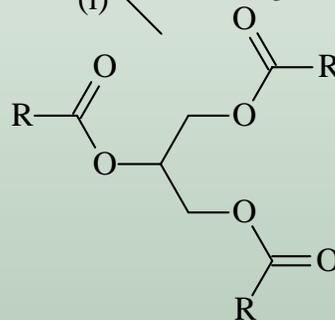
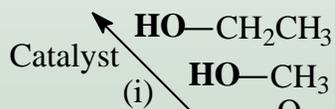
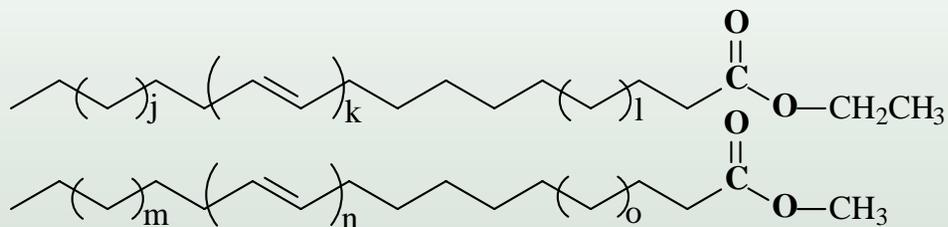


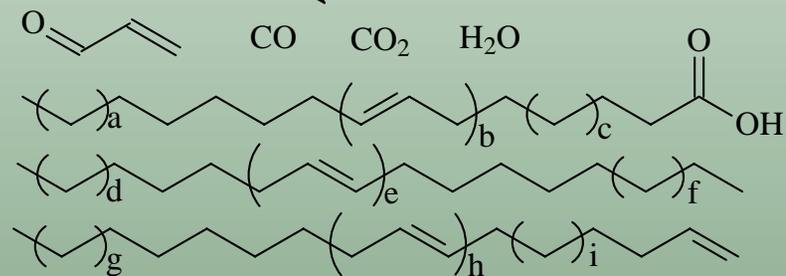


Alternative fuels from the thermo- catalytic cracking of triglycerides

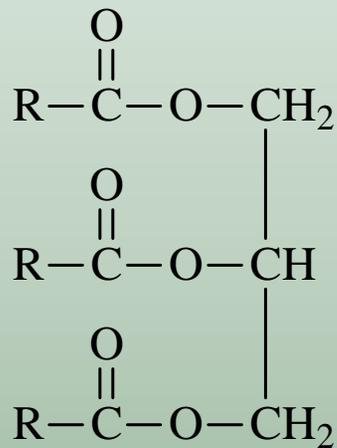
Prof. Paulo A. Z. Suarez
Laboratory of Materials and Fuels
Institute of Chemistry – University of Brasília



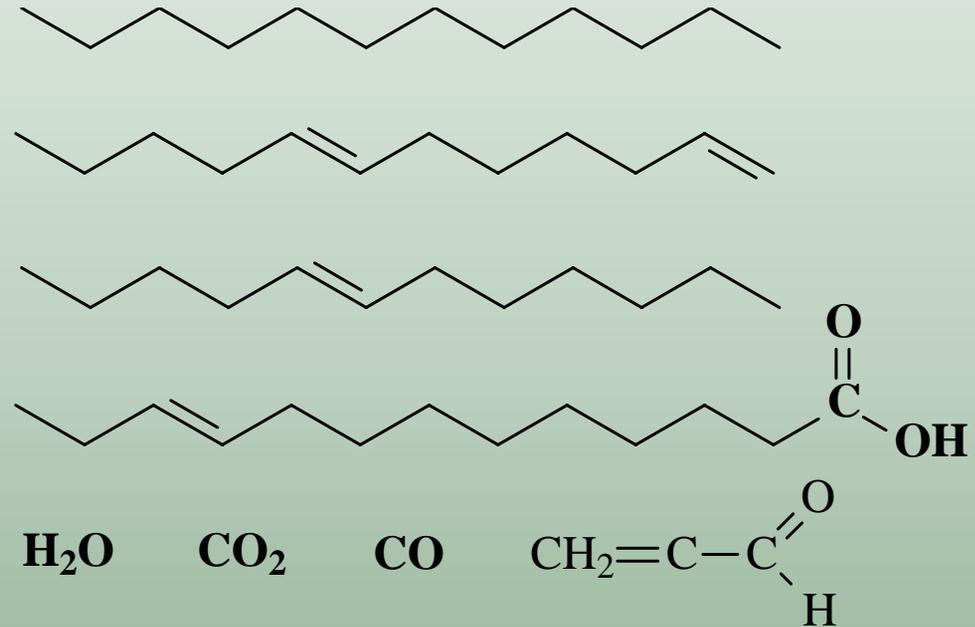
High Temperature /
Catalyst
(ii) \searrow



Triglycerides Cracking:



High temperature /
Catalyst





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The authors. It is suggested to avoid the use of mixed beds. The use of a bed of conventional type having red lead and the like will be more economical than the one possible. The greatest care should be taken to exclude foreign matter, such as iron, brass, copper, etc.

The piping system should be arranged so that material may withdraw from the storage tank without being in contact with the tank. This has the use of the conventional storage tank with overflow back to storage. Storage space for materialized by design should be of limited capacity and have adequate drain and flushing facilities to take care of any accidental spillage.

ACKNOWLEDGMENT

The authors wish to express thanks to the Raffia Storage Chemical Company, Inc., for permission to print this paper and to H. G. MacPherson, research director, for his helpful advice through the course of this work.

LITERATURE CITED

1. *Industries*, England, p. 40 (Jan. 26, 1944).
2. *Industries*, Cleveland, p. 40 (Jan. 26, 1944).
3. *World*, E. T. to Dept. of Mines, U. S. *Foreign Relations* (April 3, 1944).
4. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
5. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
6. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).

7. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
8. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
9. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
10. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
11. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
12. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
13. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
14. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
15. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
16. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
17. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
18. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
19. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
20. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
21. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
22. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
23. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
24. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
25. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
26. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
27. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
28. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
29. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
30. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
31. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
32. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
33. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
34. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
35. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
36. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
37. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
38. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
39. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
40. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
41. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
42. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
43. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
44. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
45. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
46. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
47. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
48. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
49. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
50. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
51. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
52. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
53. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
54. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
55. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
56. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
57. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
58. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
59. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
60. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
61. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
62. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
63. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
64. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
65. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
66. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
67. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
68. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
69. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
70. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
71. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
72. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
73. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
74. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
75. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
76. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
77. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
78. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
79. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
80. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
81. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
82. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
83. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
84. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
85. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
86. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
87. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
88. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
89. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
90. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
91. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
92. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
93. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
94. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
95. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
96. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
97. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
98. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
99. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).
100. *Williams*, F., et al., *Ind. Eng. Chem.*, **38**, 140-9 (1946).

China's Motor Fuels from Tung Oil

CHIA-CHU CHANG AND SHEN-WU WAN, China Vegetable Oil Corporation, Shanghai, China

Cracking the soap of vegetable oils thermally or catalytically decomposes the fatty acids into hydrocarbons. Subsequent cracking of these hydrocarbons is necessary to produce petroleum cracking. During the war industrial hydrocarbons processes were developed in China to produce motor fuels from vegetable oils. Tung oil, which could not be supported during the blockade, served as the main component. The average commercial yield of crude oil was 10% by volume of the original using all the gasoline content in crude oil being 45% by volume.

It will be seen that the work in China has inspired in other parts to increase plant capacity and to use vegetable oils in the newly stated term "vegetable" and "vegetable" oil. However, the manufacturing of fuel or energy from vegetable oils is not a simple matter. The situation is complex and the work is hard. It was a hardy developed strategy which has much to be desired. The present paper deals mainly with the technical aspects and the use of tung oil in this industry is particularly important.

EXPERIMENTAL DATA

Prior to its investigation in China, the cracking of vegetable oils had been reported by Williams (1), Williams (2), Williams and People (3), Page (4), and Williams (5).

Chinese scientists began to take up the work on a large scale shortly before going into war, and naturally pursued it with great interest. Normal steps for the systematic development of a novel industrial process ordinarily extend over many months or even years, but such a period was too long to be pursued under the emergency conditions of war. Actually, the process of the first large-scale production of cracking plants was on the basis of laboratory data of a rather fragmentary nature. Among the laboratories undertaking this investigation may be mentioned the Research Laboratory of Applied Chemistry at Yantai University, the 6th Yantai Fuel Laboratory of the National Geological Survey of China, the Laboratory of the National Bureau of Industrial Research (N.B.I.R.), the Laboratory of the Tung Oil Oil Works, and the Research Laboratory of the China Vegetable Oil Corporation. The results are summarized in the following papers, a digest has been made available to the public (6).

Experimental methods adopted for the preparation of crude oil can be roughly classified as (1) destructive distillation of a vegetable oil and (2) subsequent cracking of the product. On hydrocarbons (the kind of a vegetable oil with no sulfur and no nitrogen) and (3) pyrolysis of the soap of vegetable oils. Table I gives the distillation range according to A.S.T.M. The distillation range of the crude oil used here is the following: 10% by volume of the original using all the gasoline content in crude oil being 45% by volume.

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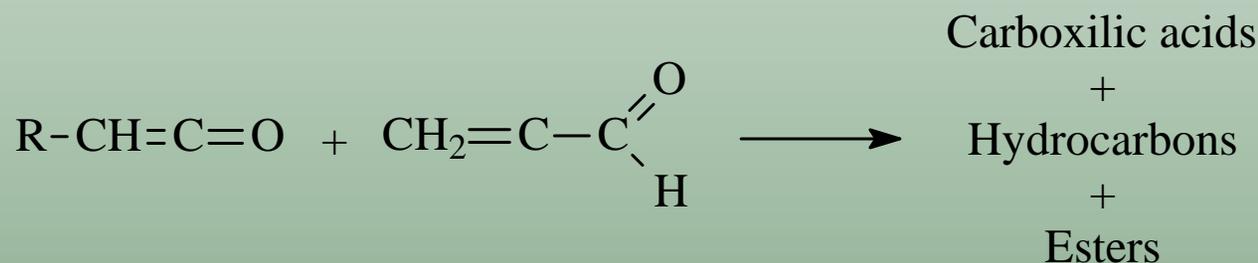
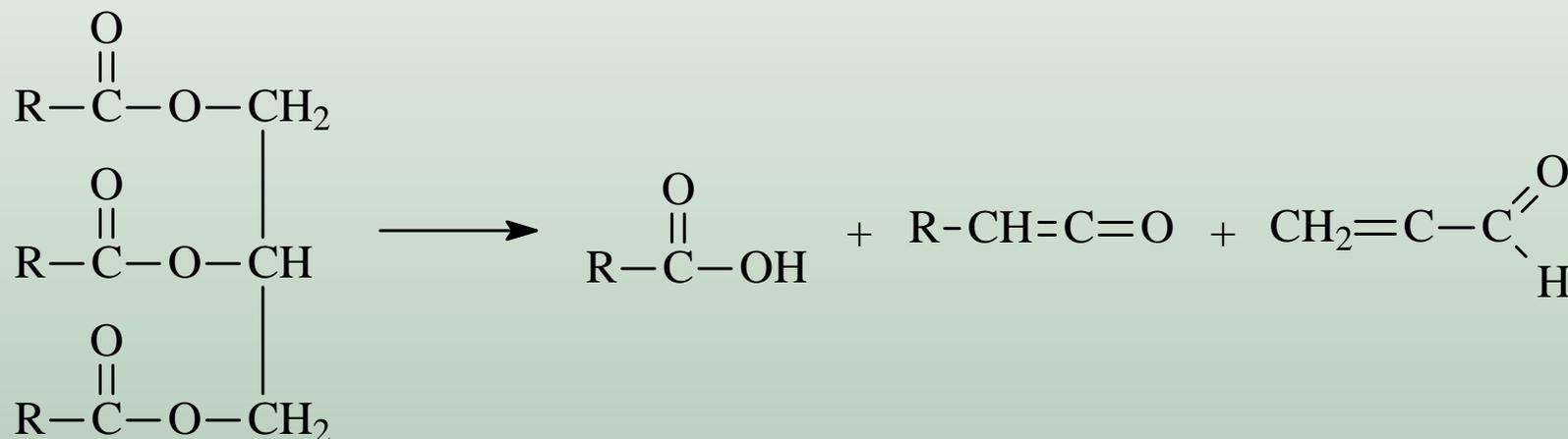
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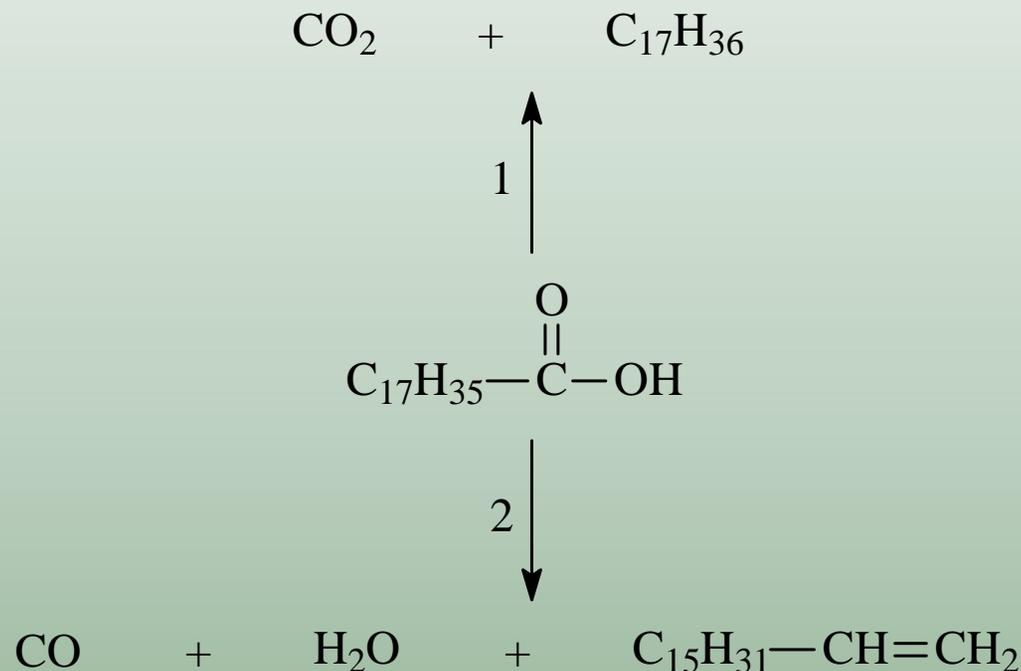
Triglycerides Cracking:



Gusmão, J.; Brodzki, D., Djéga-Mariadassou, G.; Frety, R.;
Catalysis Today 1989, 5, 533.



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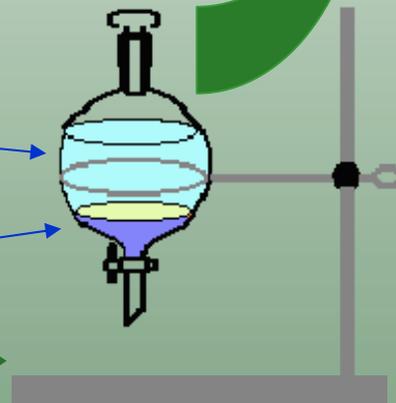


Triglycerides Thermo-Cracking:



Condensed organic phase
(80 %)

Water (10 %)



Triglycerides Thermo-Cracking:

Vegetable Oil	Pyrolysis temperature range (°C)	Distillation temperature fraction (°C) yield (wt %)			
		< 80	80 - 140	140 – 200	> 200
Soybean	350 to 400	10	15	15	60
Palm (<i>Elaeis sp.</i>)	330 to 380	7	9	9	75
Castor	350 to 400	10	10	20	60

Soares, V. C. D.; Lima, D. G. De; Ribeiro, E. B; Carvalho, D. A.; Cardoso, É. C. V.; Rassi, F. C.; Mundim, K. C.; Rubim, J. C.; Suarez, P. A. Z.

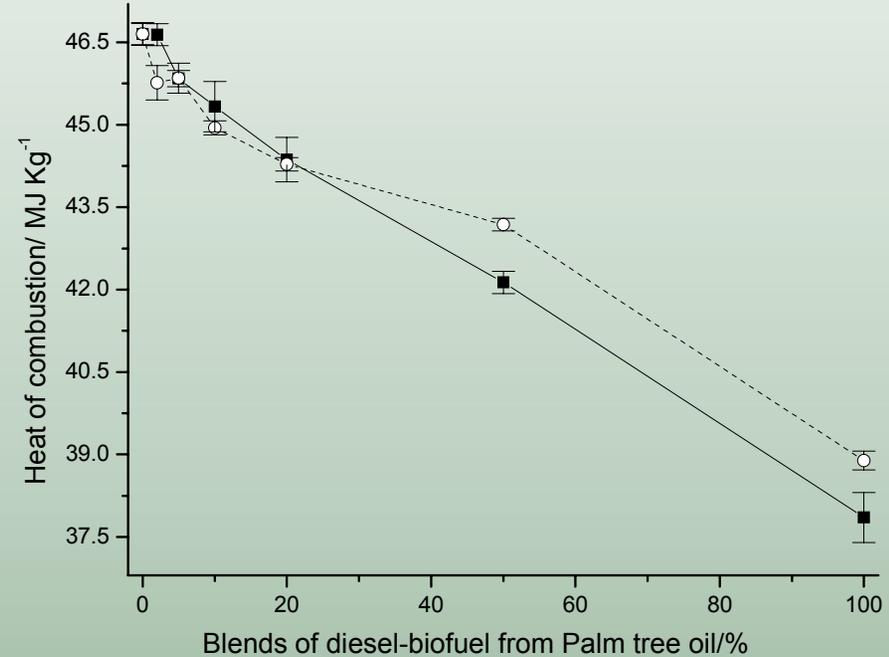
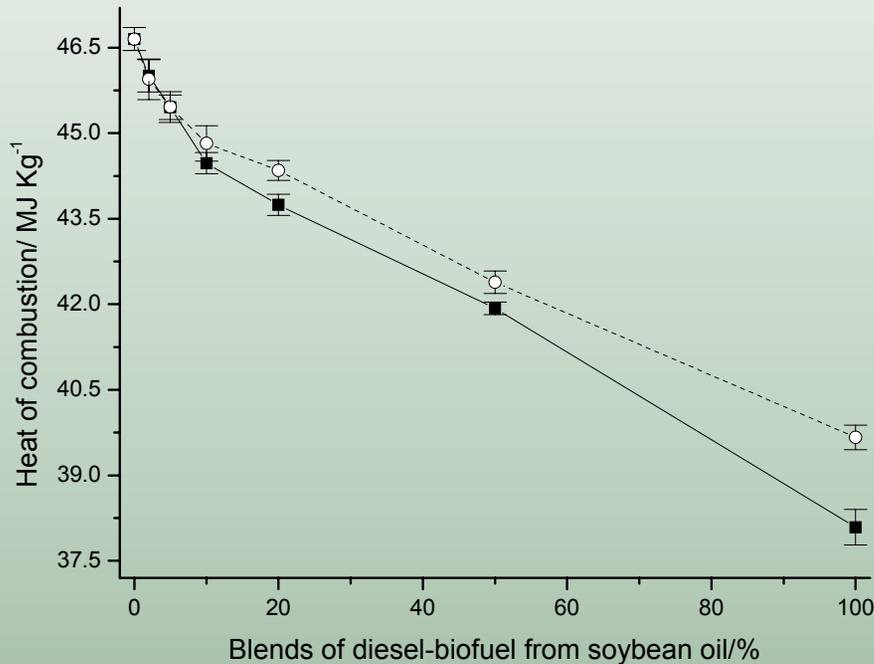
Journal Of Analytical And Applied Pyrolysis, v. 71, n. 2, p. 987-996, 2004.

Triglycerides Thermo-Cracking:

Physical-chemical property	Raw-material					Brazilian Diesel	Method	
	Soy-bean	Soap-stock	Palm-tree	Castor	Tallow-beef	Fuel Specification	ASTM	
Density at 20 °C, Kg/m ³	844.0	844	818.4	882.3	822	820 a 880	D1298 D4052	
Viscosity at 40 °C, cSt(mm ² /s)	3.5	3.02	2.7	3.7	4.83	2.5 a 5.5	D445	
Cetane number	50.1	50.4	52.7	30.9	45.3	45	D613	
Acid number (mg KOH/g)	116.2	4.54	133.0	207.5	87.07	-	D465-9	
Cooper corrosion, 3h a 50 °C	1a	1a	1a	1a	1a	1a	D130	
Distillation (°C)	initial	90.6	230.0	63.5	97.5	210.0	Take note	D86
	50 %	265.9	275.0	245.2	254.3	273.0	245.0 a 310.0	
	85 %	307.5	305.0	254.3	273.2	310.0	370.0(max)	
	final	344.9	nd	274.2	297.0	nd	Take note	

SUAREZ, P. A. Z. et al.; *J. Anal. Appl. Pyrolysis*, v. 71, n. 2, p. 987-996, 2004.
 SUAREZ, P. A. Z. et al.; submitted for publication, 2006.

Triglycerides Thermo-Cracking:



The heat of combustion of biofuel/diesel blends obtained by transesterification (■) and by pyrolysis (○) of soybean oil.

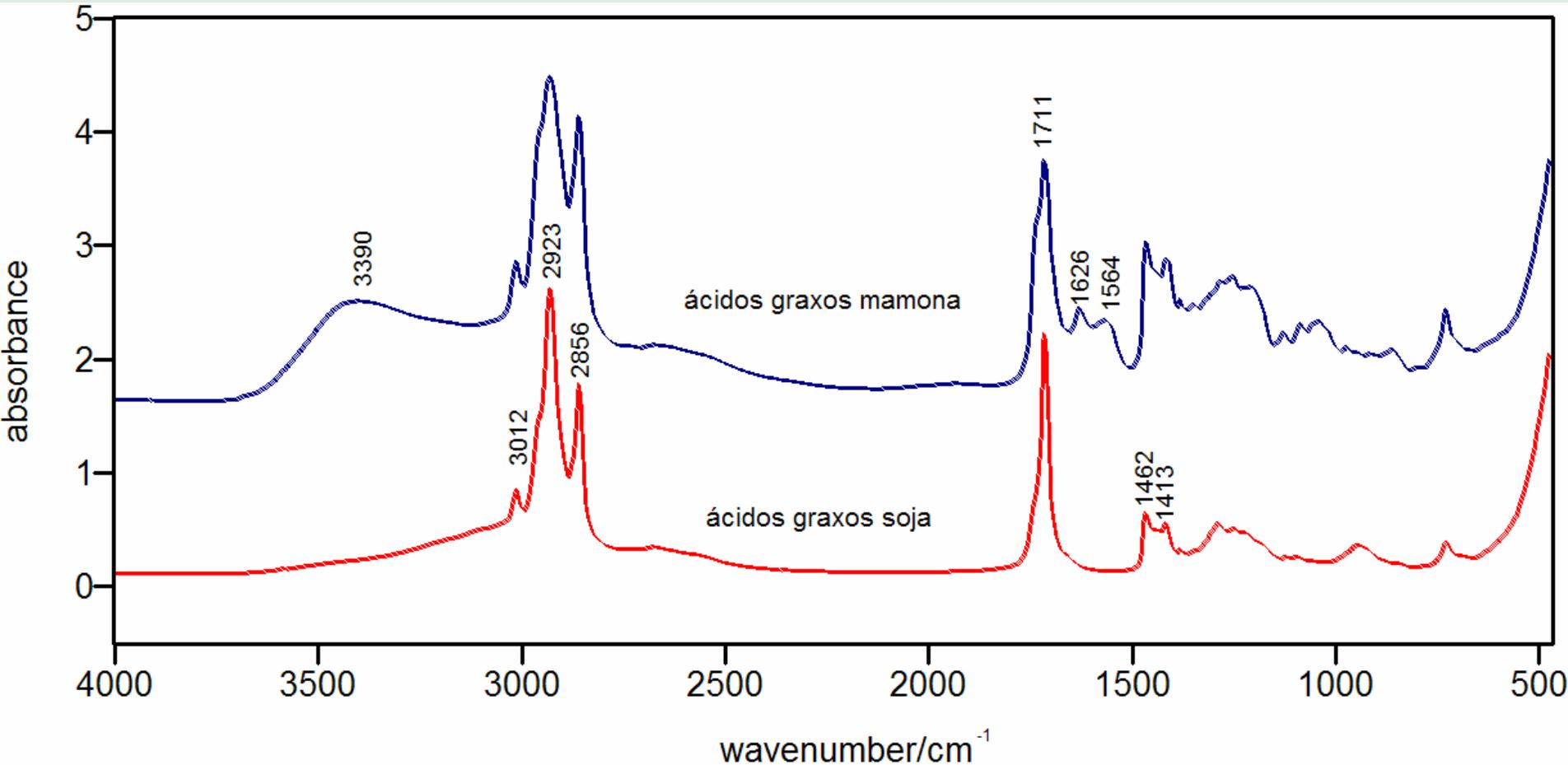
E. DeOliveira, R.L. Quirino, P.A.Z. Suarez, A.G.S. Prado, *Thermochemica Acta* (2006), accepted for publication.

Triglycerides Catalytic-Cracking:

Decarbonylation/decarboxylation of carboxylic acids:

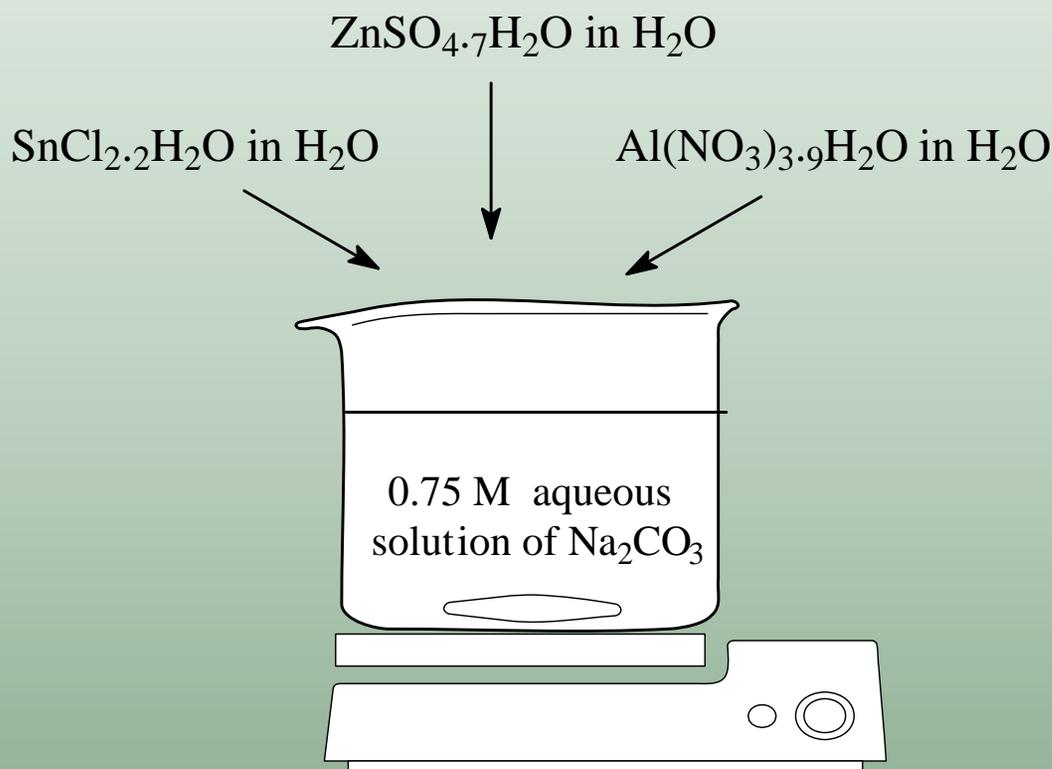
- The use of Zeolites affords gasoline-range hydrocarbons and high content in aromatic compounds.
 - Dandik, L.; Aksoy, H. A.; Erdem-Senatalar, A.; *Energy & Fuels* **1998**, 12, 1148-1152.
 - Santos, F. R.; Ferreira, J. C. N.; da Costa, S. R. R.; *Química Nova* **1998**, 21, 560.
- The use of basic solids (magnesium or calcium hydroxides) inhibits the decomposition of oxygenated compounds.
 - R. O. Idem, S. P. R. Katikaneni, N. N. Bakhshi, *Fuel Proc. Tech.* **1997**, 51, 101.

Triglycerides Catalytic-Cracking:



Triglycerides Catalytic-Cracking:

Preparation of Catalysts $(\text{Al}_2\text{O}_3)_x(\text{SnO})_y(\text{ZnO})_z$



•The mixture was left under stirring at room temperature for 30 min and then kept in a refrigerator overnight;

•The resulting coprecipitate was isolated by filtration and washed several times with distilled water;

•The washed coprecipitate was dried then activated thermally;

BET surface area:

Catalyst	BET Area (m ² /g)
(Al ₂ O ₃) ₈₀ (SnO) ₂₀ (ZnO) ₀	12.54
(Al ₂ O ₃) ₈₀ (SnO) ₁₀ (ZnO) ₁₀	42.62
(Al ₂ O ₃) ₈₀ (SnO) ₀ (ZnO) ₂₀	82.42

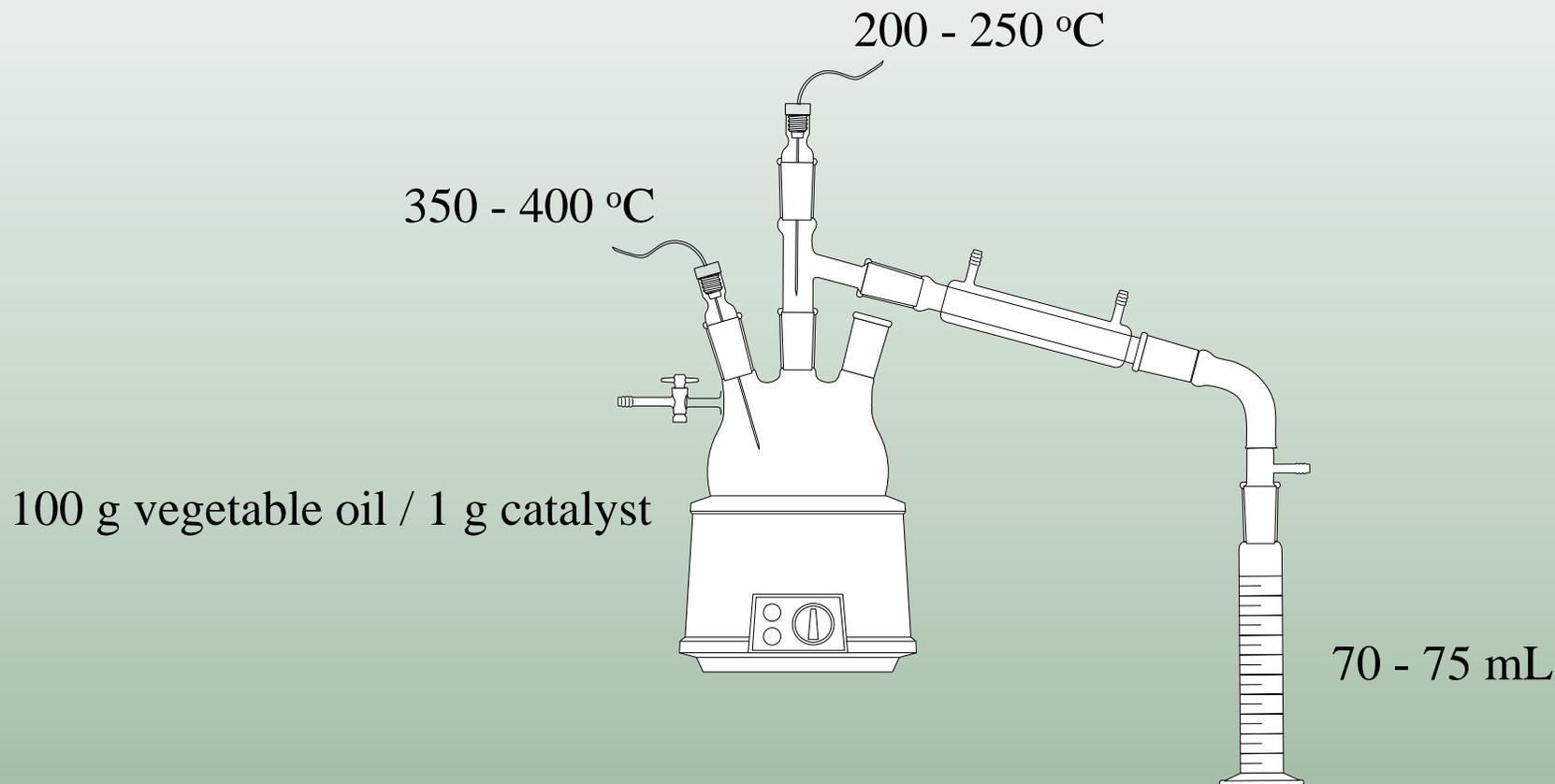
Optical Emission Spectrometry (ICP- EOS):

Catalyst	Al	Sn	Zn
(Al ₂ O ₃) ₈₀ (SnO) ₂₀ (ZnO) ₀	81.3	18.7	0.0
(Al ₂ O ₃) ₈₀ (SnO) ₁₀ (ZnO) ₁₀	82.0	10.0	8.0
(Al ₂ O ₃) ₈₀ (SnO) ₀ (ZnO) ₂₀	80.0	0.0	2.0

SUAREZ, P. A. Z. et al.; *J. Braz. Chem. Soc.*, accepted for publication, 2006.



Catalytic Experiments:



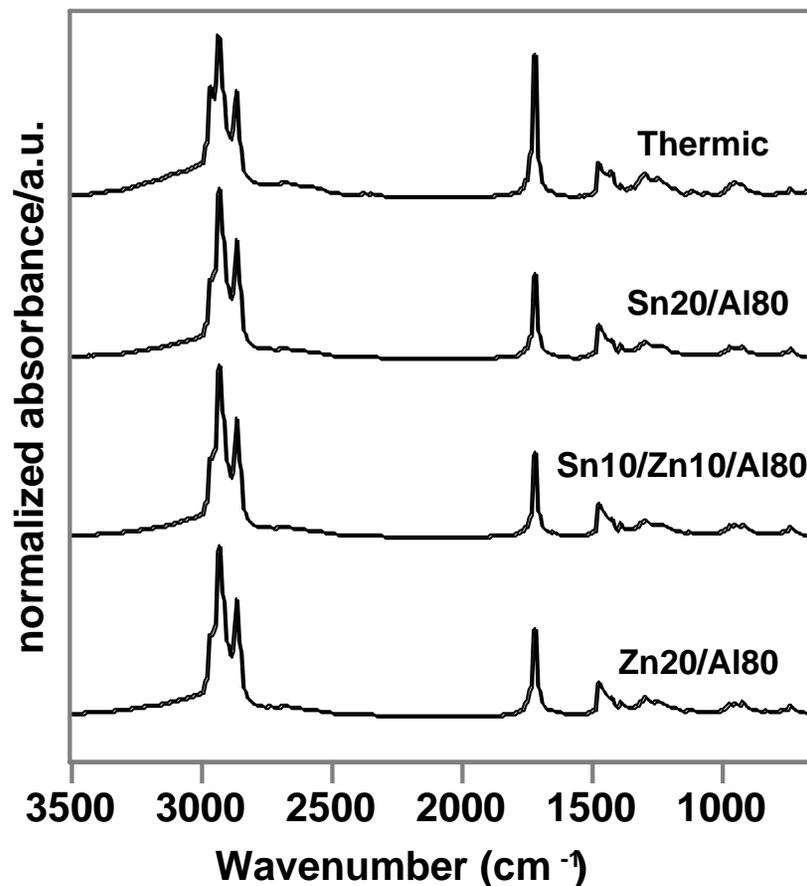
- Separation of aqueous and organic phases by decantation
- Distillation of the organic phase



Results: Soybean oil

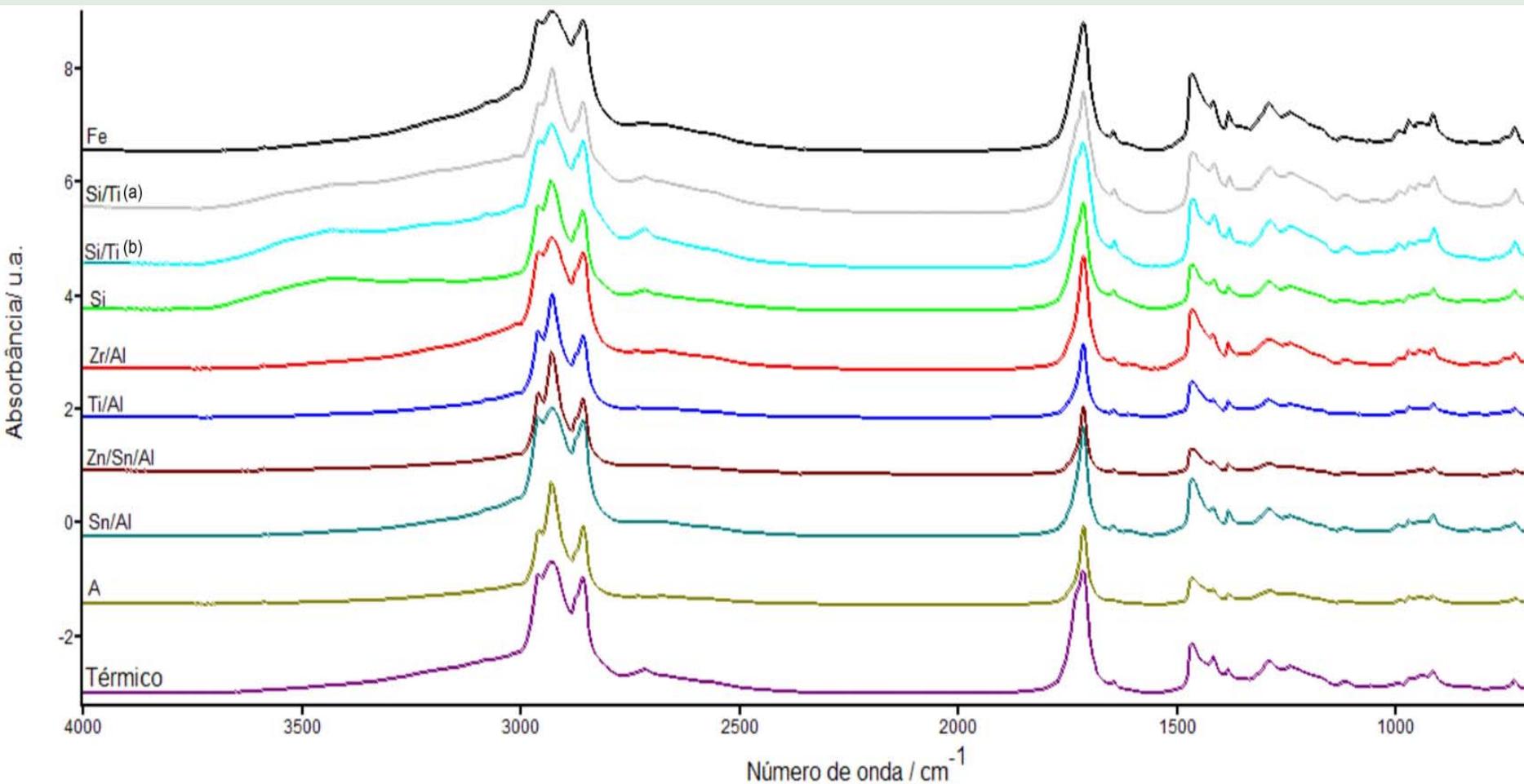
Catalyst	Recovered organic phase (g)	Distillation temperature fraction (°C) yield (wt %)			
		< 80°C	80-140°C	140-200°C	> 200°C
Sn10/Zn10/Al80	62,0	10	10	19	61
Zn20/Al80	66,5	22	7	12	59
Sn20/Al80	65,0	17	6	20	57

Results: Soybean oil



Catalyst	AI (mg KOH/g)	Integration of C=O (1710 cm ⁻¹)
-	116	73.6
Sn20/Al80	100	43.2
Sn10/Zn10/Al80	82	42.3
Zn20/Al80	87	47.3

Results: Castor oil



Results: Castor oil

Catalyst	Viscosity (mm ² /s)	T10 (°C)	T50 (°C)	T90 (°C)	D ₁₅ °C (kg/L)	D ₂₀ °C (kg/L)	Cetane index	AI (mg KOH/g)
Any (thermic)	1,9	105.2	220.7	340.0	0.849	0.845	35.4	139.1
Si	2,17	129.0	241.3	346.9	0.865	0.864	35.3	125.7
Ti/Si	2,14	120.3	233.8	341.4	0.872	0.867	34.0	116.6
Al	3.21	132.1	280.8	345.0	0.875	0.871	36.3	114.1
Al/Zr	2.35	115.9	249.1	345.2	0.856	0.853	39.2	90.4
Al/Ti	1.87	117.1	250.6	334.2	0.852	0.848	40.4	79.4
Al/Sn	1.99	120.4	244.4	340.6	0.849	0.846	41.4	77.5
Al/Zn/Sn	1.64	115.2	235.6	336.4	0.846	0.842	40.0	77.2



Remarks:

- **No significant differences were observed in the recovered distillation temperature fractions;**
- **All the catalytic systems formed by doped alumina are active for the decarbonylation/decarboxylation of carboxylic acids during soybean and castor oils pyrolysis and also for dehydroxylation of castor oil products, reducing the AI up to 50 %.**



Process UnB/Embrapa:



UnB/Embrapa Patent: PI BR 0204019-0, 2002.

Process UnB/Embrapa:

Mass and energy Balance:

Raw-material:

- “Nabo Forrageiro” – 814 Kg of grains

Energy used:

- Electric – oil extraction and filtration
- Petroleum Gas – cracking

Temperature:

- 390 °C

Process UnB/Embrapa:

Mass Balance:

Vegetable oil processed:	212 kg	100 %
Liquid Hydrocarbons produced:	166 kg	78 %
Gas produced (including hydrocarbons):	34 kg	16 %
Water produced:	11 kg	5 %

Energy Balance:

Total energy consumption (A):	37,49 kW (35,31 kW gas)
Heat of combustion of the products (B):	100,57 kW
Heat of combustion of the diesel-like (C):	71,23 kW

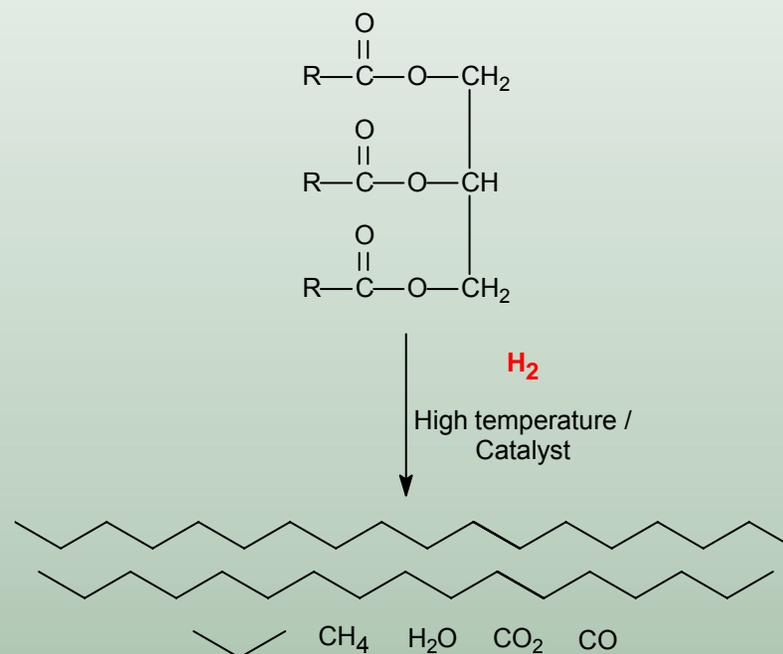
$$B/A = 2,68; C/A = 1,9$$



Process UnB/Embrapa:

- 1 – The diesel-like fuels obtained from wild turnip and soy-bean match the ANP specifications for diesel fuel (ANP 310 – 2001);
- 2- The acidity value is between 50 and 60 mg KOH/g (less than when carried out in lab-scale reactors – residential time)
- 3 – The energy balance is positive (ca.3:1).
- 4 – The light fractions have energy equivalent to the energy consumption.

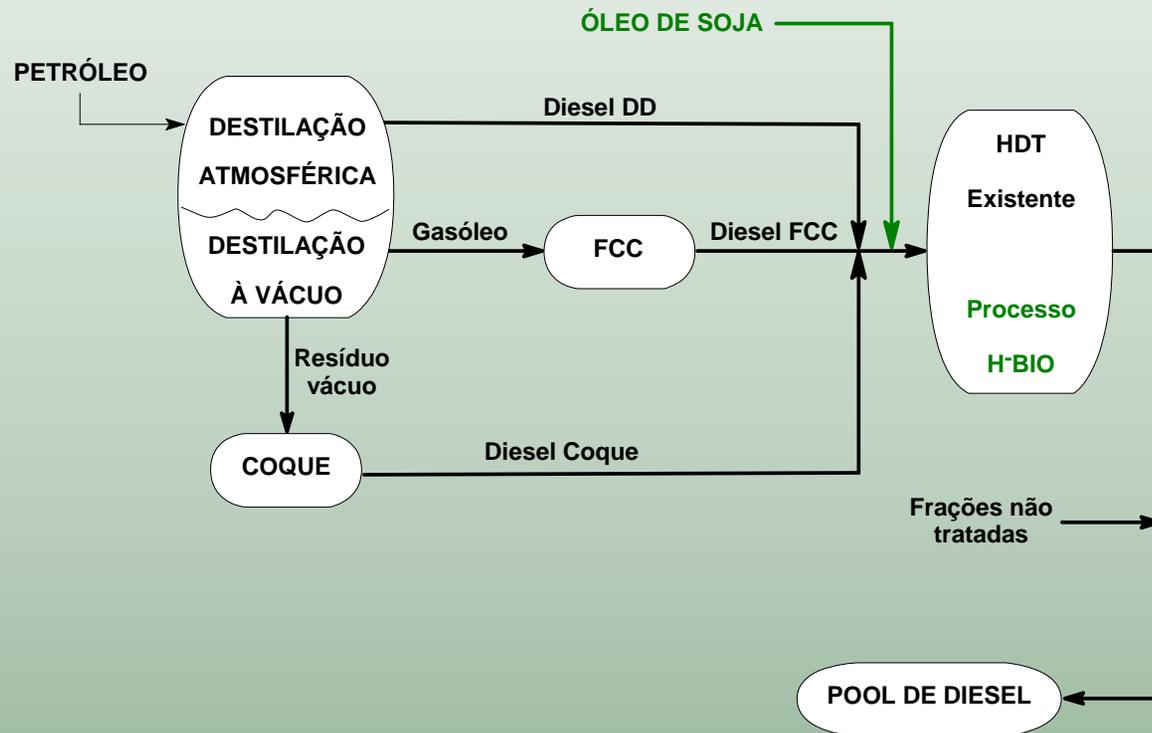
Triglycerides Hydro-Cracking:



➤ Completely conversion into hydrocarbons using Ni,Mo / $\gamma\text{-Al}_2\text{O}_3$ in the presence of H_2 .

-Gusmão, J.; Brodzki, D., Djéga-Mariadassou, G.; Frety, R.;
Catalysis Today **1989**, 5, 533.

PETROBRAS process (H-BIO):



- Mixtures using up to 18 % of soybean oil;

CENPES Patent: PI 0500591, 2005.



Final Remarks:

- It is possible to produce a “diesel-like” fuel from triglycerides;
- The physical-chemical properties match the petrol-diesel specification;
- Further studies are needed to understand the impact of oxygenated compounds in the engines.



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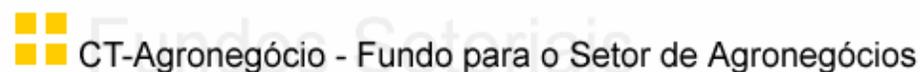
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Acknowledgments:





Thank you very much!

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