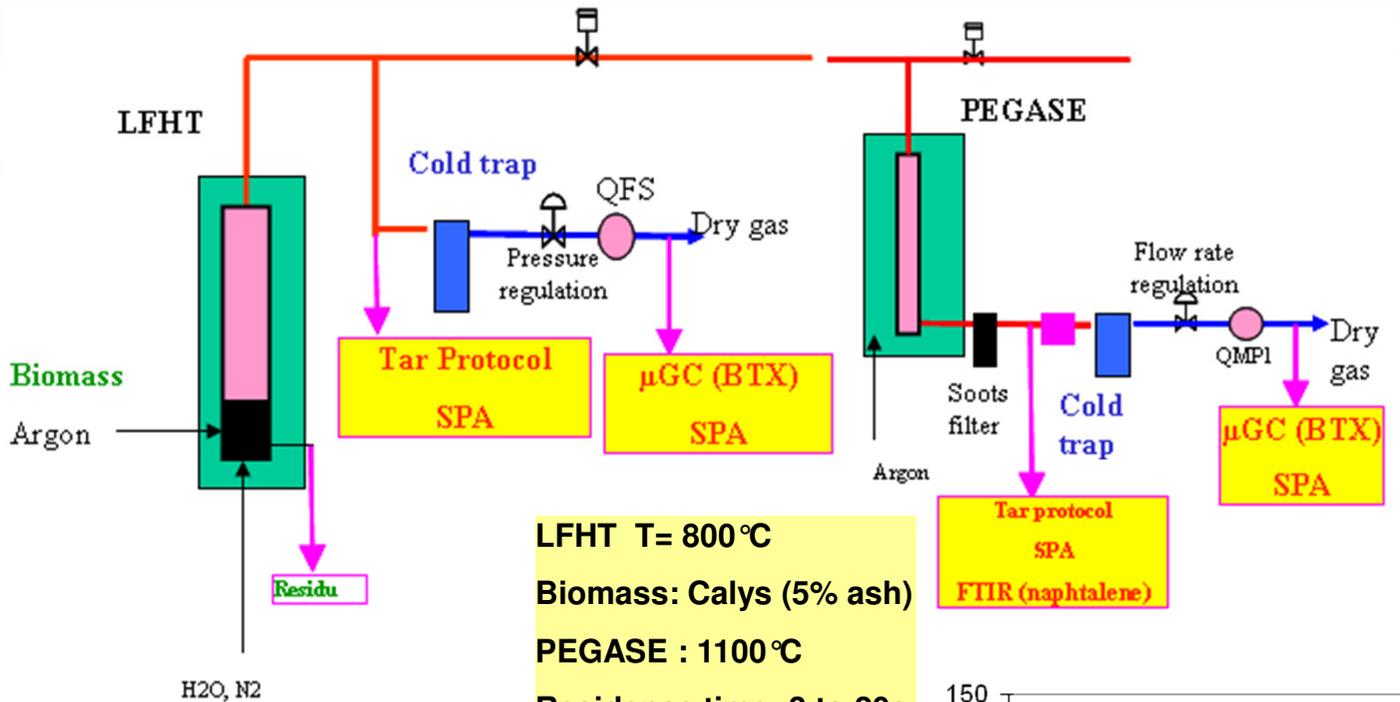
- LOD > 7 to 20 ppmV (50 to 100 mg/Nm³) depending the matrix
 - ~ Follow the gasification process before tar gas cleaning
- Comparison with other methods TP and SPA is in the $\pm 20\%$
- Quasi-On line method (every minutes for resolution 0,5 cm⁻¹)
- Stability of the calibration (every year depending the gas cell)
- OPUS software improved (automatic subtraction)

w Future work

- Use other FTIR softwares
- Improve resolution (< 0,5 cm⁻¹) to have more points in the C₁₀H₈ IR window
- Find another online method with LOD < 7ppmV (<50 mg/Nm³)
 - ~ After tar gas cleaning

High Temperature Fluidized Bed (LFHT)

- 1 to 5 kg/h biomass
- 800 to 1000 °C
- 1 to 15 bars
- SiC bed



High Temperature Reactor (PEGASE)

- 2 Nm³/h
- 900 to 1500 °C
- 1 to 4 bars
- Working alone with gas bottle or linked to LFHT

LFHT T= 800 °C
Biomass: Calys (5% ash)
PEGASE : 1100 °C
Residence time: 3 to 20s

H2O: 25 to 33%V
CO: 10 to 15%V
CO2: 7 to 10%V
H2:
CH4: 3 to 6%V
C2H4: 200 to 1200 ppmV
C6H6: 500 to 1400 ppmV
C2H2: 50 to 1000 ppmV
NH3: 5000 to 8000 ppmV
HCN: 300 to 1200 ppmV

