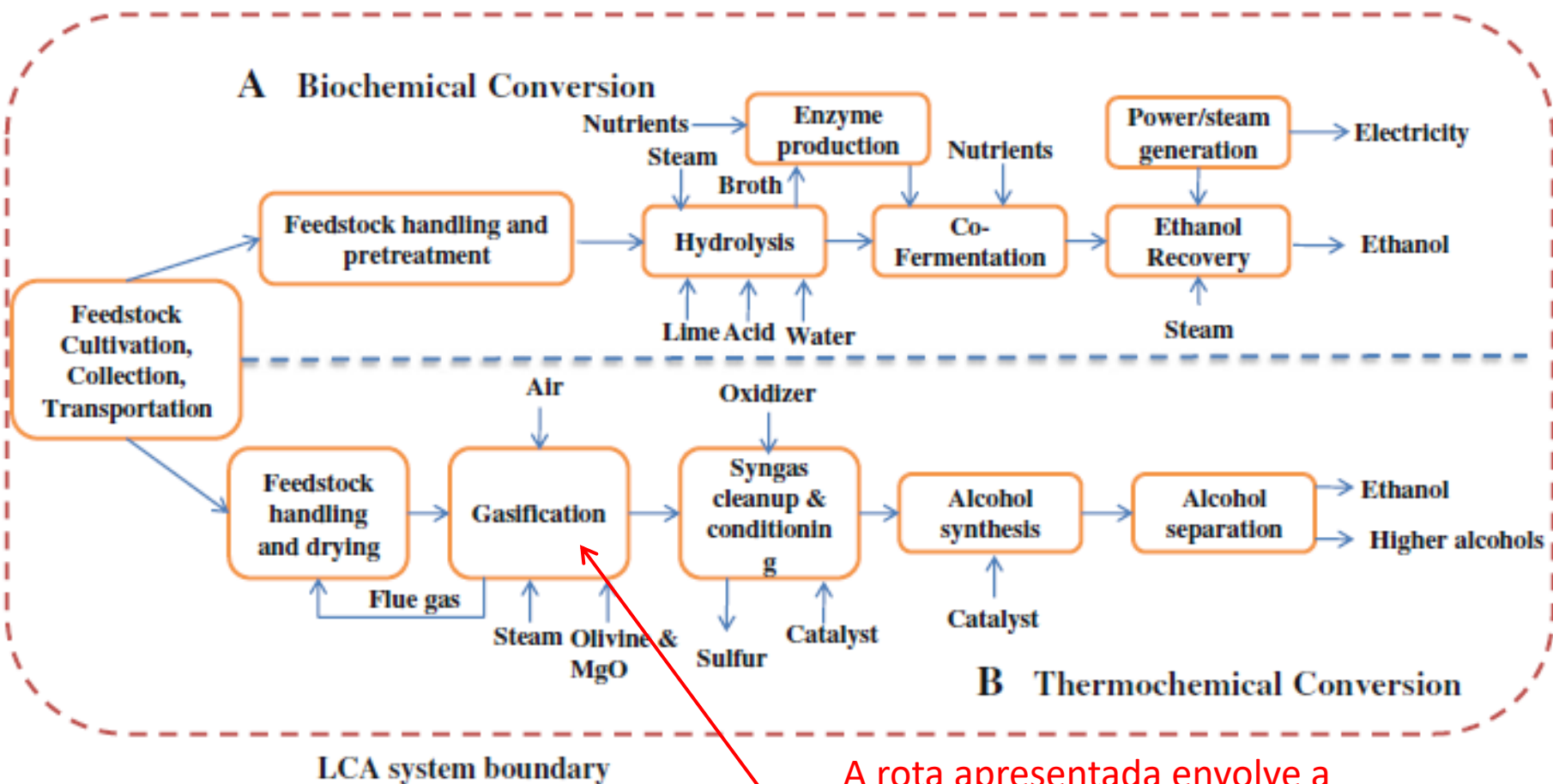
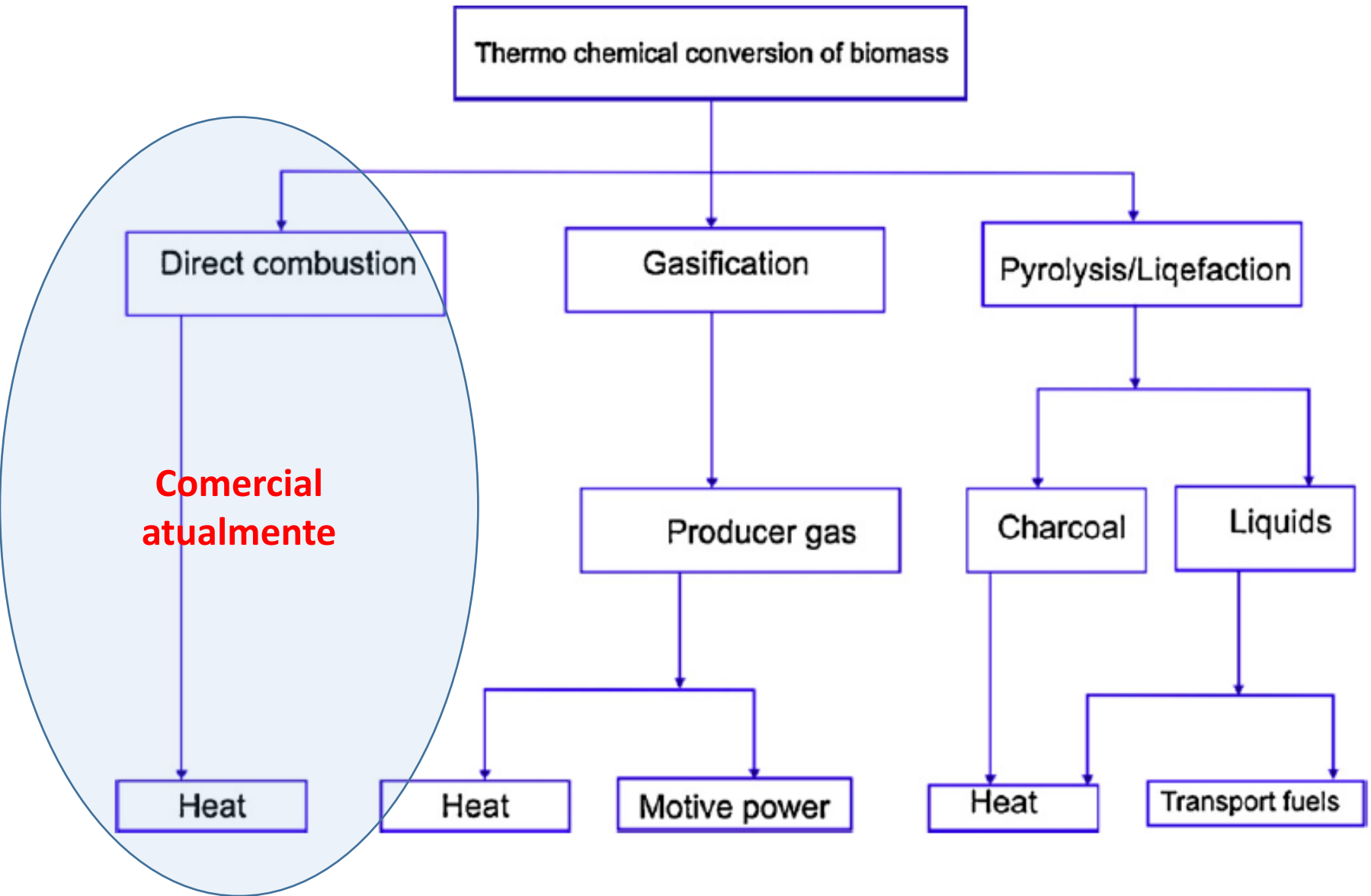


Rotas termoquímicas e bioquímicas comparadas



A rota apresentada envolve a maximização da gaseificação. Há outras vias possíveis, incluindo bio-óleo e carvão

Rotas termoquímicas possíveis



Combustão (co-geração de energia elétrica) >> tecnologia que se estabeleceu no setor sucro-energético

recaptulando

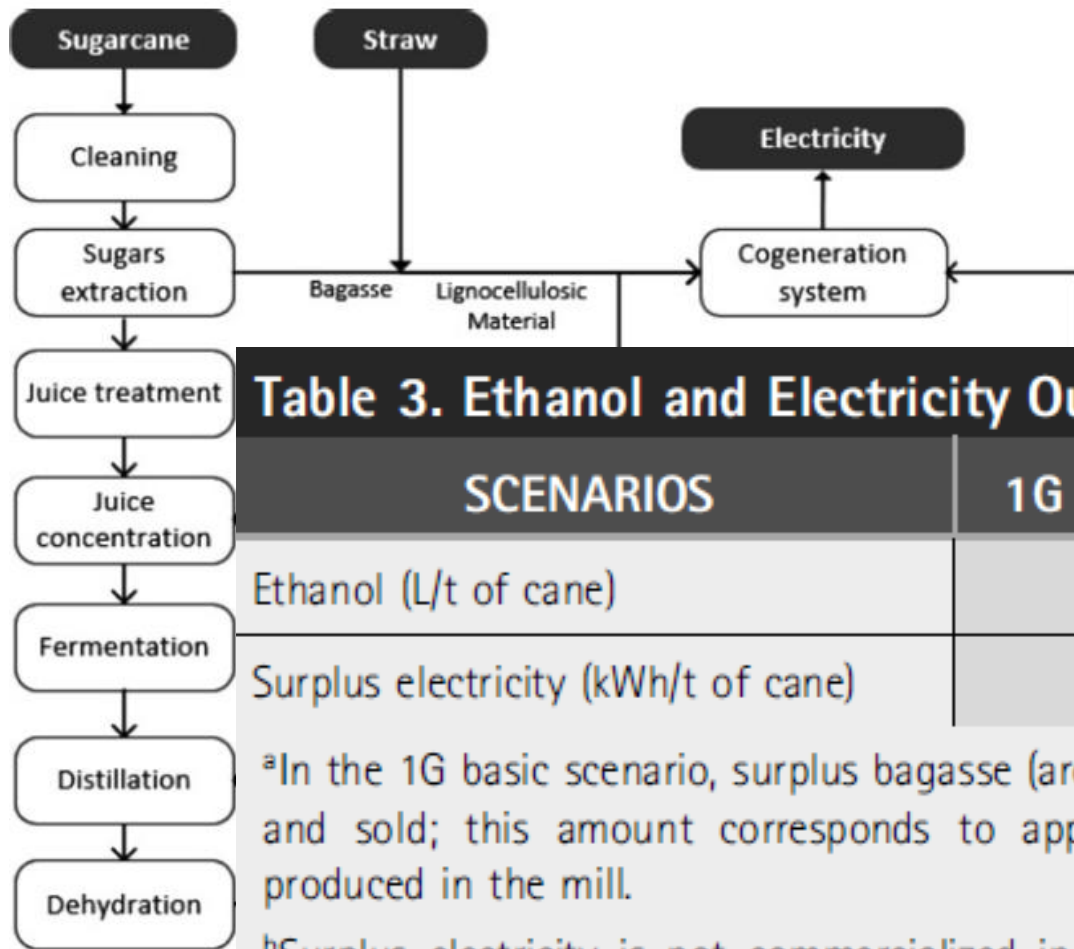


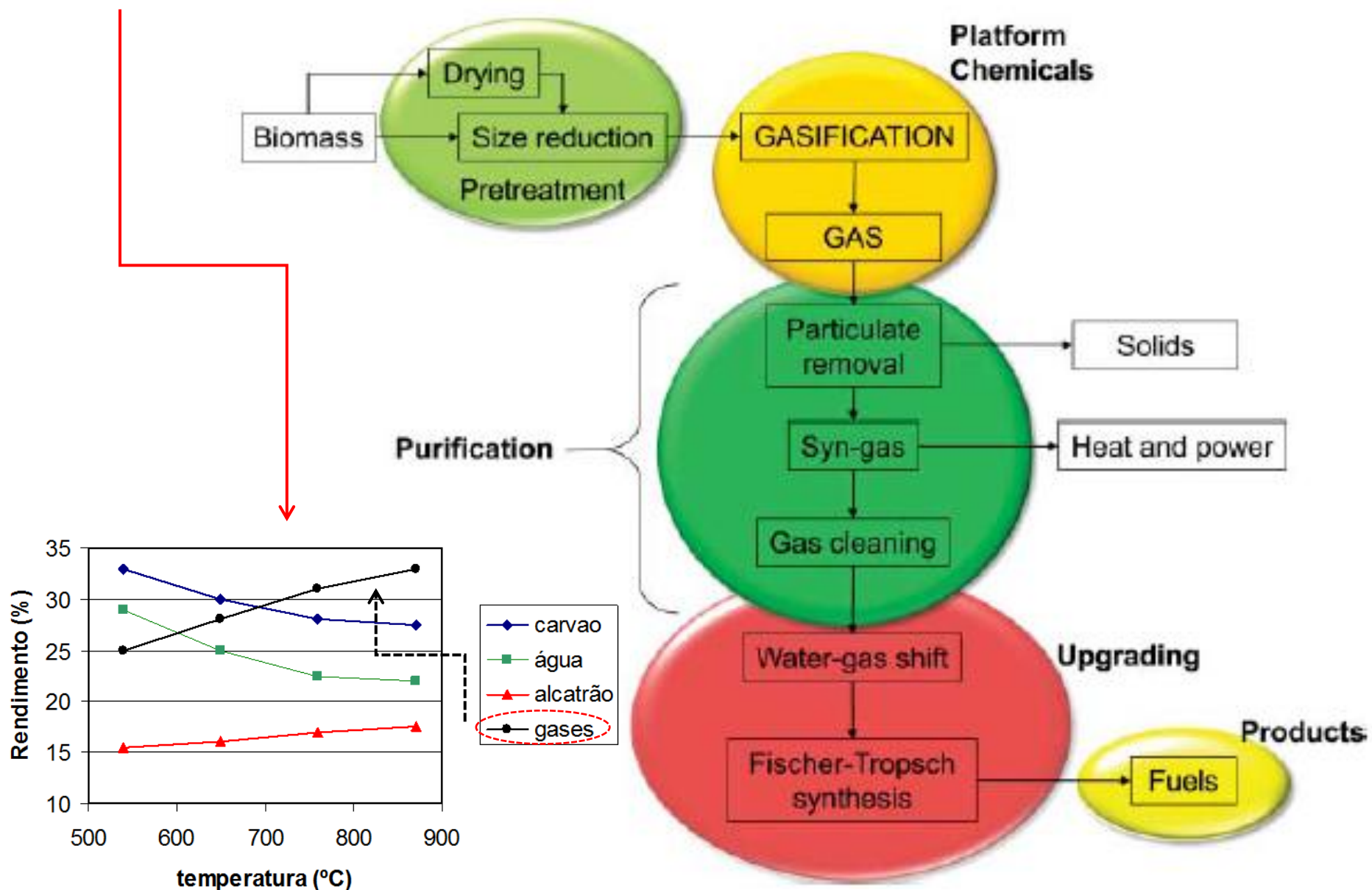
Table 3. Ethanol and Electricity Outputs for 1G Scenarios

SCENARIOS	1G BASIC ^a	1G OPTIMIZED
Ethanol (L/t of cane)	85	85
Surplus electricity (kWh/t of cane)	12 ^b	186

^aIn the 1G basic scenario, surplus bagasse (around 24 kg/t of cane) is generated and sold; this amount corresponds to approximately 10% of the bagasse produced in the mill.

^bSurplus electricity is not commercialized in the 1G basic scenario since this amount would not justify the investment in production and transmission lines.

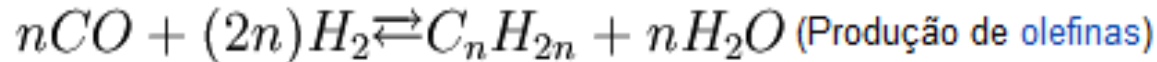
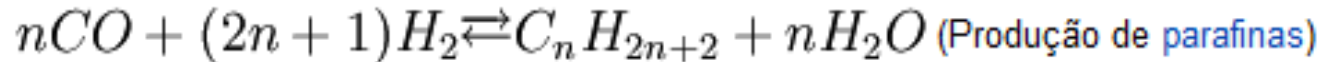
Gaseificação maximizada como rota de conversão termoquímica



Processo de Fischer-Tropsch

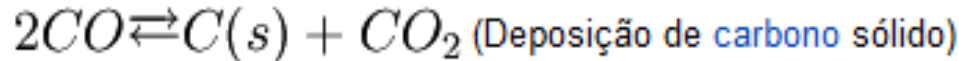
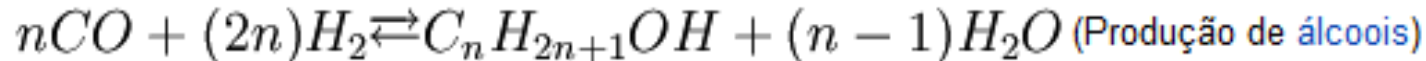
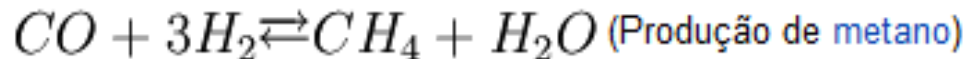
Reações

As reações principais são:



Se trata em ambos os casos de reações muito **exotérmicas**, ou seja, que liberam uma grande quantidade de **calor**.

Reações secundárias, indesejadas:

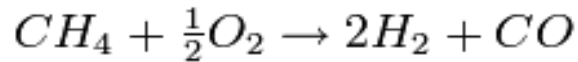


A reação depende de catalisadores de cobalto ou ferro.

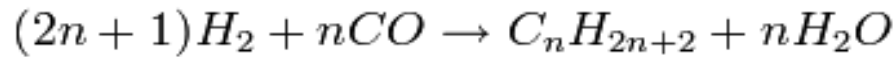
Para um bom rendimento se requer alta pressão (tipicamente 20 - 30 bar) e temperatura (200 - 350°C).

Processo de Fischer-Tropsch em uma refinaria de biomassa >> a gaseificação deveria maximizar CO e H₂

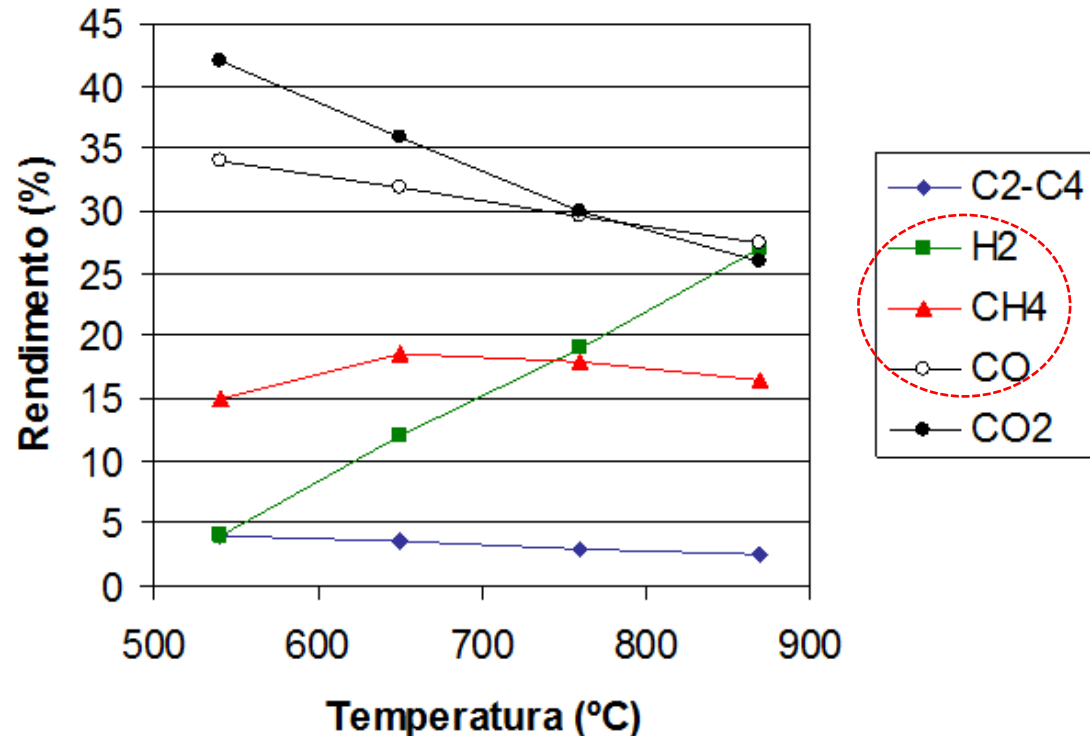
Reação do metano com oxigênio, formando o monóxido de carbono:



Reação do hidrogênio com o monóxido de carbono, formando o hidrocarboneto:

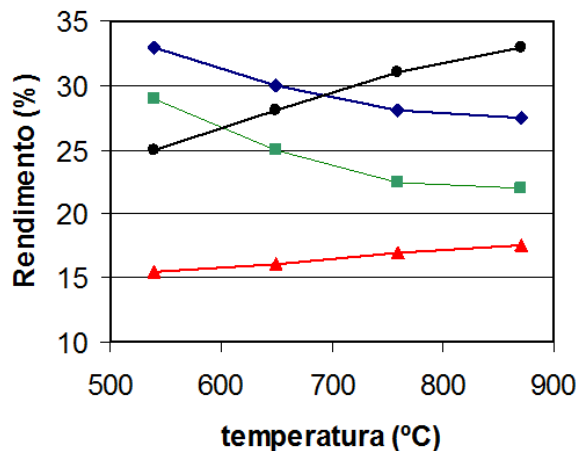
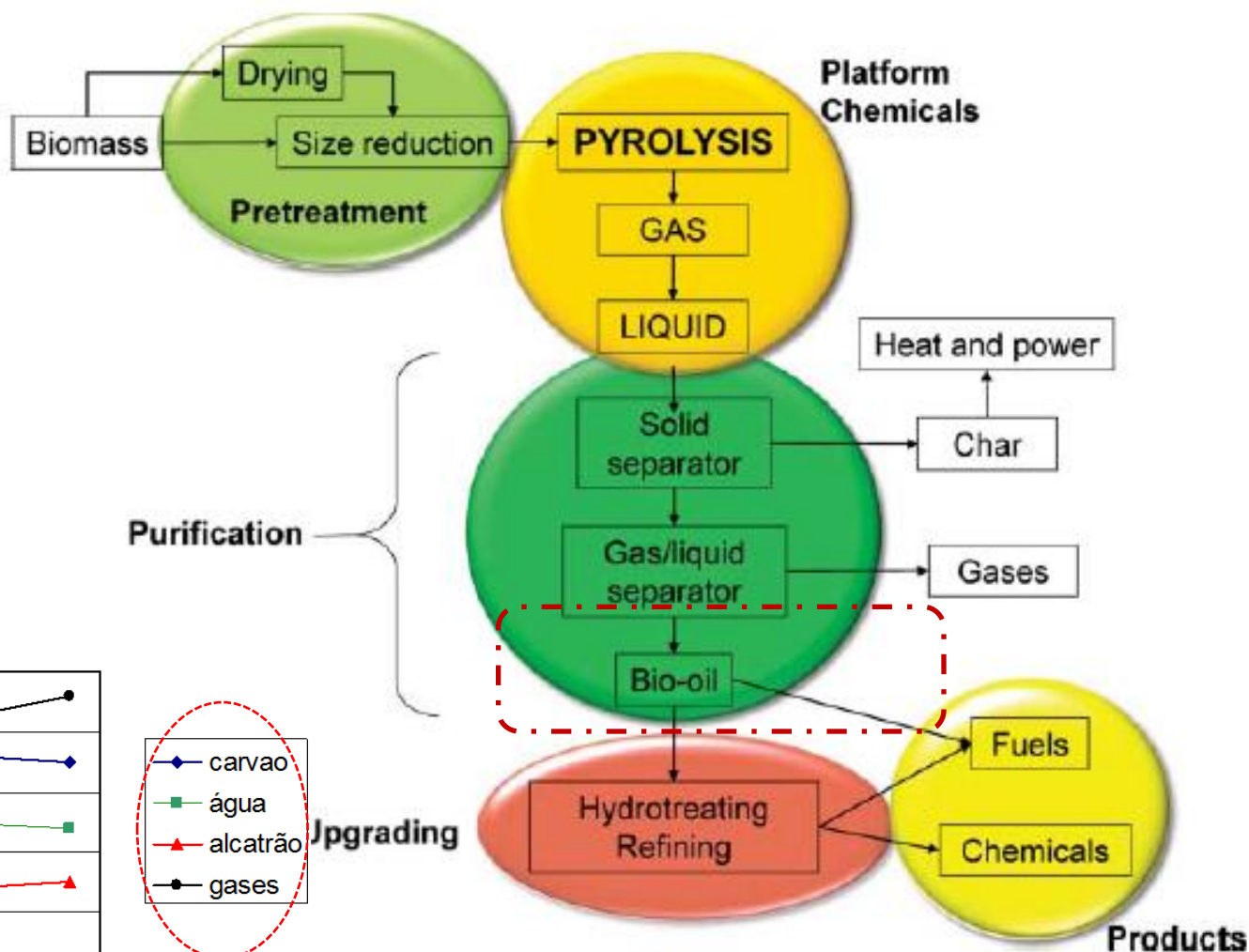


Termodegradação
de biomassa

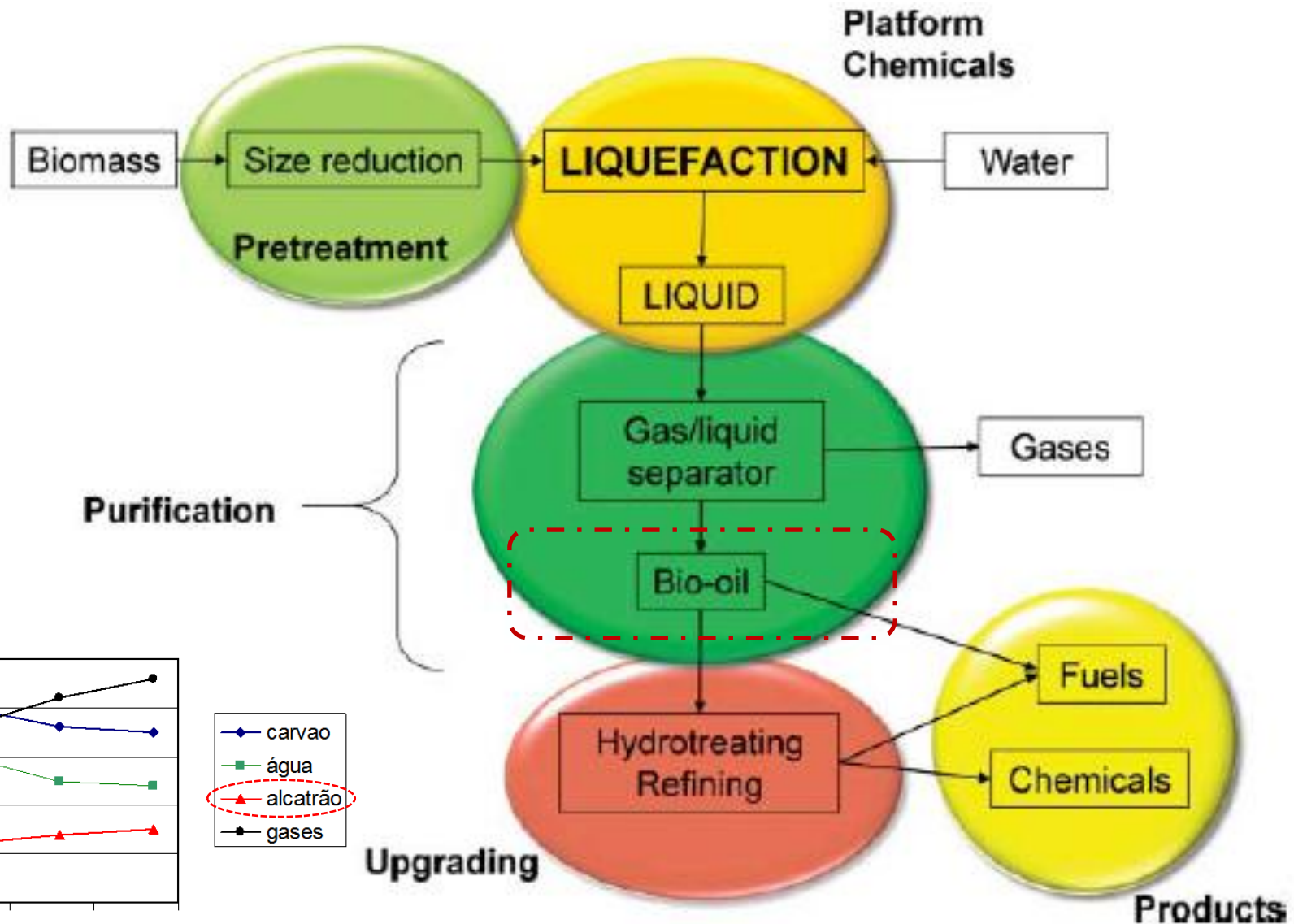


Bio-óleo como produto principal

Pirólise maximizada como rota de conversão termoquímica



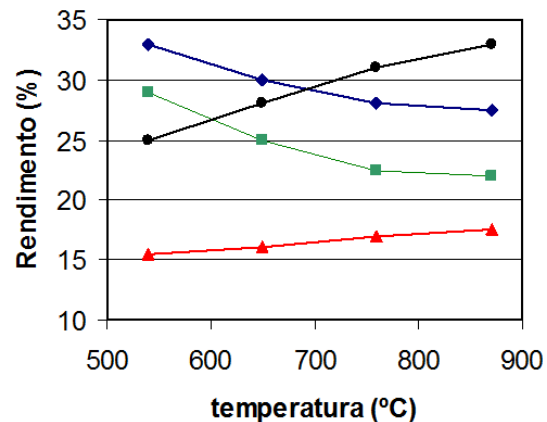
Liquefação maximizada como rota de conversão termoquímica



Purification

Upgrading

Products



Bio-óleo versus Petróleo

Comparison between bio-oil and crude oil. Data are from Refs. [10,11,28].

	Bio-oil	Crude oil
Water [wt%]	15–30	0.1
pH	2.8–3.8	–
ρ [kg/l]	1.05–1.25	0.86
$\mu_{50^\circ\text{C}}$ [cP]	40–100	180
HHV [MJ/kg]	16–19	44
C [wt%]	55–65	83–86
O [wt%]	28–40	<1
H [wt%]	5–7	11–14
S [wt%]	<0.05	<4
N [wt%]	<0.4	<1
Ash [wt%]	<0.2	0.1

Características do bio-óleo de acordo com a biomassa e o método de preparação

Bio-oil composition in wt% on the basis of different biomass sources and production methods.

	Corn stover	Softwood	Hardwood
Ref. #	[45]	[195]	[195]
T [°C]	500	500	–
Reactor	Fluidized bed	Rotating bed	Transport bed
Water	9	29–32	20–21
Aldehydes	4	1–17	0–5
Acids	6	3–10	5–7
Carbohydrates	12	3–7	3–4
Phenolics	2	2–3	2–3
Furan etc.	1	0–2	0–1
Alcohols	0	0–1	0–4
Ketones	7	2–4	7–8
Unclassified	57	24–57	47–58

Exemplo de desenvolvimento industrial no setor

Uso de bio-óleo em mistura com resíduo pesado de petróleo na estação de craqueamento

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Co-processing of pyrolysis oil in conventional refinery operations to produce biomass-derived gasoline and diesel fuel blendstocks

Conference Paper · October 2017

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Overview - Two different worlds

Collision or Sinergy?

Bioworld

v.

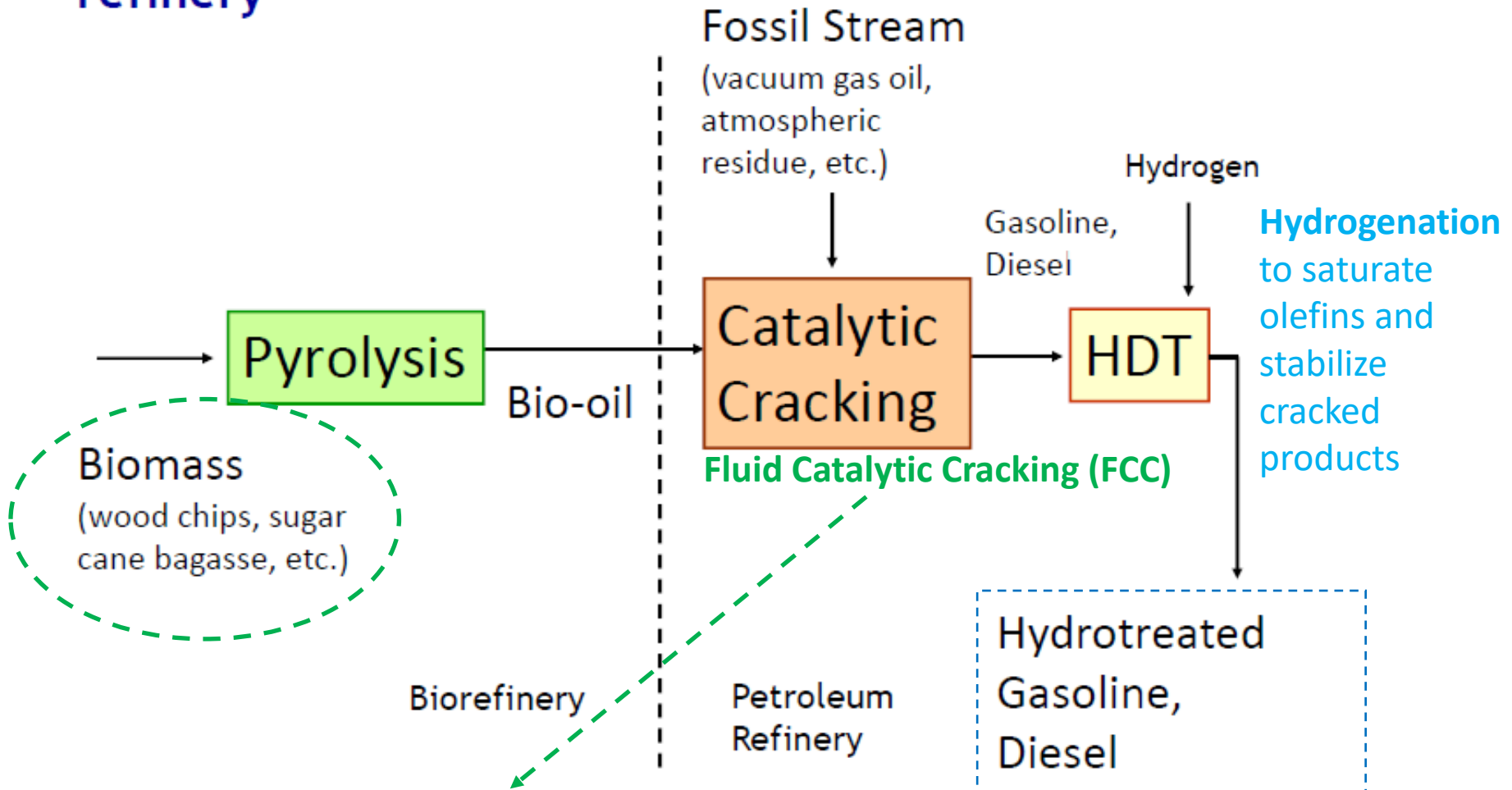
Fossilworld



- Maturity: Young vs. Mature
- Scale: Small vs. Big

Co-processing liquid lignocellulosic raw materials in a conventional refining scheme and generating HYBRID products (with fossil and renewable carbons).

Integrating biorefinery with a petroleum refinery



- **Feedstock** (heavy oil) is preheated and fed into the FCC unit.
- It contacts a **hot powdered catalyst** (usually zeolite-based) in a reactor.
- The heavy molecules "crack" into lighter hydrocarbons in a **fluidized bed**.
- Spent catalyst is sent to a **regenerator** where coke is burned off.

Demonstration-scale tests

FCC Unit



- Demonstration-scale catalytic cracking unit (FCC)
- Location: São Mateus do Sul (Brazil-PR)
- Feed Rate: 200 kg/h
- Bio-oils
 - Three pinewood bio-oils from two different suppliers: BTG (Netherlands) and Ensyn (Canada)
 - Sugar cane bagasse (not published)

Bio-oil co-processing results in the FCC

	Gasoil	90% Gasoil + 10% Bio-oil	80% Gasoil + 20% Bio-oil
Yields, wt. %			
Dry Gas (H ₂ , C1-C2)	3.9	2.8	2.5
LPG (C3-C4)	15.2	12.9	9.9
Gasoline (C5-220 °C)	40.4	40.7	37.7
Diesel (220-344 °C)	18.1	17.4	16.5
Bottoms (+ 344 °C)	14.8	14.0	13.7
Coke	7.4	7.5	8.5
CO	0.1	1.9	3.1
CO ₂	0.1	0.5	0.8
Water	0.0	2.3	7.3

Sources:

1) Pinho, AR, Almeida MBB, Mendes, FL, Ximenes VL, Casavechia, LC Co-processing raw bio-oil and gasoil in an FCC unit. Fuel Processing Technology. v. 131, p. 159-166, 2015.

2) Pinho, AR, Almeida, MB, Mendes, FL, Casavechia LC, Talmadge MS, Kinchin C, Chum HL Fast pyrolysis liquid co-processing from pinewood chips with vacuum gas oil in an FCC unit for second generation fuel production, Fuel, 188, 462-473, 2017.

Gasoline quality

Before and after hydrogenation

20% of bio-oil in the feed

Hydrogenation	Fossil		Biogasoline	
	Before	After	Before	After
Sulfur UV, ppm	1097	105	1050	107
Phenolics UV, ppm	3162	2782	19326	18760
MON <i>Motor octane number (900 rpm/90 oC)</i>	83.3	82.8	84.4	83.0
RON <i>Research octane number 600 rpm/50 oC)</i>	95.8	93.5	96.5	94.5
Biocarbon (ASTM D6866), wt.%	0		5	

- Phenolic compounds did not interfere on sulfur reduction
- Phenolic compounds remain in the gasoline after hydrogenation
- C14 analysis proved that the renewable carbons are present in the gasoline and diesel range (not shown here) products

Sources:

- 1) Pinho AR, Almeida MBB, Mendes FL, Ximenes VL, Casavechia, LC Co-processing raw bio-oil and gasoil in an FCC unit. Fuel Processing Technology. v. 131, p. 159-166, 2015.
- 2) Pinho AR, Almeida MBB, Mendes FL,; Ximenes VL, Production of lignocellulosic gasoline using fast pyrolysis of biomass and a conventional refining scheme. Pure and Applied Chemistry. v. 86, n. 5, p. 859-865, 2014.



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Co-processing raw bio-oil and gasoil in an FCC Unit



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Fuel 188 (2017) 462–473



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Full Length Article

Fast pyrolysis oil from pinewood chips co-processing with vacuum gas oil in an FCC unit for second generation fuel production



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Michael S. Talmadge ^c, Christopher M. Kinchin ^c, Helena L. Chum ^c

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