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# Fractionation of Flash Pyrolysis Condensates by Staged Condensation

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# Fractionation of Flash Pyrolysis Condensates by Staged Condensation

Tim Schulzke; Group Manager Thermochemical Processes and Hydrocarbons  
Stefan Conrad, Jan Westermeyer; Thermochemical Processes and Hydrocarbons

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Chania, Crete, 01.10.2015

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# AGENDA

1. Ablative Flash Pyrolysis
2. Staged pyrolysis vapour condensation
  - Two staged condensation
  - Three staged condensation
  - Creation of Value
3. Summary

# AGENDA

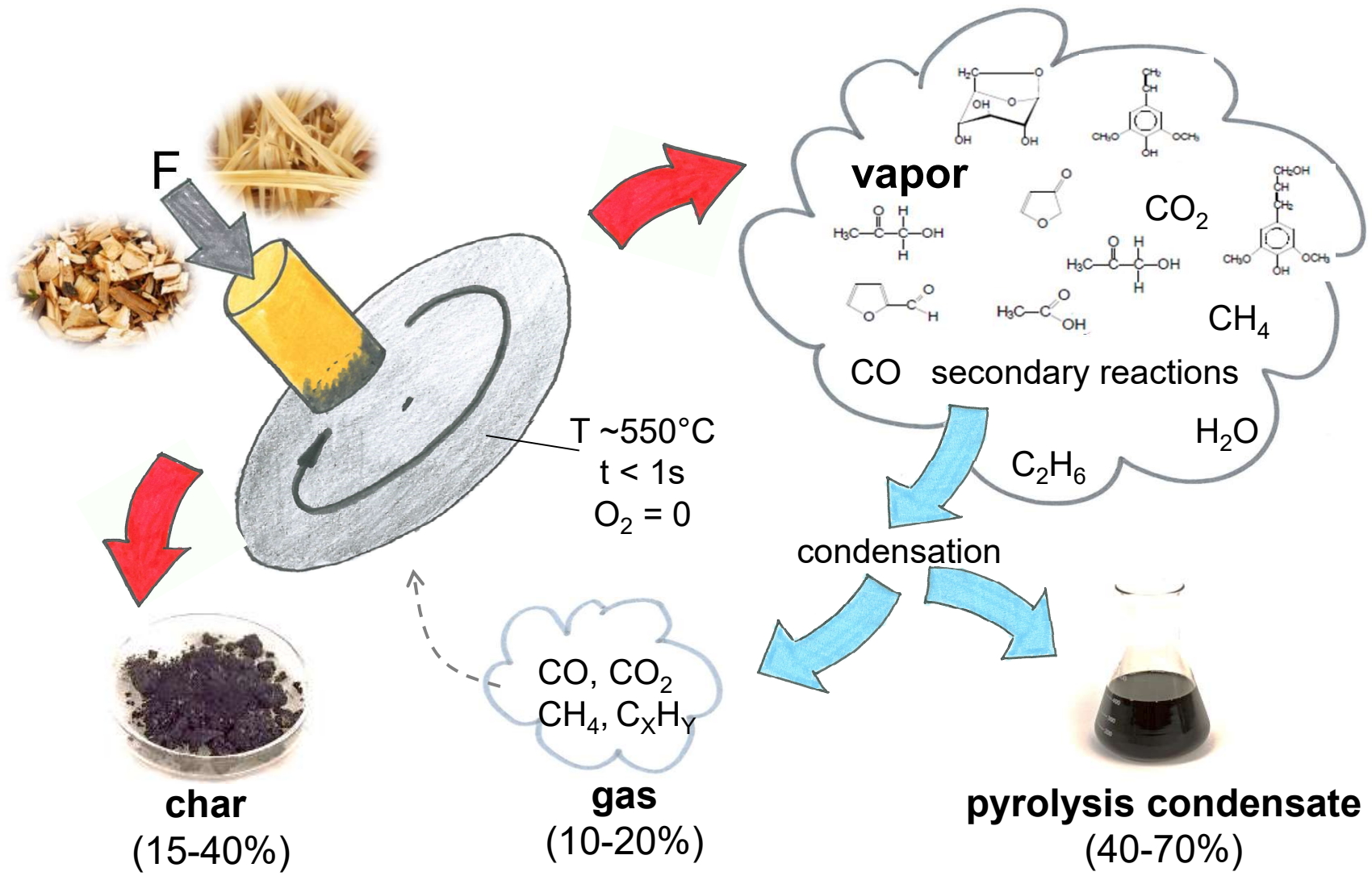
## 1. Ablative Flash Pyrolysis

## 2. Staged pyrolysis vapour condensation

- Two staged condensation
- Three staged condensation
- Creation of Value

## 3. Summary

# Ablative Flash Pyrolysis – Principle



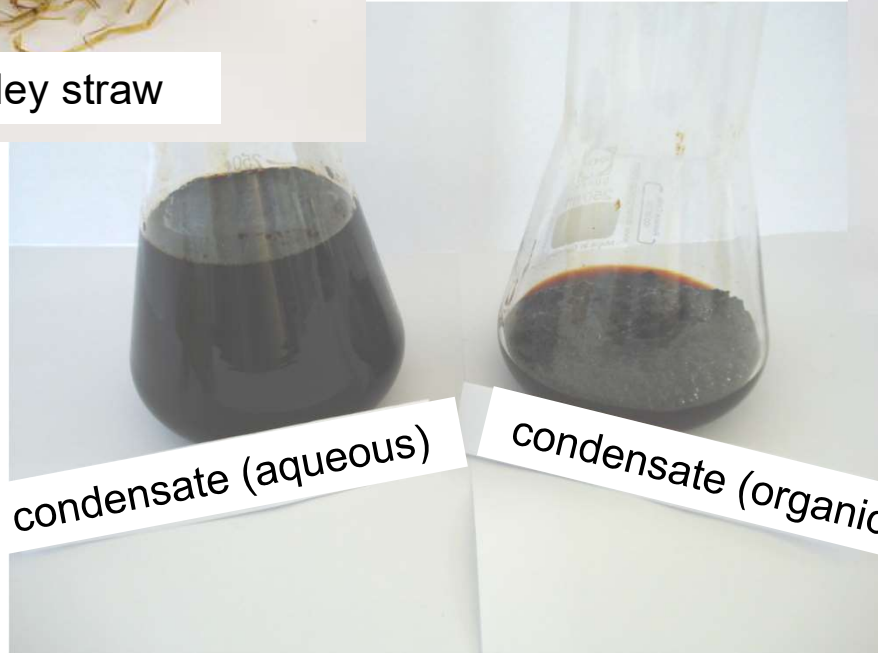
# Ablative Flash Pyrolysis – Products



wheat/barley straw



pyrolysis char



condensate (aqueous)

condensate (organic)

# Ablative Flash Pyrolysis – Laboratory Plant

Input:

< 10 kg/h

Heating:  
electrical

Cooling:  
indirect

Aerosol sep.:  
ESP





# Ablative Flash Pyrolysis – Quality of Condensates

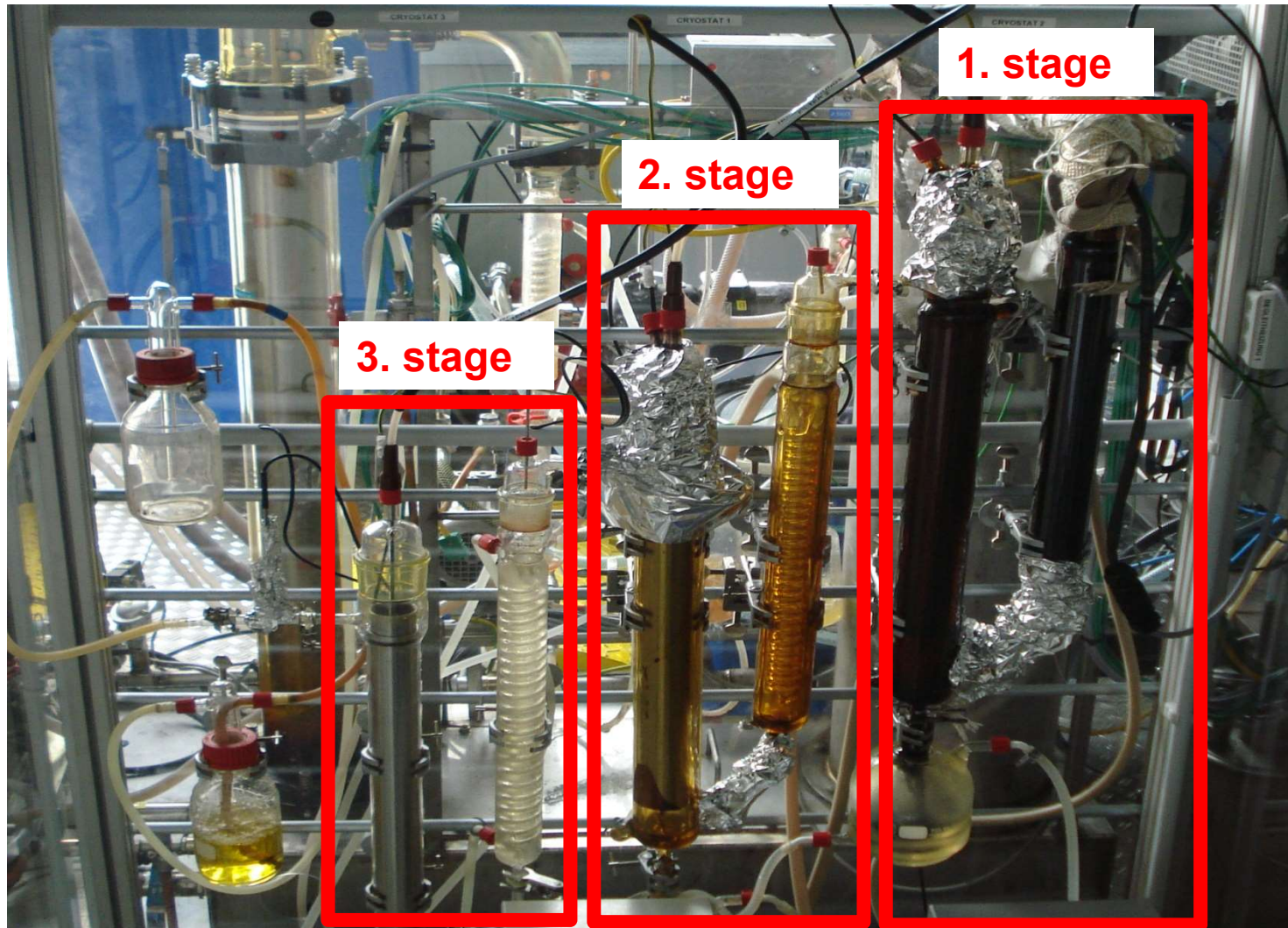
	<b>aqueous</b>	<b>organic</b>
mass ratio	67.5 %	32.5 %
total Water	61.7 %	25.3 %
nonaromatic Acids	7.4 %	5.9 %
nonaromatic Alcohols	1.5 %	0.3 %
nonaromatic Aldehydes	0.0 %	1.1 %
nonaromatic Ketones	5.9 %	7.1 %
Phenols	1.2 %	12.0 %
Sugars	1.6 %	1.5 %
Heterocyclic Sub.	1.4 %	2.9 %
not GC-detectable Sub.	19.1 %	42.4 %
lower Heating value	7.9 MJ/kg	22.3 MJ/kg

wheat / barley straw, 549 °C

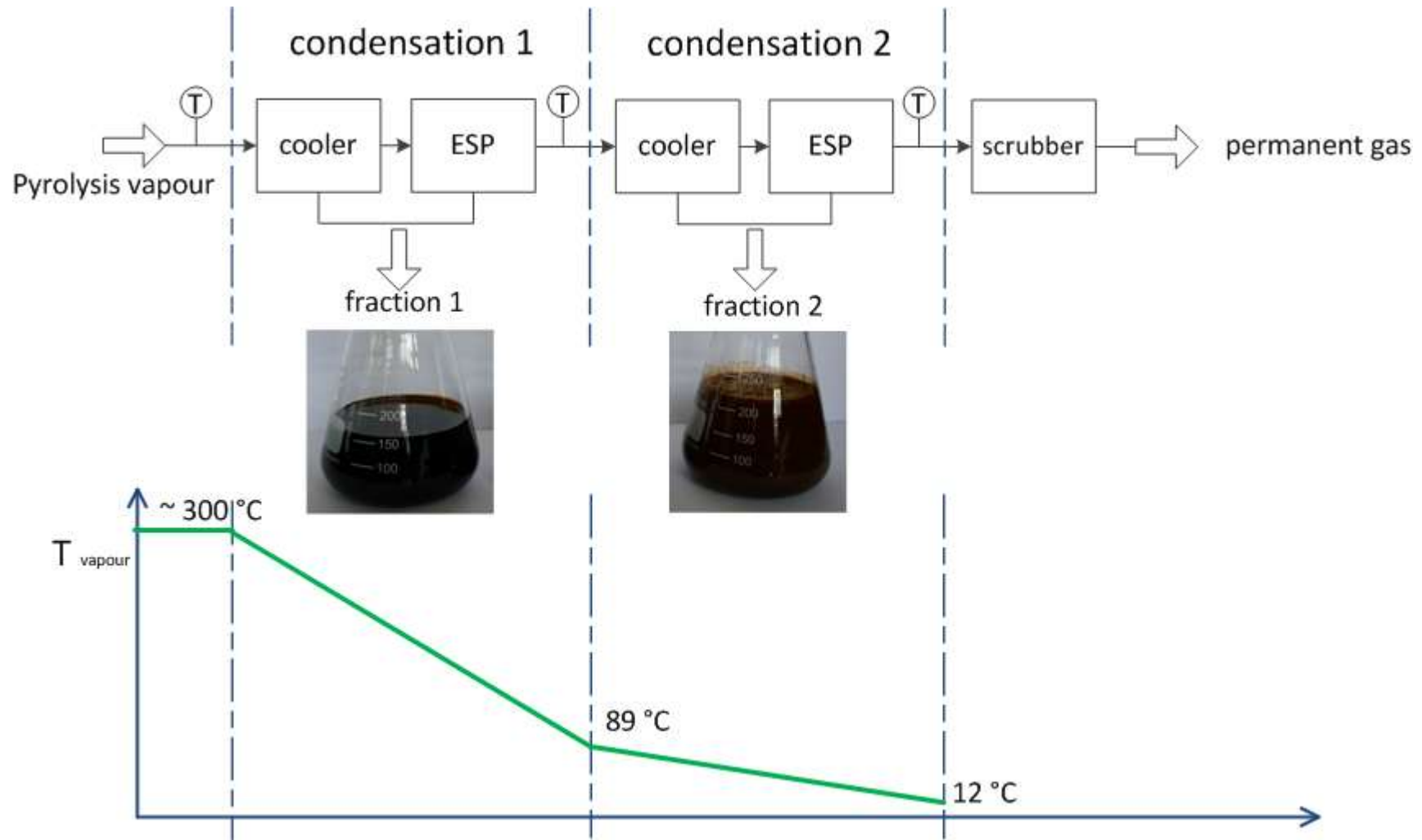
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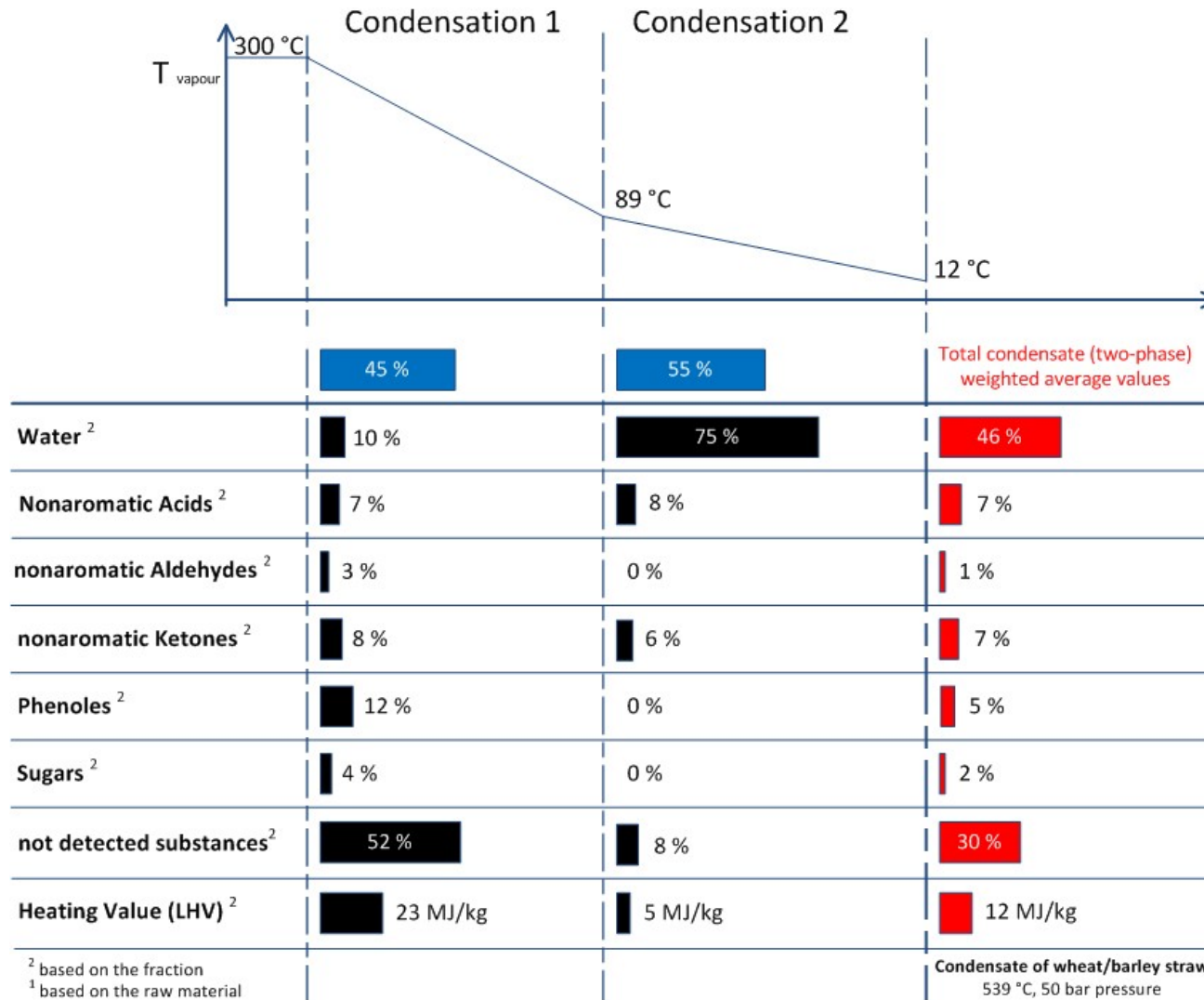
# Staged condensation – Approach



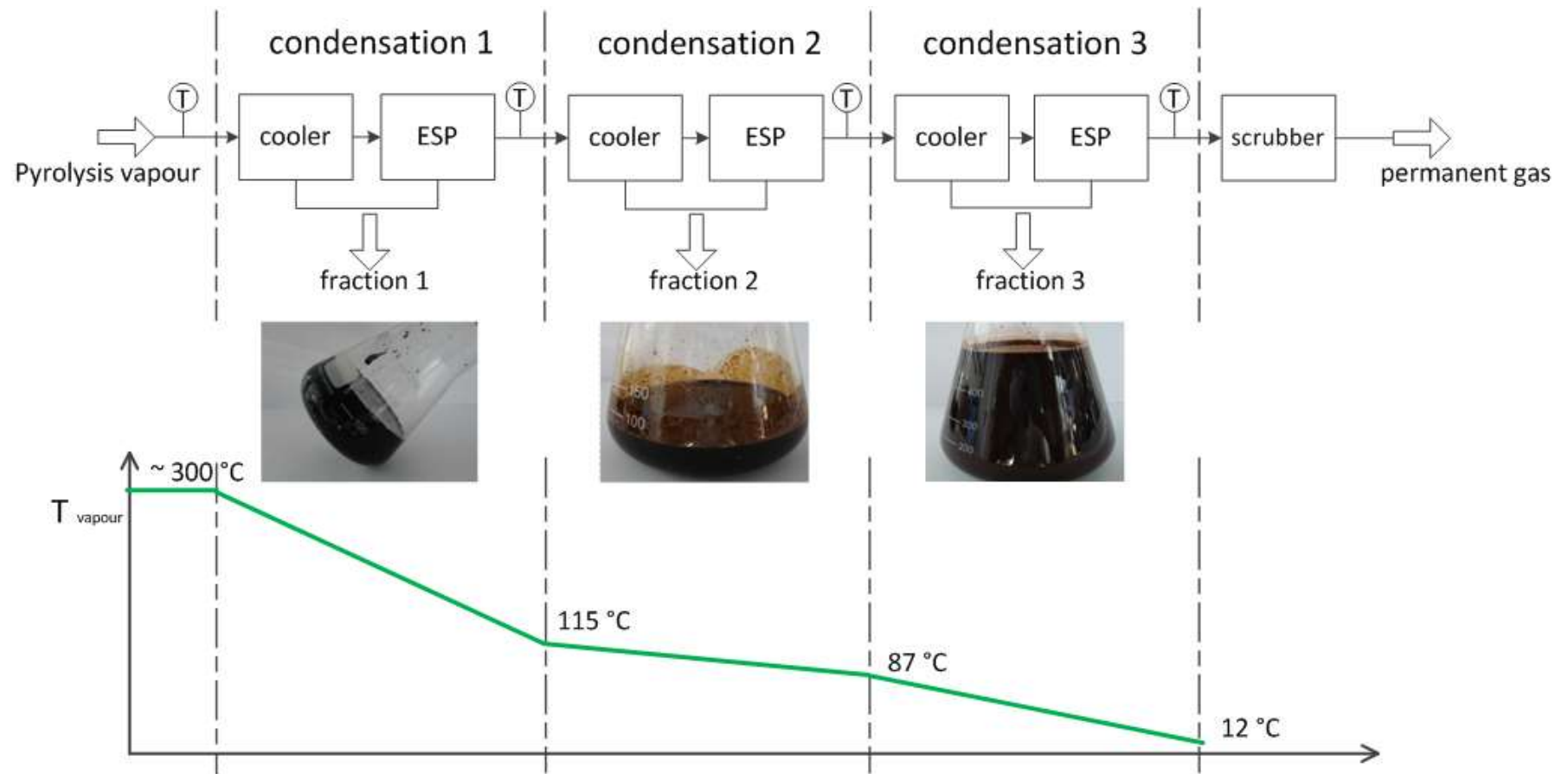
# Staged Condensation – Two stages experiment



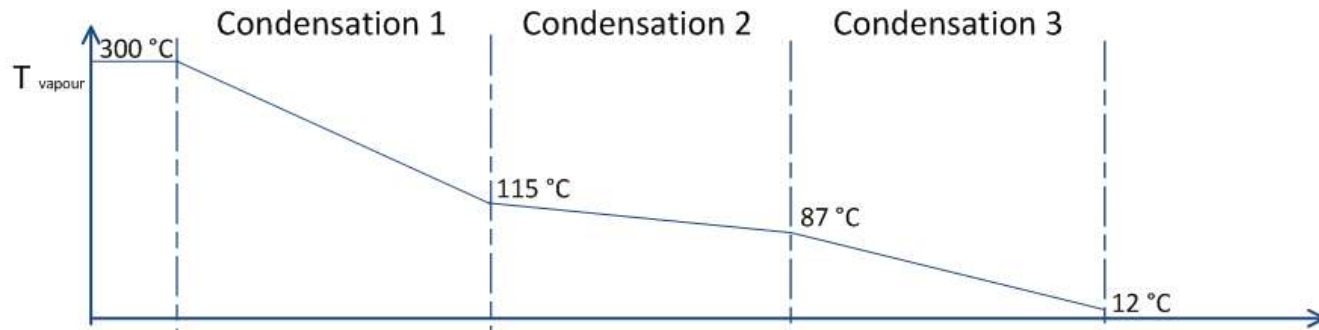
# Staged Condensation – Two stages experiment



# Staged Condensation – Three stages experiment



# Staged Condensation – Three stages experiment



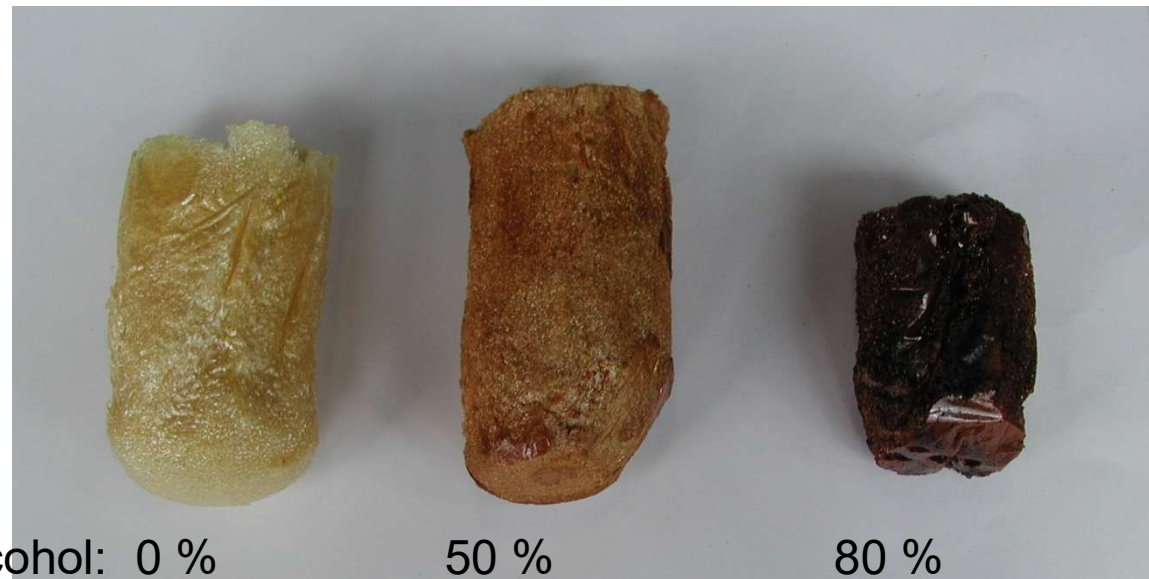
	Condensation 1	Condensation 2	Condensation 3	Total condensate (two-phase) weighted average values
<b>Ratio<sup>1</sup></b>	23 %	10 %	67 %	
<b>Water<sup>2</sup></b>	2 %	8 %	70 %	46 %
<b>Acids<sup>2</sup></b>	1 %	6 %	9 %	7 %
<b>nonaromatic Aldehydes<sup>2</sup></b>	0 %	3 %	0 %	1 %
<b>nonaromatic Ketones<sup>2</sup></b>	1 %	12 %	7 %	7 %
<b>Phenoles<sup>2</sup></b>	11 %	20 %	1 %	5 %
<b>Sugars<sup>2</sup></b>	6 %	5 %	0 %	2 %
<b>not detected substances<sup>2</sup></b>	79 %	38 %	10 %	30 %
<b>Heating Value (LHV)<sup>2</sup></b>	28 MJ/kg	22 MJ/kg	6 MJ/kg	12 MJ/kg
<sup>2</sup> based on the fraction <sup>1</sup> based on the raw material				Condensate of wheat/barley straw 550°C, 50 bar pressure

# Staged Condensation – Creation of Value

## ■ Higher boiling fraction (2 staged condensation)

black viscous liquid, high heating value

- Sugars, Phenolics → raw material for rigid PU foams
- Fraction as a whole → Gasification (Synthesis gas)
- energetic utilization (heat, bunker fuel)





# Staged Condensation – Creation of Value

## ■ Highly viscous fraction (3 staged condensation)

black pasty liquid, high heating value

- Sugar (Levoglucosan) → raw material for chem. Industry
- Fraction as a whole → Gasification (Synthesis gas)  
→ energetic utilization (heat)

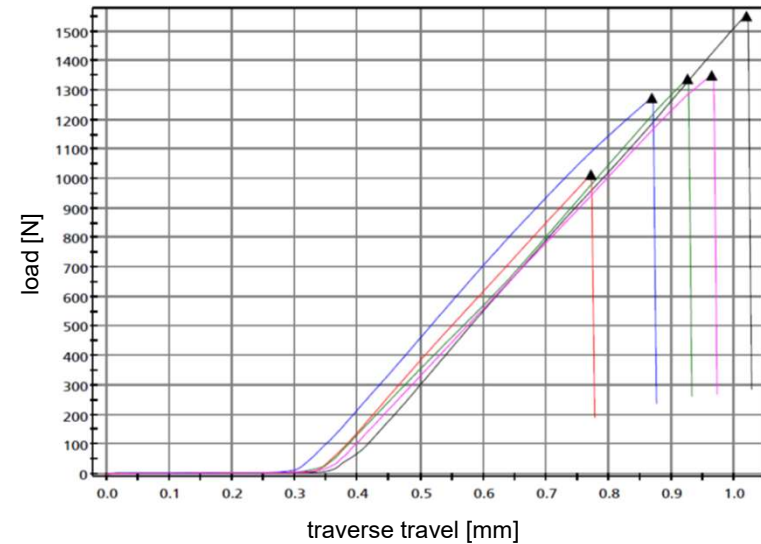
## ■ Medium viscous fraction (3 staged condensation)

dark brown, honey-like liquid, medium heating value

- Phenols (Syringols) → raw material for Phenoplastic
- Aldehydes (Acetaldehyde) → raw material for Phenoplastic
- Fraction as a whole → Refinery (transportation fuels)  
energetic utilization (power, heat)

# Staged Condensation – Creation of Value

- **Medium viscous fraction (3 staged condensation)**  
dark brown, honey-like liquid, medium heating value



specimen	max. load [N]	area [mm <sup>2</sup> ]	tensile strength [N/mm <sup>2</sup> ]
1	1551	221	7,02
2	1274	255	5,00
3	1015	221	4,59
4	1338	187	7,16
5	1350	170	7,94

# Staged Condensation – Creation of Value

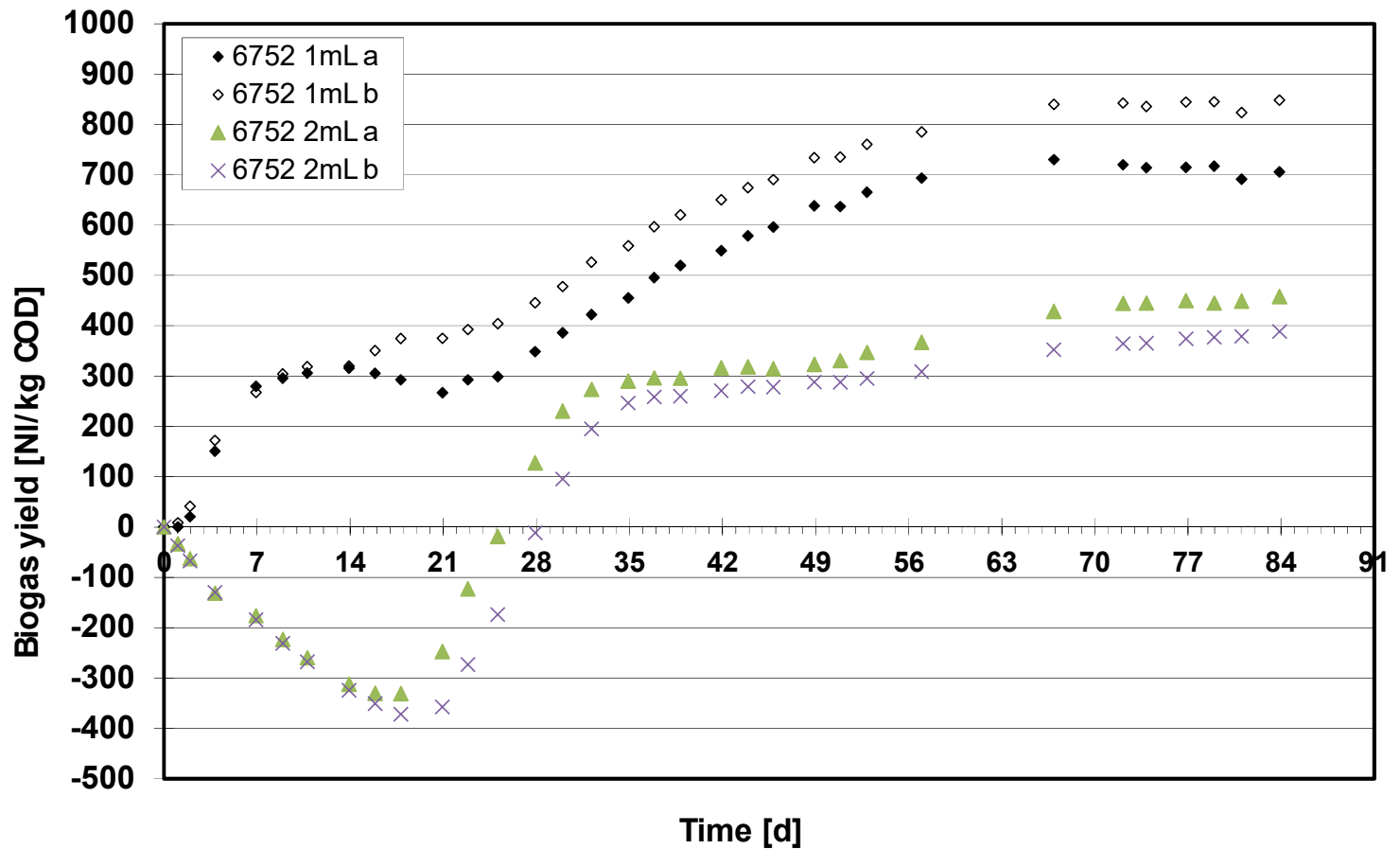
## ■ Aqueous fraction (2 and 3 staged condensation)

reddish brown aqueous liquid, low heating value

- Water
- org. acids (acetic acid)      ➡ pure acid (raw material for chem. Industry)
- Alcohols, Ketones (Acetol)   ➡ Solvents
- Fraction as a whole          ➡ Fermentation (biogas)

# Staged Condensation – Creation of Value

- Aqueous fraction (2 and 3 staged condensation)  
reddish brown aqueous liquid, low heating value



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## 1. Summary

# Summary

## Flash pyrolysis ...

- makes biomass available in liquid form
- makes material use possible
  - the pyrolysis temperature has influence on the formation of individual substances

## Staged condensation of pyrolysis vapors ...

- represents an upgrading-method
  - Preliminary separation of material groups
  - Enrichment of material groups with similar characteristics
  - enables an efficient processing of the fractions

## Target

- Comprehensive (economic) value creation from the individual fractions

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# FRAUNHOFER UMSICHT

## Department Biorefinery & Biofuels

# Thank you for your kind attention!

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