Bioenergy - II: Fuels and Chemicals from Renewable Resources

UNIVERSIDADE FEDERAL DE PERNAMBUCO
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PRODUCTION OF ETHYLIC BIODIESEL FROM HYDROLYSIS AND ESTERIFICATION OF ACID ANIMAL FAT

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INTRODUCTION AND MOTIVATION

Feedstocks for biodiesel in Brasil

Low Acidity

- **Soybean oil**
- **Tallow**
- **Palm oil**
- **Cottonseed oil**
- **Castor oil**
- **Sunflower**
- **Jatropha**

INTRODUCTION AND MOTIVATION

Feedstocks for biodiesel in Brasil

Low Acidity	High Acidity
❖Soybean oil	Residues from edible oil
❖Tallow	High acid Tallow
❖Palm oil	Residue from palm oil
❖Cottonseed oil	Waste Frying oil
❖Castor oil	High acid Jatropha oil
❖Sunflower	High acid Oiticica oil
❖Jatropha	

INTRODUCTION AND MOTIVATION
Biodiesel Production

Conventional Transesterification

- ❖ Acidity < 1%
- ❖Dryied feedstock
- ❖Alkaline Catalyst

Biodiesel from High acid Feedstock

- ❖Produce Soaps
- ❖Decrease Yields
- ❖Difficult separation
- ❖More waste effluent

INTRODUCTION AND MOTIVATION
Biodiesel Production
Solution

High acid Feedstock →

Esterification

Convert Free Fatty Acids into Esters with acid catalyst

↓

Oil with acidity < 1% ←

Transesterification

Convert remaining Tryglycerides with alcaline catalyst

↑

Biodiesel

INTRODUCTION AND MOTIVATION
Biodiesel Production
Alternative Way

High acid Feedstock → **Hydrolysis**

Convert Tryglycerides into Free Fatty Acids (Thermal or Enzymatic)

↓

Free Fatty Acids

← **Convert Free Fatty Acids into Esters with acid catalyst**

↑ **Esterification**

Biodiesel

OBJECTIVE

Produce biodiesel from hydrolysis of high acid beef tallow followed by esterification reaction with ethanol and acid catalyst

Residue Beef Tallow

Ethanol

Hydrolysis

Esterification

Table 1 – Fatty acid composition of beef tallow
[a] Carbons in the chain:double bonds. [b] Zheng and Hanna (1996).

Beff Tallow

Fatty acid composition of beef tallow

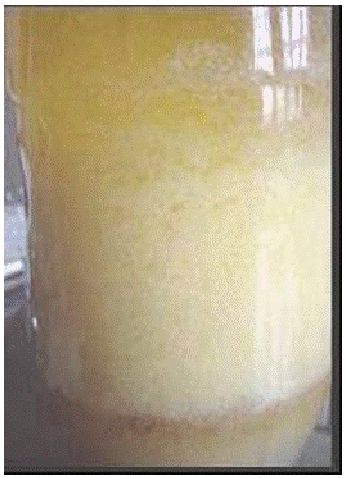
Acidity: 10% of Free Fatty Acids

Fatty acid	Systemic name	Formula	Structure[a]	wt% this work	wt% Zheng[b]
Miristic		C14H28O2	14:0	5.1	4.8
Palmitic	Hexadecanoic	C16H32O2	16:0	28.7	28.4
Palmitoleic		C16H30O2	16:1	3.2	4.7
Stearic	Octadecanoic	C18H36O2	18:0	14.4	14.8
Oleic	cis-9-Octadecenoic	C18H34O2	18:1	48.6	44.6
Linoleic	cis-9,cis-12-Octadecadienoic	C18H32O2	18:2	--	2.7

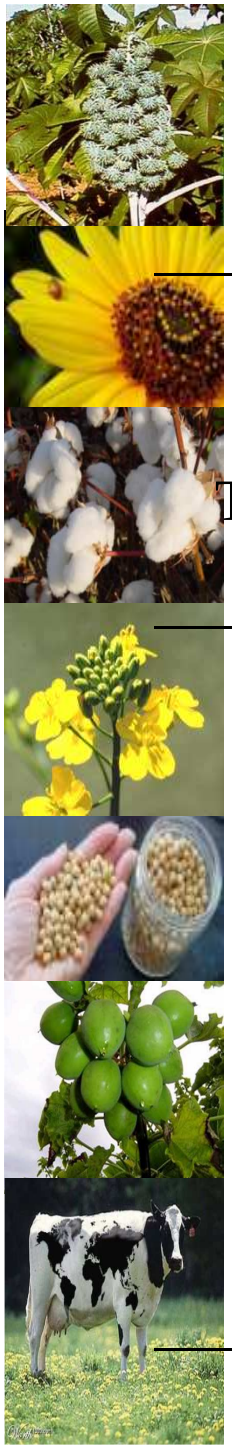
ENZYMATIC HYDROLYSIS OF TRYACYLGLYCEROLS

Castor seed

Tallow



40℃
30% WATER
20% Seed



HYDROLYSIS

Time (h)	Experiment 1 Acidity (%)	Experiment 1 Conv. (%)	Experiment 2 Acidity (%)	Experiment 2 Conv. (%)	Experiment 3 Acidity (%)	Experiment 3 Conv. (%)
0	6,50	0	6,70	0	6,60	0
0,5	26,36	75,34	24,19	72,30	24,17	72,69
1	37,64	82,73	42,43	84,21	32,10	79,44
1,5	33,69	80,71	49,76	86,54	40,91	83,87
2	38,45	83,09	52,86	87,33	41,88	84,24
3	-	-	53,19	87,41	-	-
4	-	-	56,53	88,15	-	-
24	-	-	73,89	90,93	-	-

ESTERIFICATION

1h

70℃ - 130℃

500 rpm

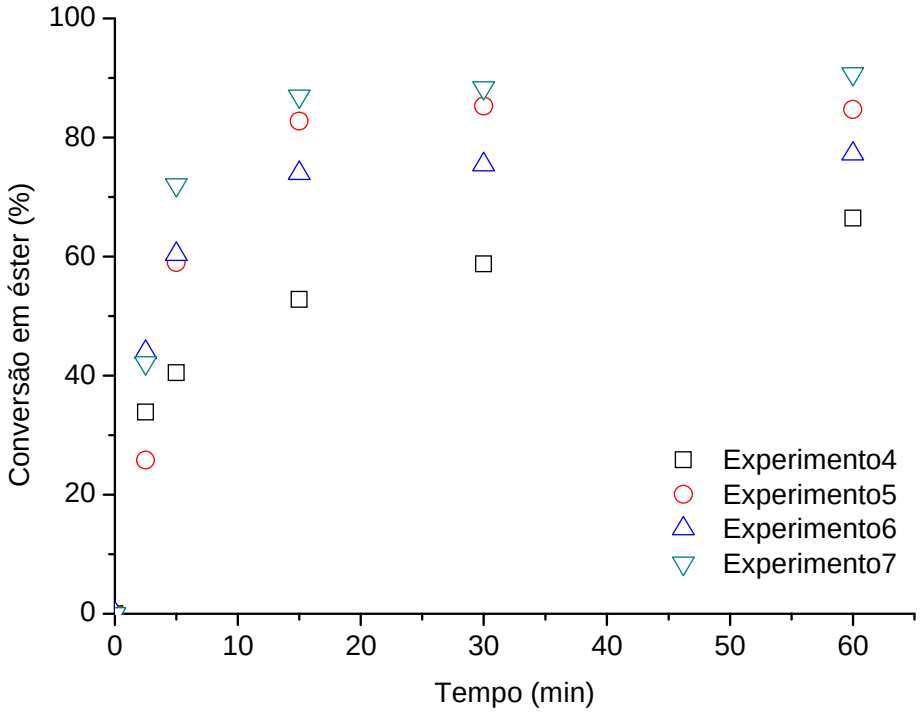
0.2% - 0.8% H2SO4

Alcohol/Oli 5:1 – 9:1

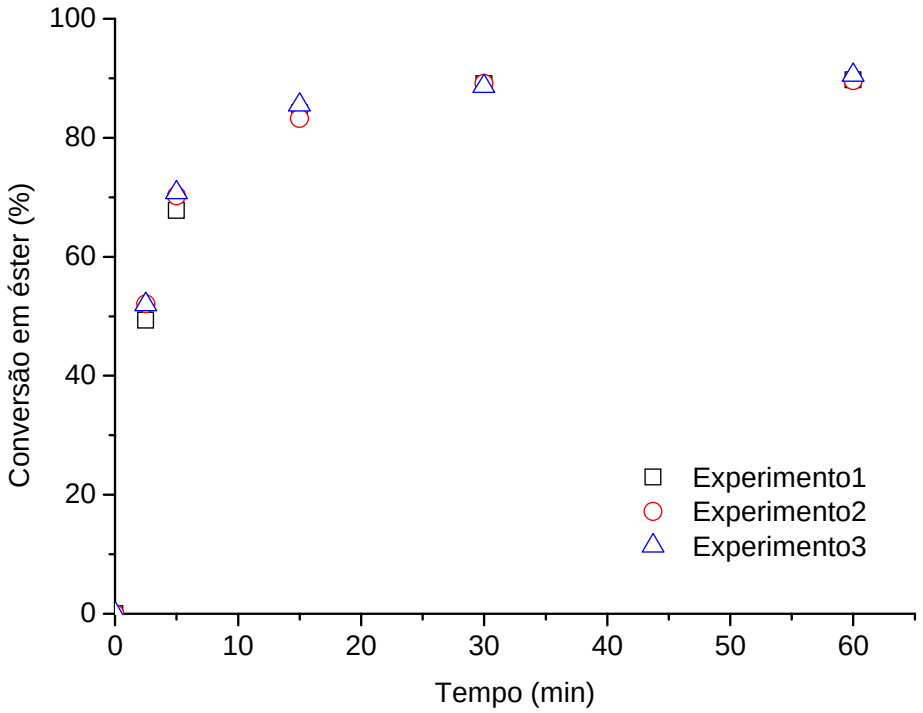
Pressure 80 psi

ESTERIFICATION

70℃

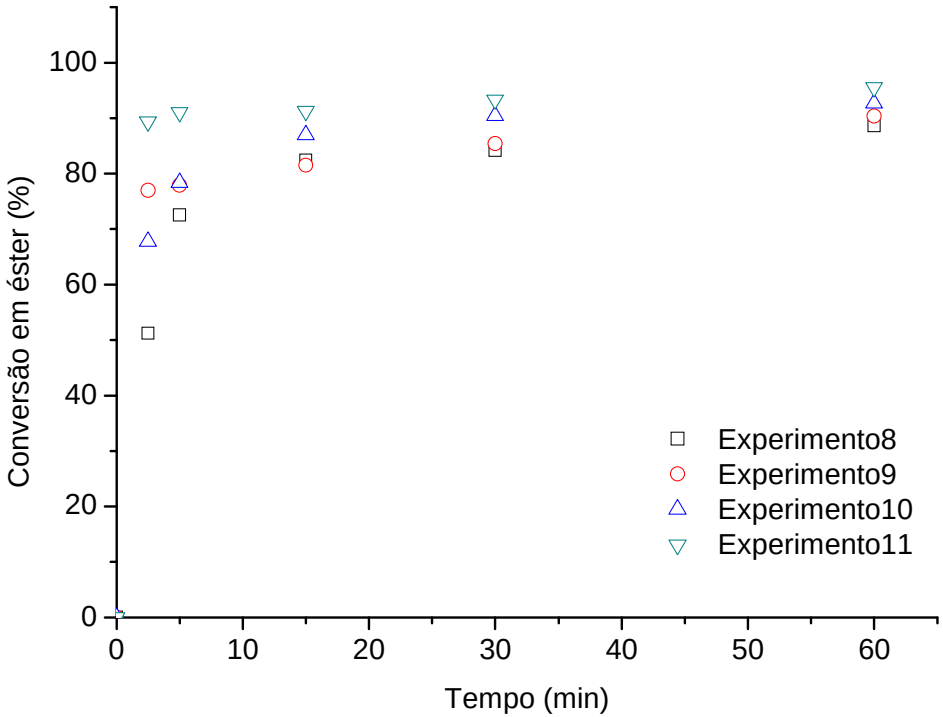


100℃



ESTERIFICATION

130℃



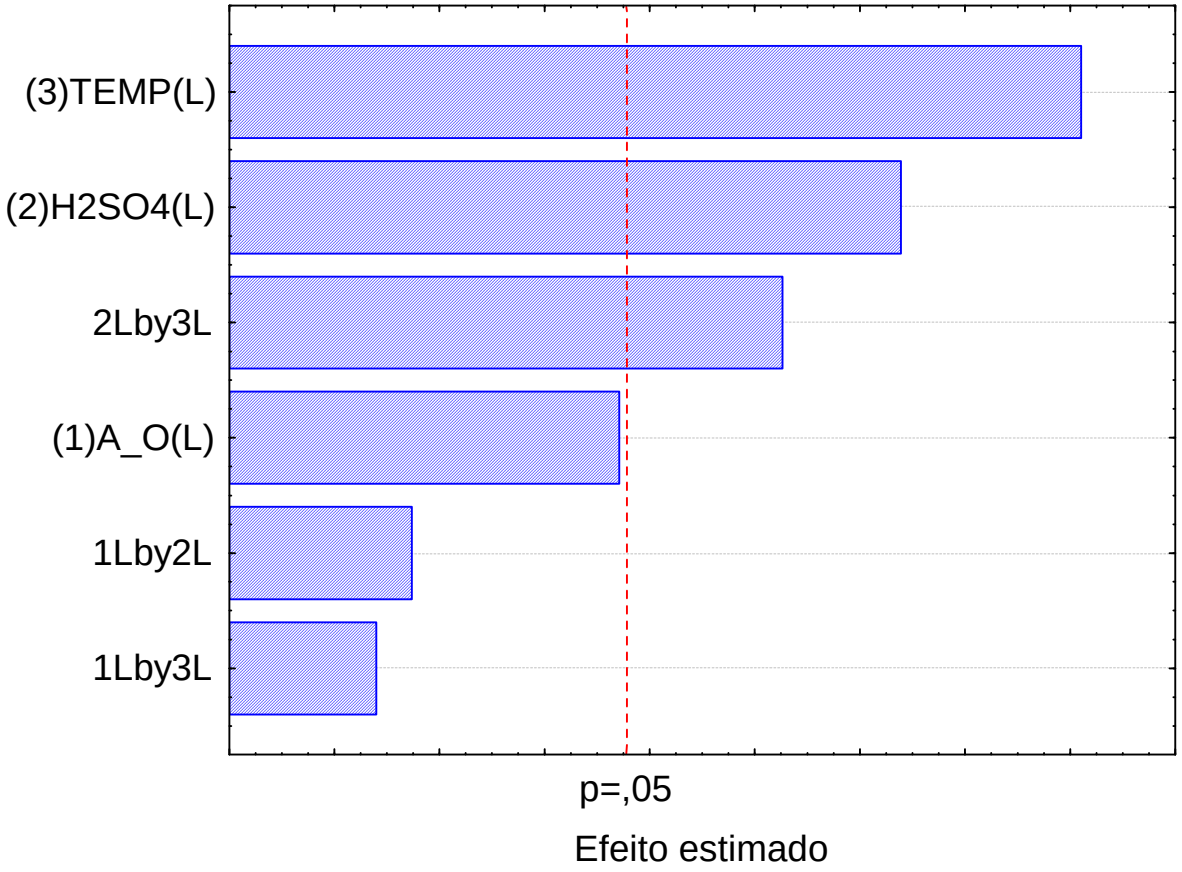
ESTERIFICATION

Effect of Variables on Conversion

Média	85,6
Efeitos 1 (álcool/óleo)	5,4
Efeitos 2 (Catalisador)	10,8
Efeitos 3 (Temperatura)	14,3
Efeito da Interação 12	-1,5
Efeito da Interação 13	-0,8
Efeito da Interação 23	-8,6

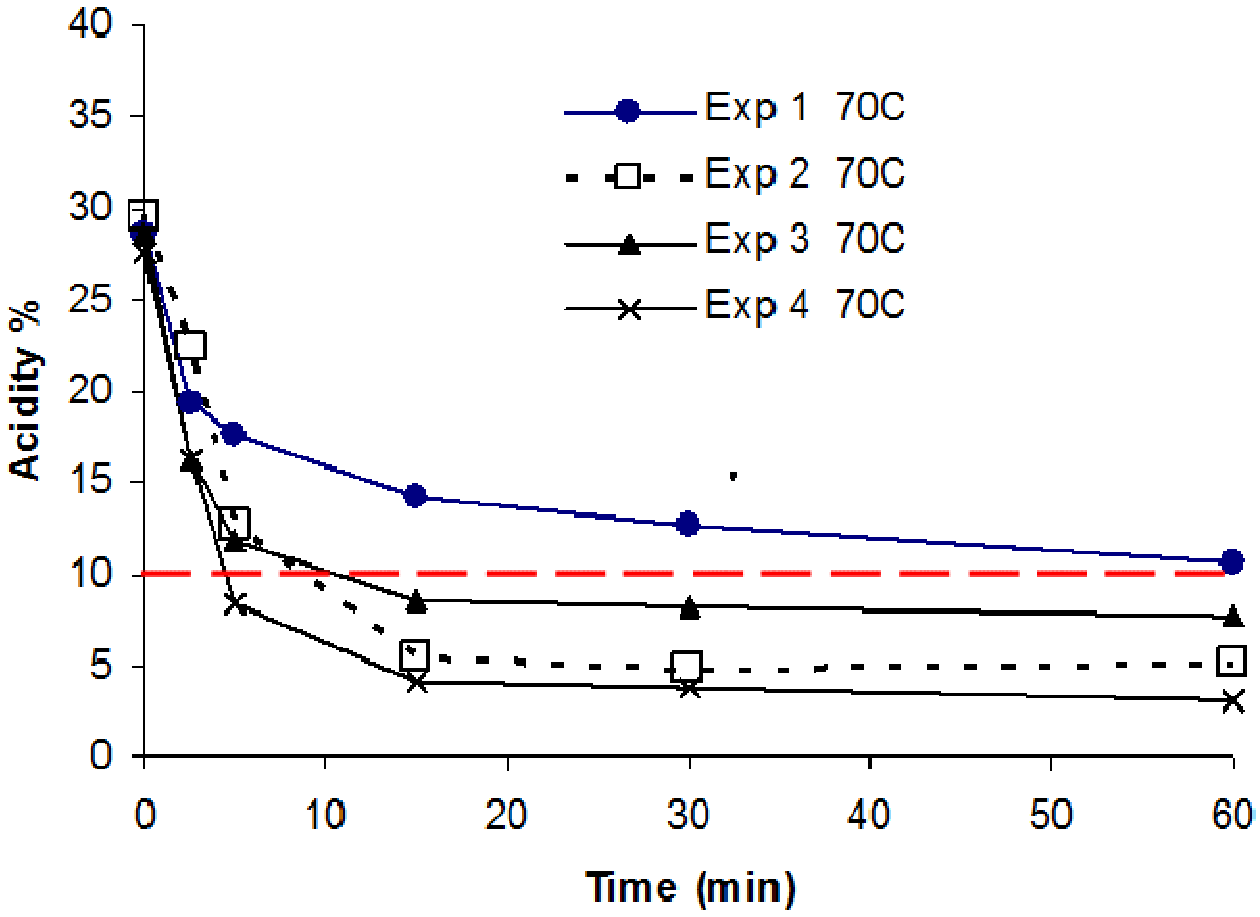
ESTERIFICATION

Effect of Variables on Conversion



ESTERIFICATION

FFA+Ethanol -> Ester+Water



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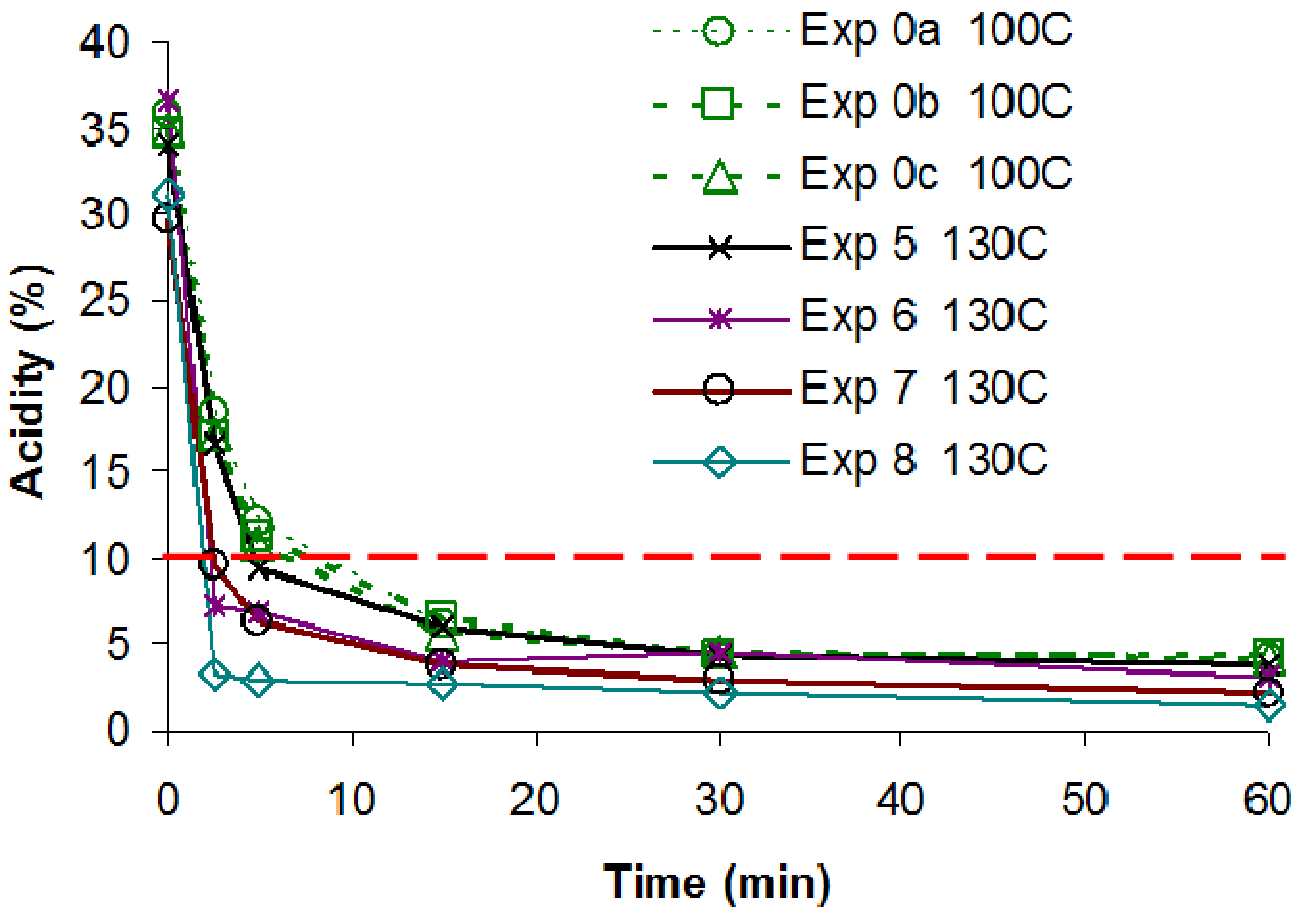

ESTERIFICATION
In 02 Stepes at 100 C

Separation and Purification

Biodiesel

Property	Result	*Specification (Biodiesel)
Massa específica a 20°C (kg/m^3)	878.3	850 to 900
Viscosidade cinemática a 40°C (cSt)	5.4	3.0 to 6.0
Índice de acidez (mg KOH/g)	0.36	0.50
Ester Yield	96.6%	> 96%

CONCLUSIONS

- **Biodiesel from acid feedstocks is a need in Brazil**
- **Ethylic Biodiesel is preferable**
- **Enzymatic Hydrolysis followed by Esterification is a promise alternative**
- **Other acid feedstock can be used: Oiticica, Jatropha, Used Frying Oil**