Karlsruher Institut für Technologie

Hydroprocessing of FT waxes for production of Kerosene and Chemicals

Prof. Dr.-Ing. Reinhard Rauch

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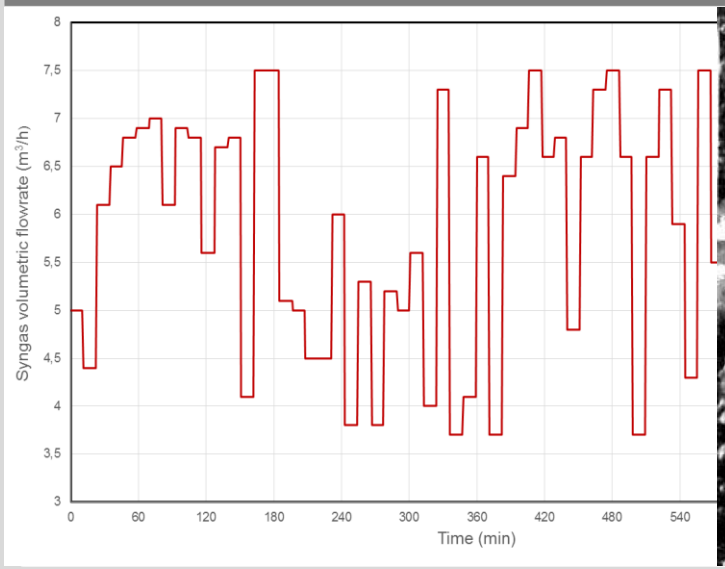
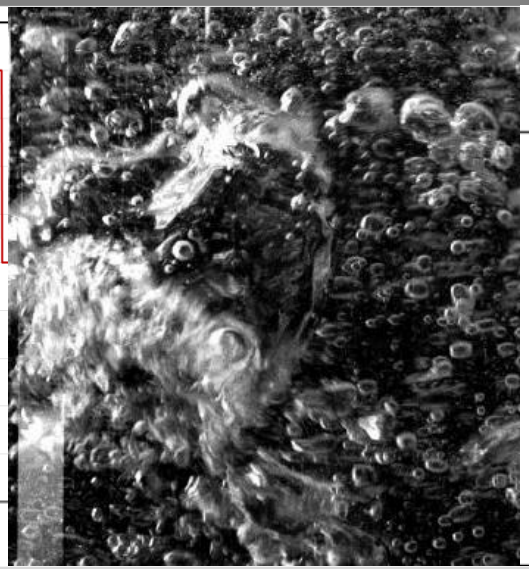
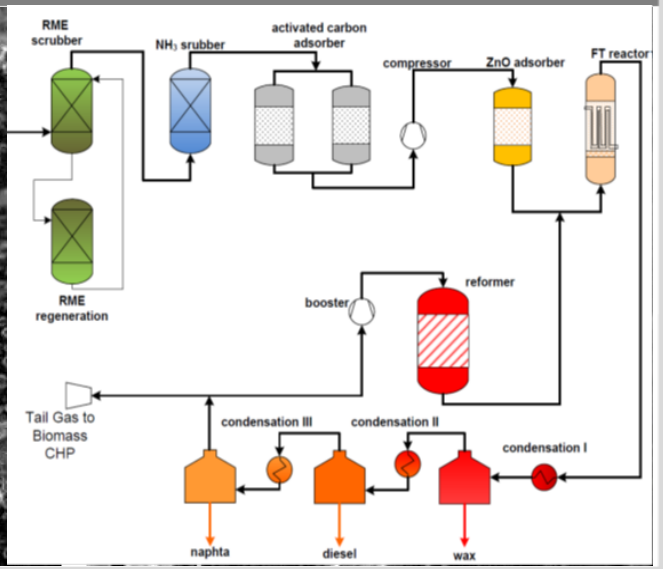
Bereich Chemische Energieträger - Brennstofftechnologie







Agenda

- Technology description of hydroprocessing
- Difference in Hydroprocessing of FT waxes compared to classical crude
- Experimental results
- Conclusion

Fischer Tropsch Synthesis

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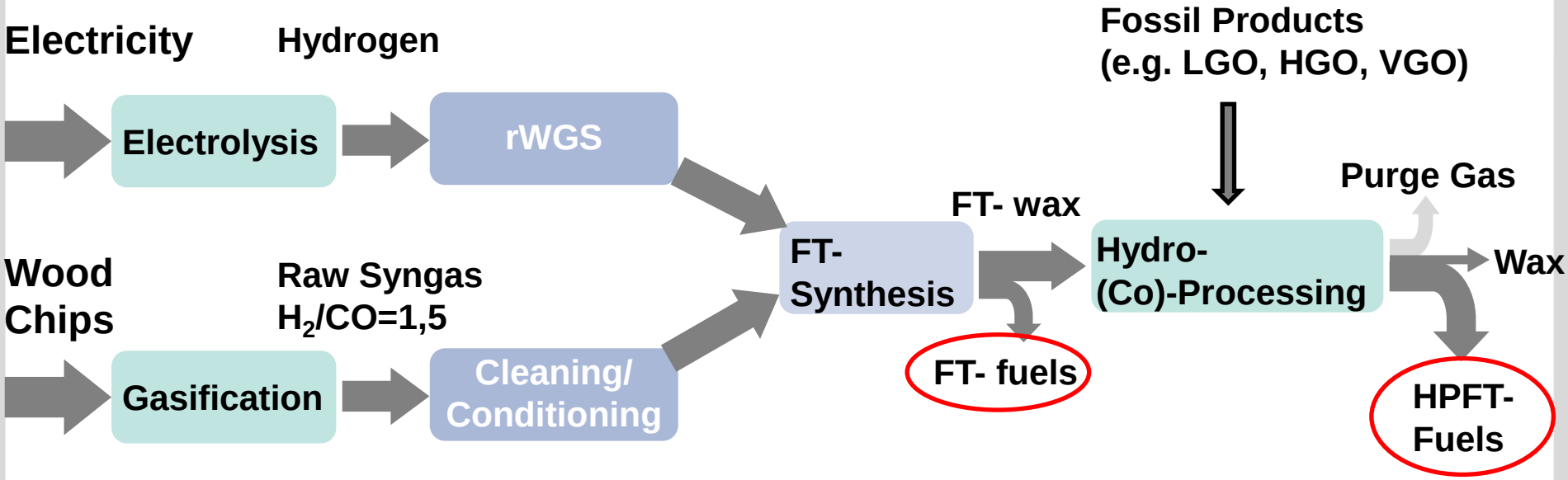
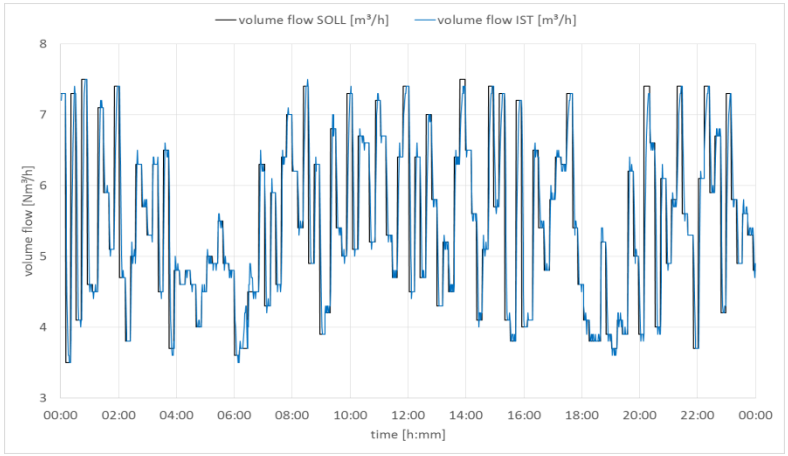
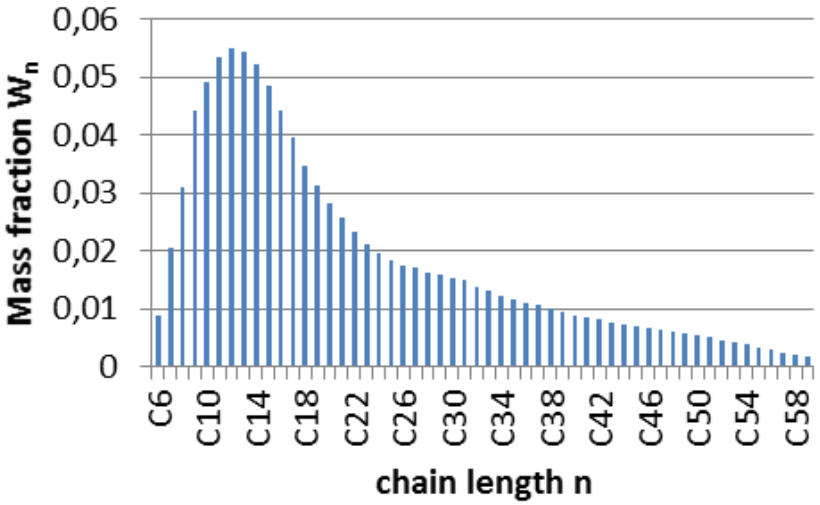
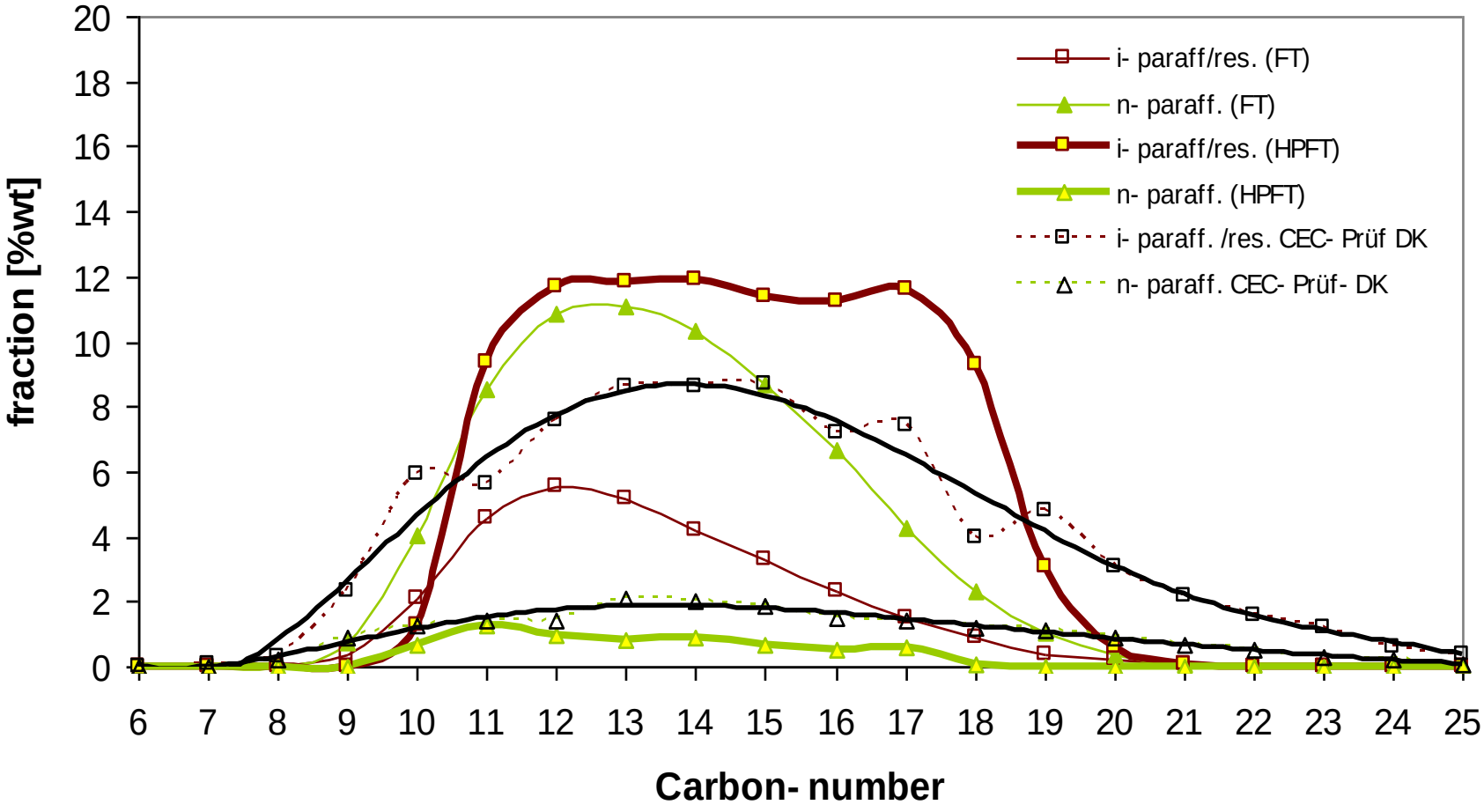






Comparison of Produced FT Fuels

	FT- Diesel	HPFT- Diesel	CEC- Prüf.
ACN:	>72 t_d = 2,5 s	68,5 t_d = 2,91 s	>51,8 /
CFPP/CP/FP:	-12/ -9/ - °C	-62/ -60 / -98°C	-18/ -5 °C

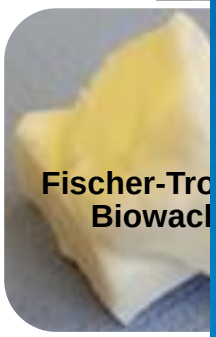


Conversion of FT wax

- Hydroprocessing
  - Hydrocracking and hydroisomerisation in presence of catalyst and high pressure hydrogen atmosphere
  - Used for removal of sulphur and nitrogen in almost every refinery
- Hydroprocessing can be done in the following ways
  - Stand alone units (e.g. in a centralised FT refinery)
  - Co-Processing in a standard refinery
  - Integration into the FT synthesis

- Fluid Catalytic Cracking
  - Standard unit in refinery for conversion of vacuum gas oil to olefins and gasoline

Upgrading of FT Waxes



Bildquelle 1: http://www.archiexpo.de/prod/ehc-global/product-59711-1289149.html

Bildquelle 2: http://www.archiexpo.de/prod/ehc-global/product-59711-1289149.html

Bildquelle 3: http://www.anton-paar.com/za-en/products/industries/application/asphalt-bitumen/

Bildquelle 4: https://de.wikipedia.org/wiki/Vaseline

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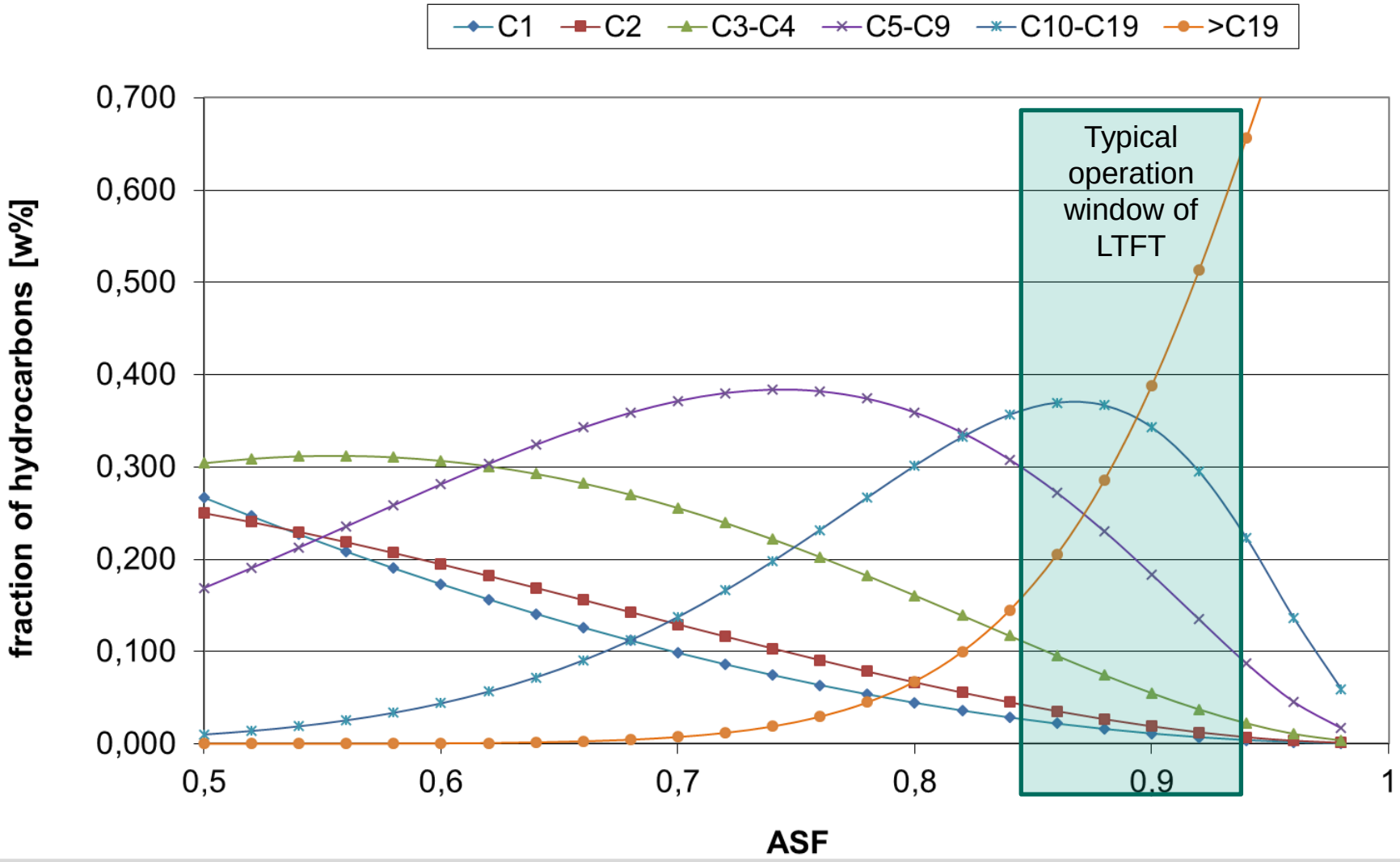
Theoretical distribution of hydrocarbons



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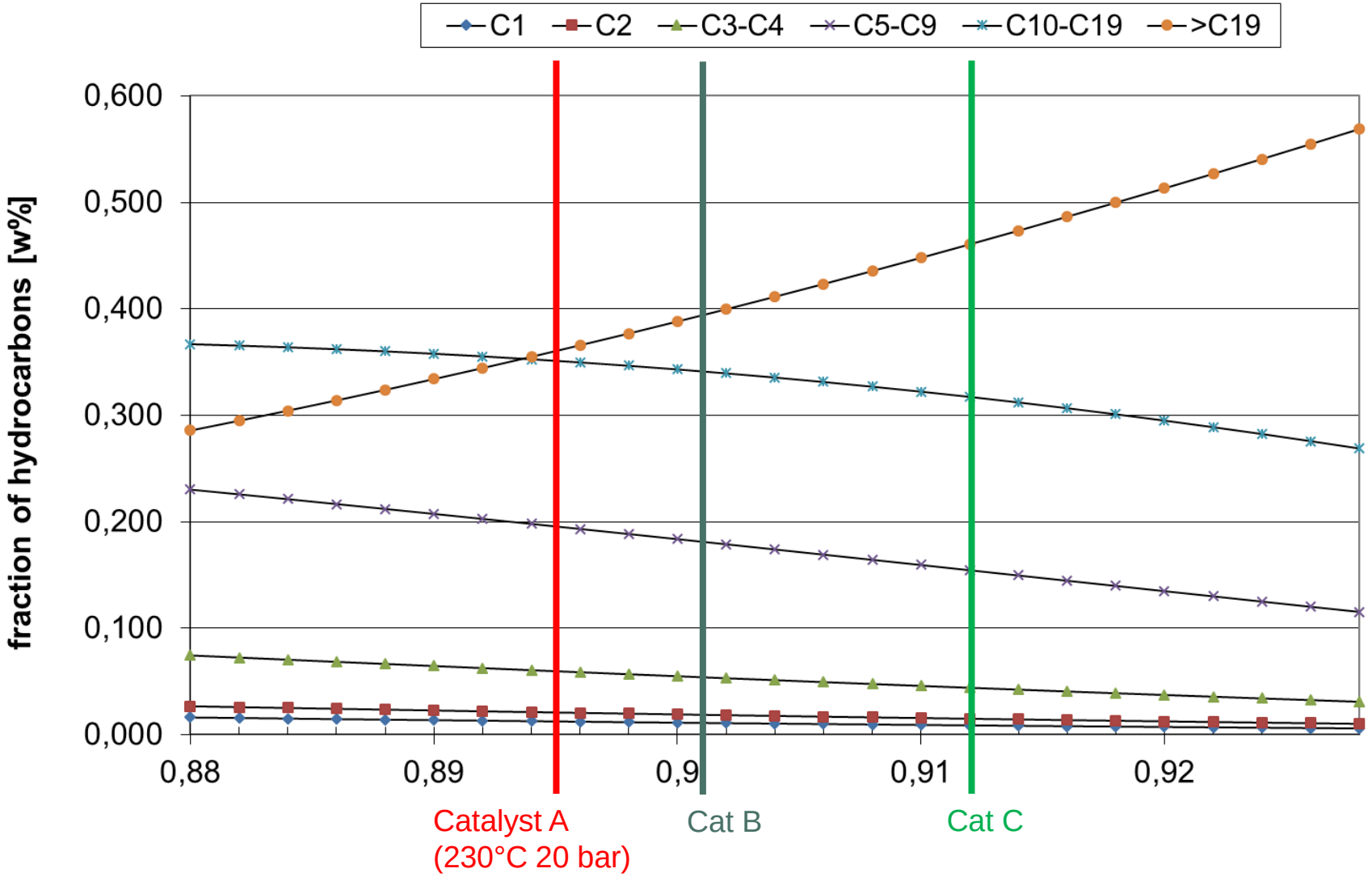
Detailed ASF distribution (typical for LTFT)



Product distribution by variation of α and change of boiling range

	Boiling range	Theory by ASF (α: 0.906)	Improved α (0.912)	Change of boiling range (150-350°C)[1]
Naphtha	< 200°C	26.2w% (C5-C11)	23.8w%	13.0w% (C5-C8)
Middle destillate (diesel)	200-360°C	33.7w% (C12-C21)	32.4w%	43.2w% (C9-C21)
waxes	>360°C	40.1w% (>C21)	43.8w%	43.8w% (>C21)

[1] according to results from EC project RENEW possible

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Summer and Winter Diesel

	Optimal distribution	Summer cut	Winter cut
Naphtha	13.0w% (C5-C8)	13.0w% (C5-C8)	13.0w% (C5-C8)
Middle destillate (diesel)	43.2w% (C9-C21) 150-350°C	43.2w% (C9-C21) 150-350°C	31.5w% (C9-C17) 150-300°C
waxes	43.8w% (>C21)	43.8w% (>C21)	55.5w% (>C17)

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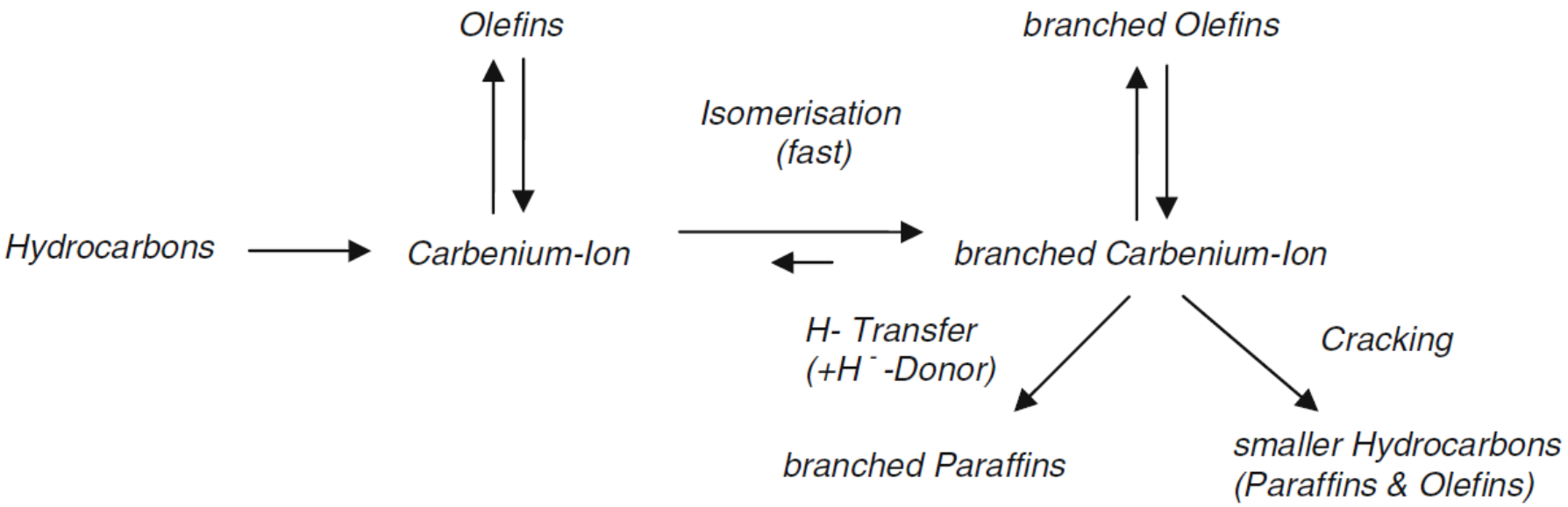
Reaction network for catalytic cracking



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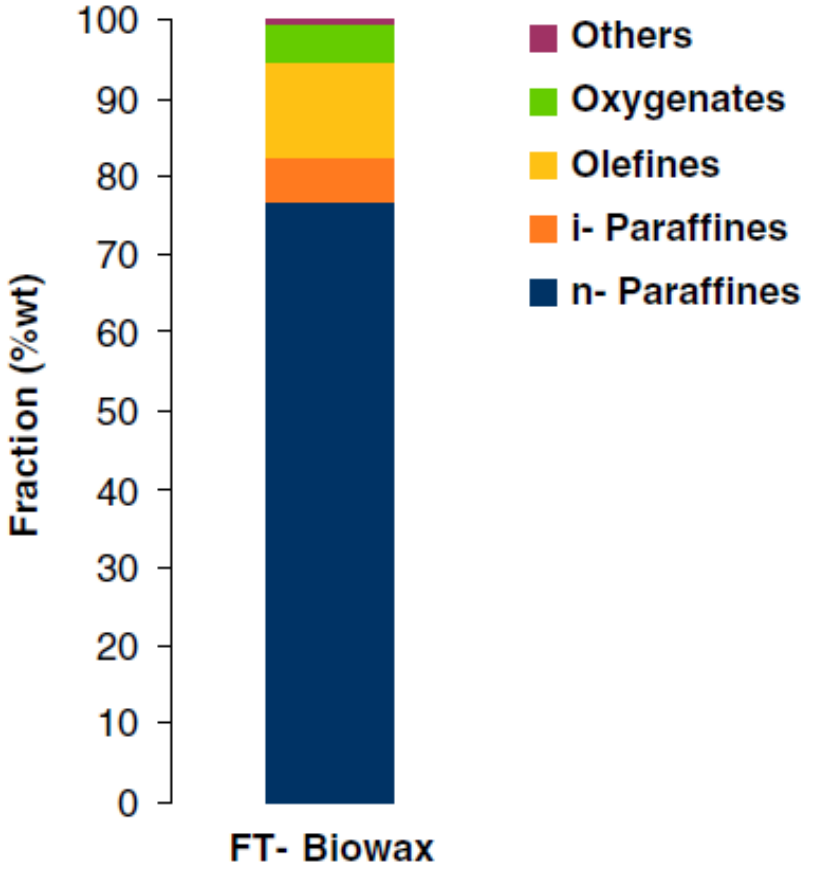
Properites of FT Wax

Carbon range	C25–C105
Melting range	~90-130°C
Density at 130°C	0.742 kg/dm³
Viscosity at 130°C	6.62 mm²/s
C/H/O	85/14.7/0.3 %wt.



Comparison of Hydrocracking

	Conventional hydrocracking*	Mild hydrocracking*	FT waxes hydrocracking**
Pressure (MPa)	10-20	5-8	3.5-7
Temperature (K)	623-703	653-713	597-645
H_2/feedstock (m^3/m^3)	800-2000	400-800	500-1800
LHSV (h^{-1})	0.2-2	0.2-2	0.5-3
Reactor technology	trickle bed	trickle bed	trickle bed
Conversion (%)	70-100	20-40	20-100

C Bouchy et al. / *Fischer-Tropsch Waxes Upgrading via Hydrocracking and Selective Hydroisomerization, Oil & Gas Science and Technology – Rev. IFP,* Vol. 64 (2009), No. 1

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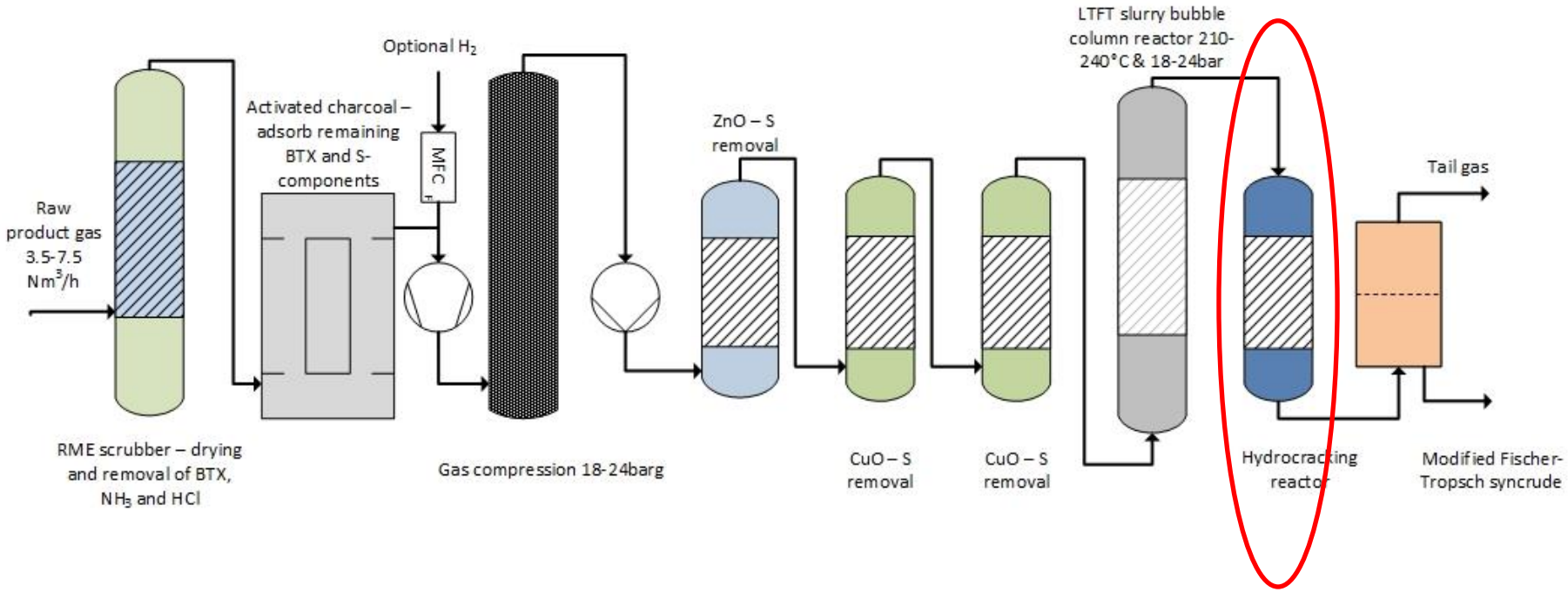
Integration of HP into the FT

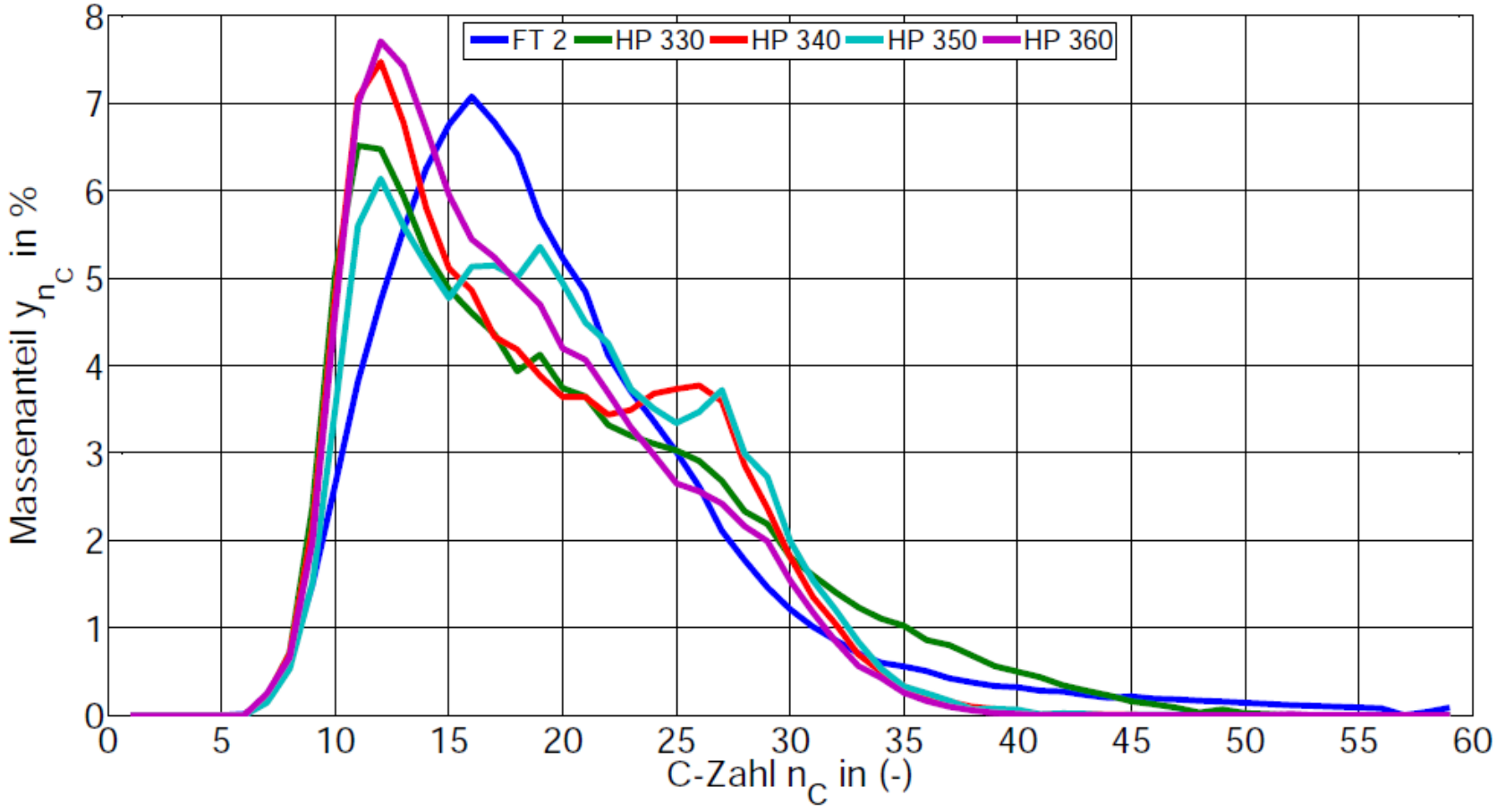


TU WIEN Technische Universität Wien / Vienna University of Technology

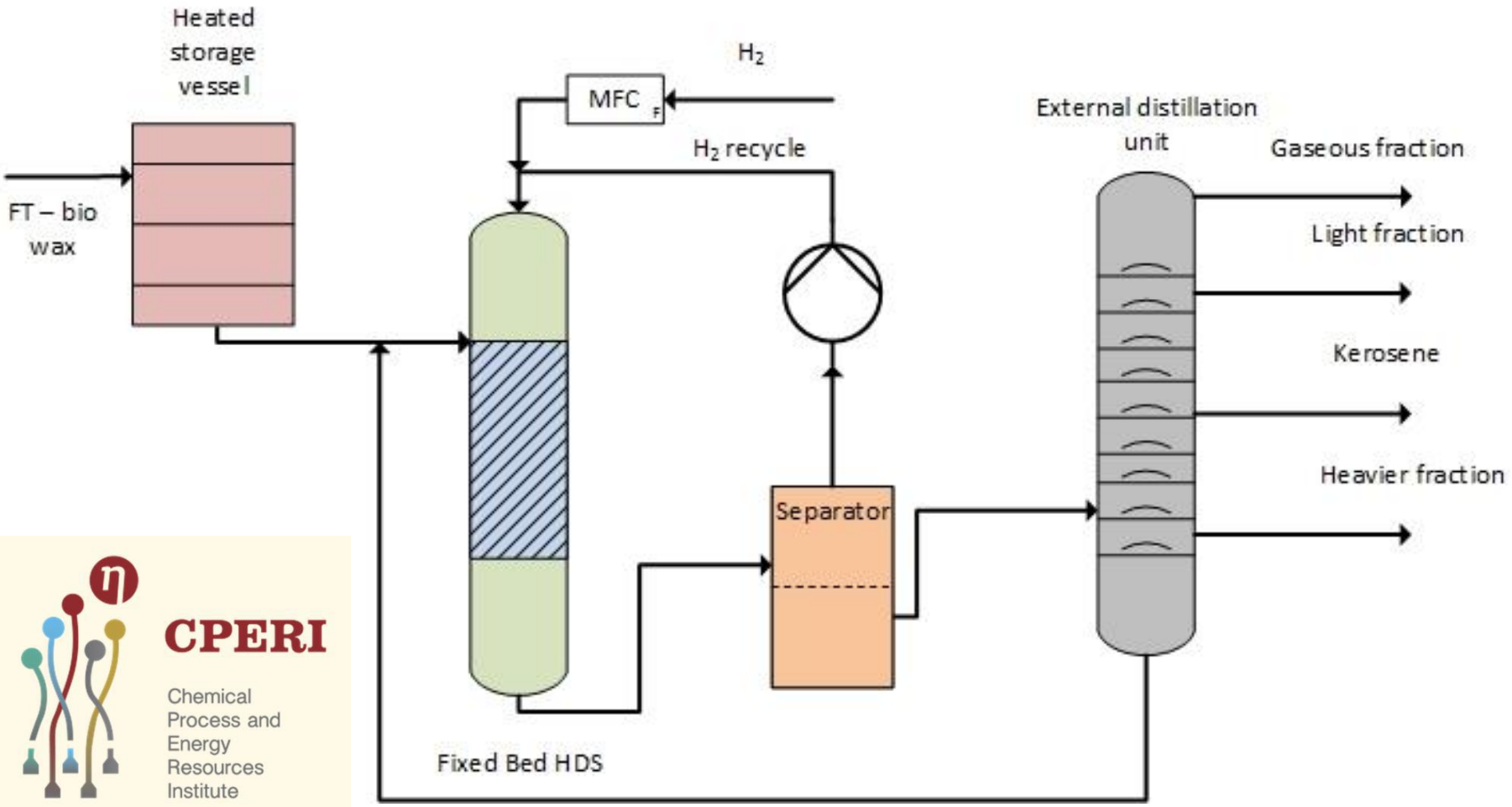
bioenergy2020+

A. Sauciuc, Biocombustible materials obtained from biomass using cobalt based catalysts -PhD Thesis Transilvania University of Brasov, 2012

Results: change of product distribution



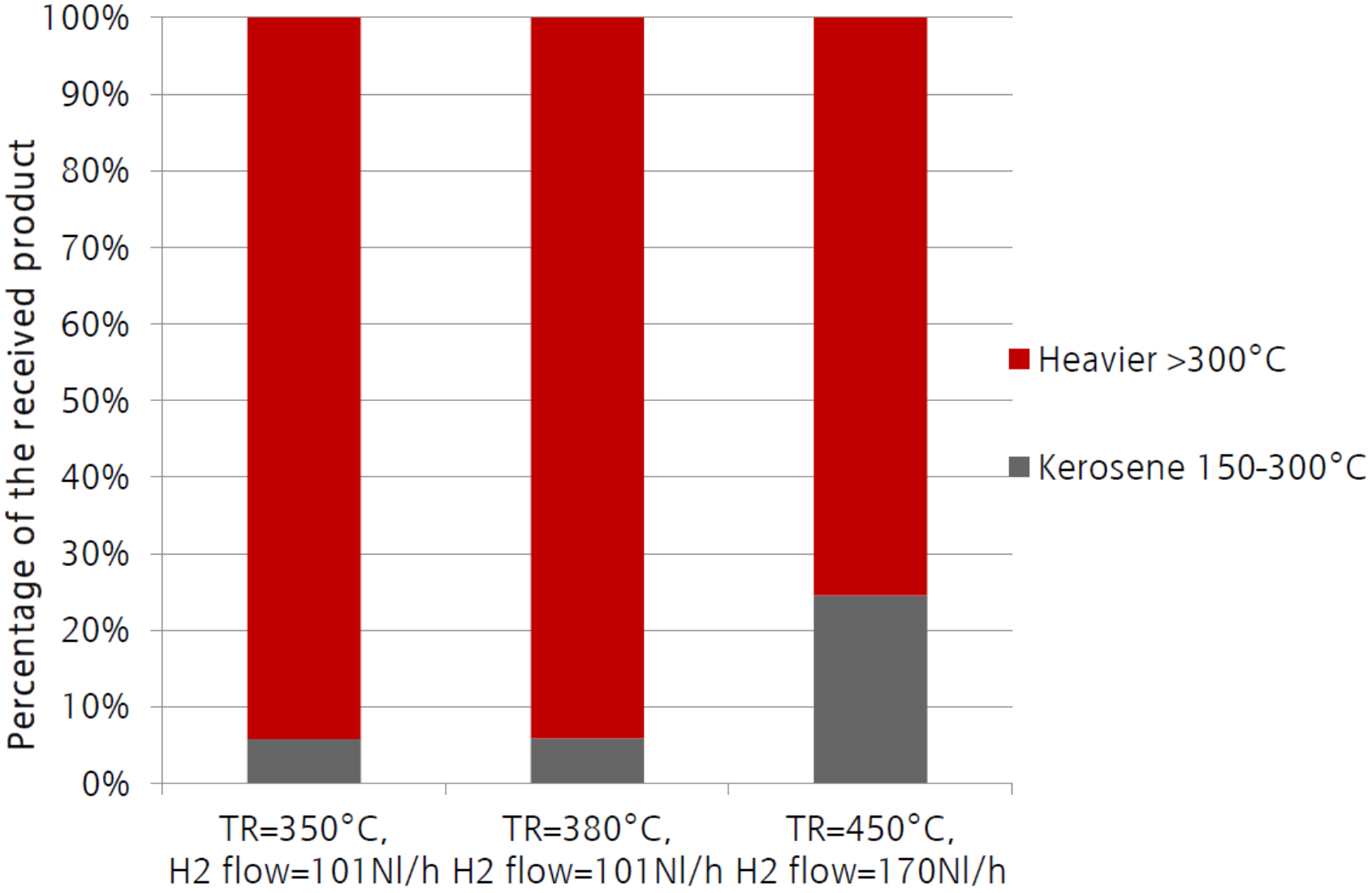
Stand alone Hydroprocessing



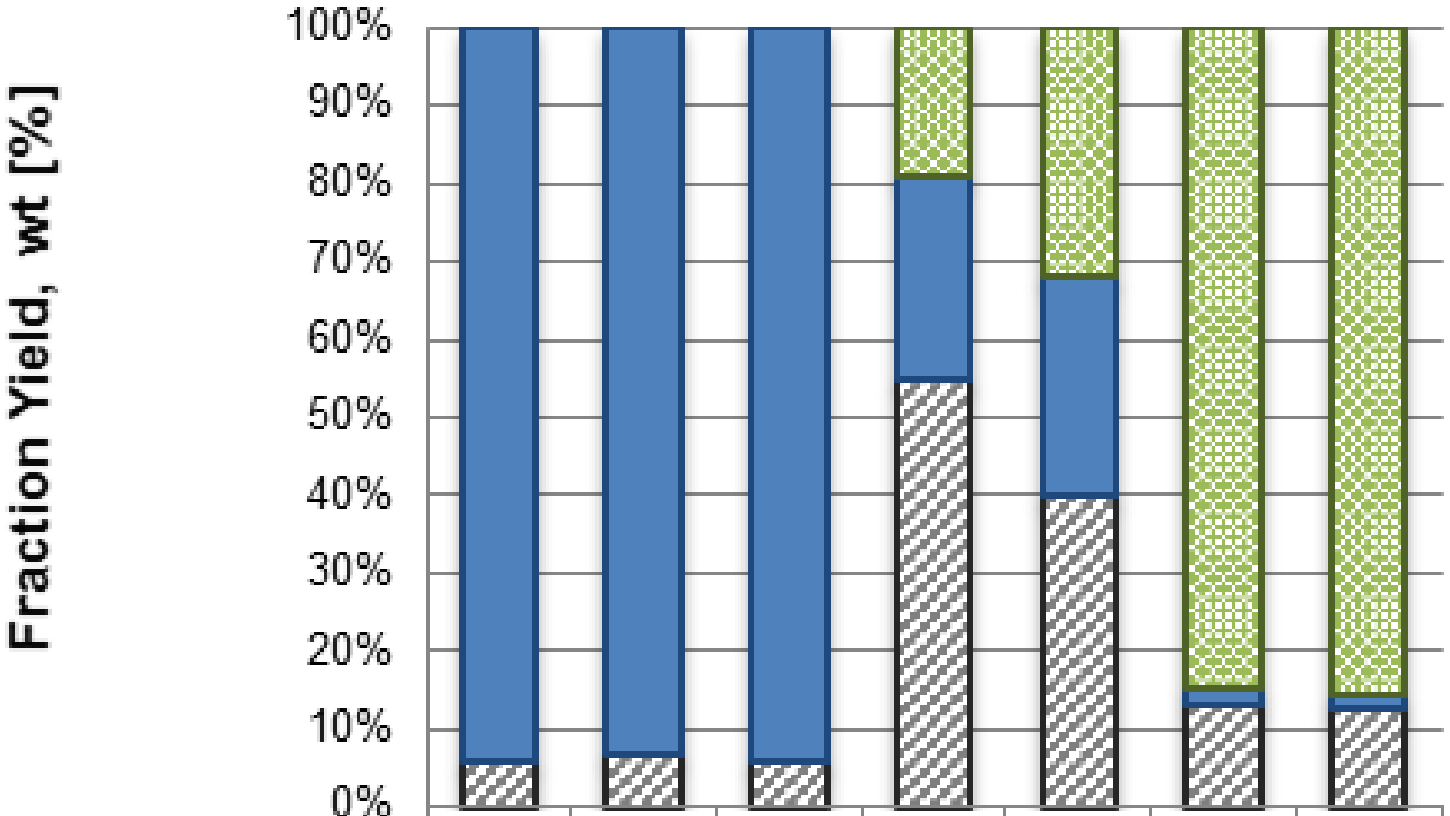
CPERI
Chemical Process and Energy Resources Institute

R. Rauch, M. Jovicic, C. Aichernig, E.F. Iliopoulou, E. Heracleous, A.A. Lappas, Hydroprocessing and catalytic cracking of Fischer-Tropsch biowaxes to biokerosene, Process. Technol. For. Biobased Prod. Ind. (2014)

Results HP catalyst A



Results HP catalyst B



	300° C	325° C	325° C	350° C	350° C	375° C	375° C
Lighter < 150°C	0,00	0,00	0,00	18,96	31,92	84,92	85,60
Heavier > 300°C	94,29	93,23	94,14	26,26	28,10	1,82	1,91
Kerosene 150-300°C	5,71	6,77	5,86	54,78	39,97	13,26	12,49

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Conclusion on conversion of FT Waxes

- Easiest and most economic is to produce candles
- About 20-50% of the waxes can be converted to kerosene (boiling range 150-300°C)
- Cold flow behaviour in the range of -30 to -60°C (freezing point)
- Analysis according to ASTM D7566, Annex A1 for F-T SPK* (F-T SPK have been approved as maximum 50% blend stock in jet fuel)

*Synthetic Paraffinic Kerosene

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