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Blends of Babassu, Palm Kernel and Coconut FAME with Fossil Kerosene.

Technical Aspects of Low Carbon Number Methyl Esters as a Possible Source for Renewable Jet Fuel.

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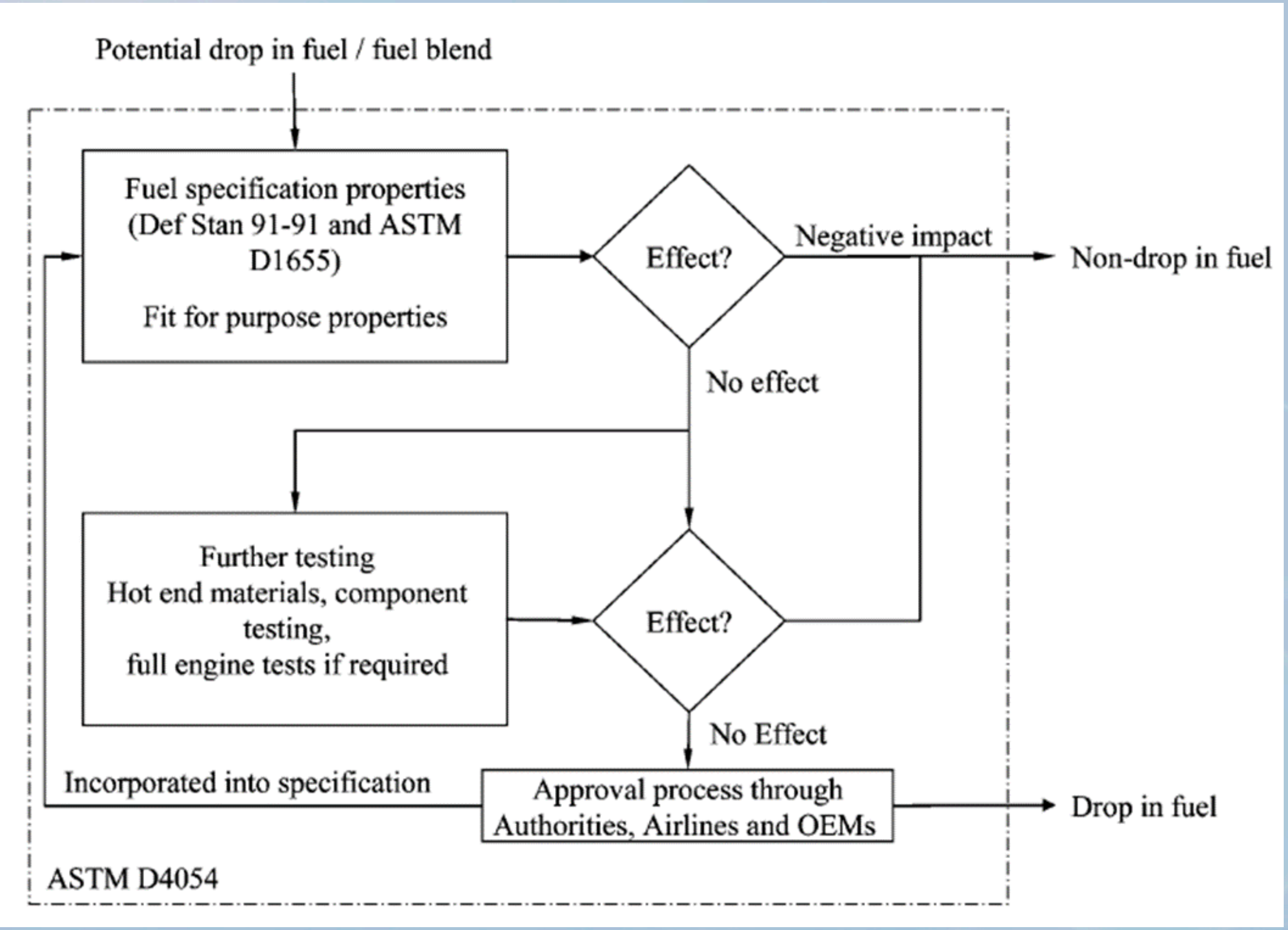
- Fuel Characterization.
- Fuel Compatibility Tests.
- Conclusions

STATE OF THE ART . STANDARDS

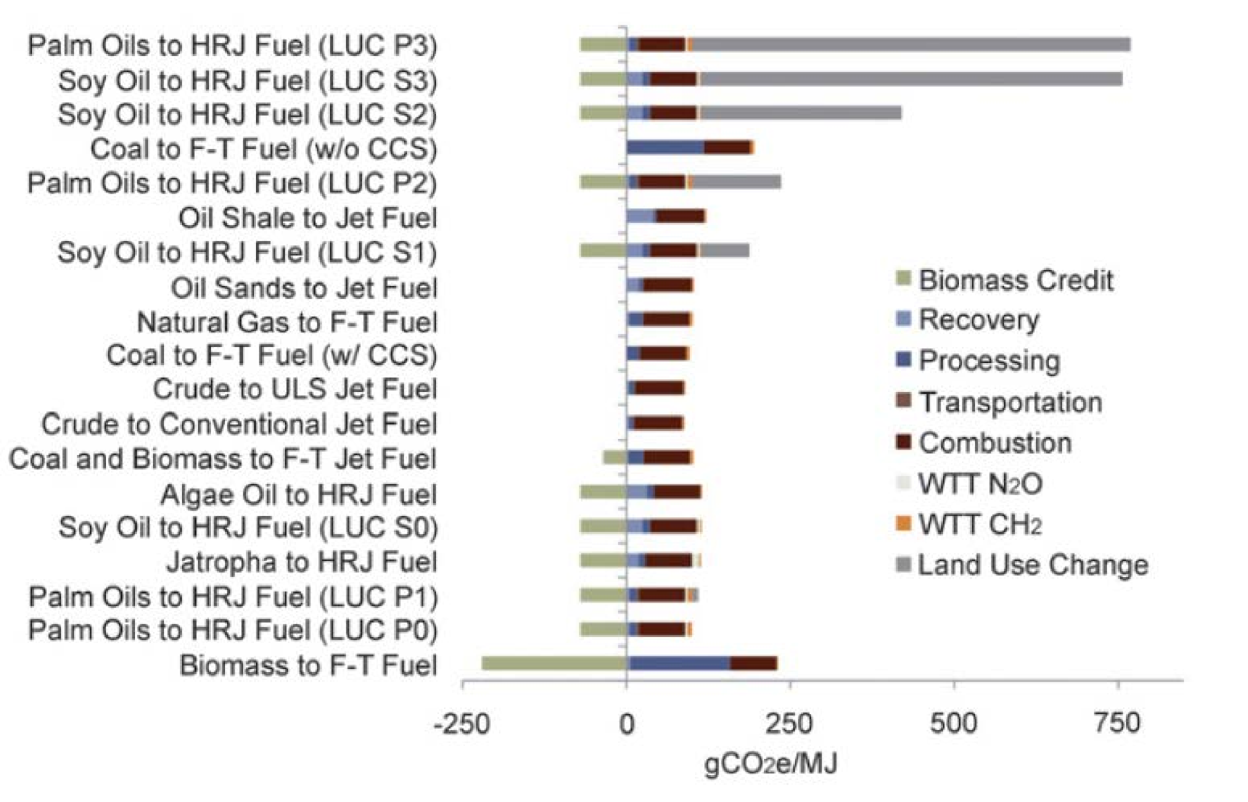
- ASTM D1655: Standard specification for aviation turbine fuels (2009).
- DEF STAN 91-91 Specification for air turbine fuel (Jet A1)
- ASTM D 4054: Standard Practice for Qualification and Approval of New Aviation Turbine Fuels and Fuel Additives (2009).
- ASTM D 7566: Standard specification for aviation turbine fuel containing synthesized hydrocarbons (2011).

STATE OF THE ART . STANDARDS



L. Rye, S. Blakey and C. W. Wilson/ Energy & Environmental Science (2009)

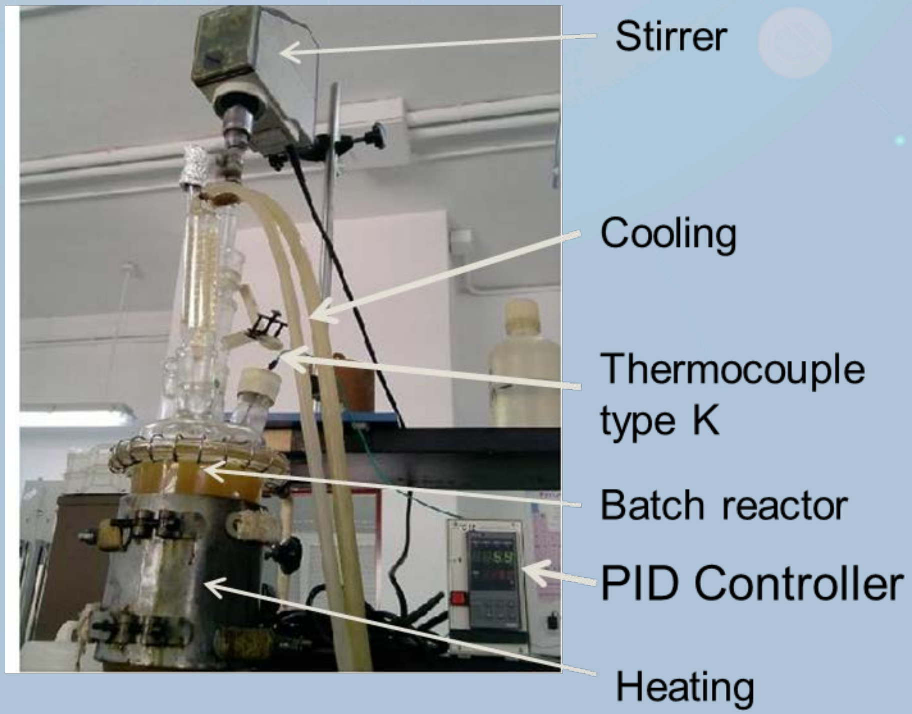
State of the art.



Soy oil to HRJ fuel		Palm oil to HRJ fuel	
LUC S0	No land use change	LUC P0	No land use change
LUC S1	Grass land conversion to soybean field	LUC P1	Logged over forest conversion to palm plantation field
LUC S2	Worldwide conversion of non-crop land	LUC P2	Tropical rainforest conversion to palm plantation field
LUC S3	Tropical rainforest conversion to soybean field	LUC P3	Peatland rainforest conversion to palm plantation field

L. Rye,* S. Blakey and C. W. Wilson/ Energy & Environmental Science (2009)

Transesterification



- T = 60º C
- Stirring 600 rpm.
- Reaction time= 2 h.
- 6:1 methanol / oil mol/mol
- 1% w/w Sodium Methoxide (Catalyst)
- Dry wash (Magnesol D60)

Distillation. (Labscale)

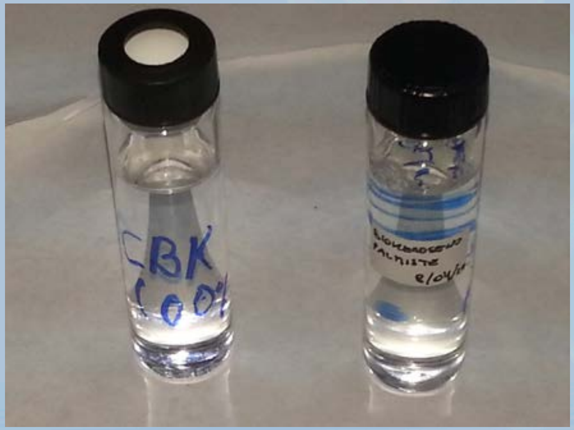
	Coconut FAME	Palm Kernel FAME	Babassu FAME
Melhyl caprylate C8:0	8.3	Traces	3.9
Melhyl caprate C 10:0	3.0	Traces	3.3
Methyl laurate C 12:0	55.5	56.6	20.9
Methyl myristate C14:0	14.9	15.0	31.3
Methyl palmitate C16:0	6.4	8.5	18.0
Methyl stearate C 18:0	2.5	1.7	5.5
Methyl oleate C 18:1	7.5	17.1	12.5
Methyl linoleate C18:2	1.9	1.1	0.2

Distillation

* 2.67 hPa

CBK	PBK	BBK
17.3	3.6	13.3
7.0	3.5	11.3
66.7	90.8	69.3
8.9	2.1	5.6
0.1		0.6

Feedstock	Start point * (ºC)	AET (ºC)	End point* (ºC)	AET (ºC)
Coconut CBK 100	47	273	114	349
Palm kernel PBK 100	35	259	113	348
Babassu BBK 100	47	273	124	359



Distillation. Upscale modelling

Design usual specifications: **PRO/II**

Feed (100 kg/h)

Coconut FAME:

LKC: (C12:0).- bottom stream 5 kg/h
HKC: (C16:0).- distillate stream 0.1 kg/h

Palm kernel FAME:

LKC: (C12:0).- bottom stream 16 kg/h
HKC: (C16:0).- distillate stream 0.01 kg/h

Babassu FAME:

LKC: (C14:0).- bottom stream 15 kg/h
HKC: (C16:0).- distillate stream 0.6 kg/h

Vacuum pressure: 2 torr (2.67 hPa)

Total condenser

Design additional specifications:

	Coconut	Palm Kernel	Babassu
Minimum Reflux	0.02351	0.07916	0.0963
z=R/Rmin	2.5	2	1.75
Reflux[a]	0.05878	0.1583	0.1685
Reflux[b]	0.0742	0.1804	0.12
Number of stages	8	9	8
Feed stage	7	8	6

a Shortcut method   b Distillation Method

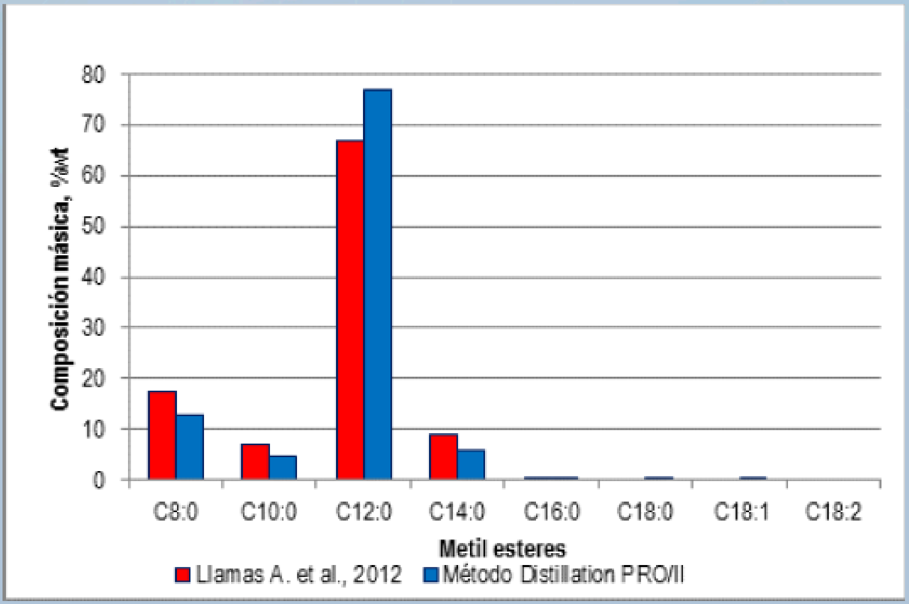
Distillation. Upscale modelling

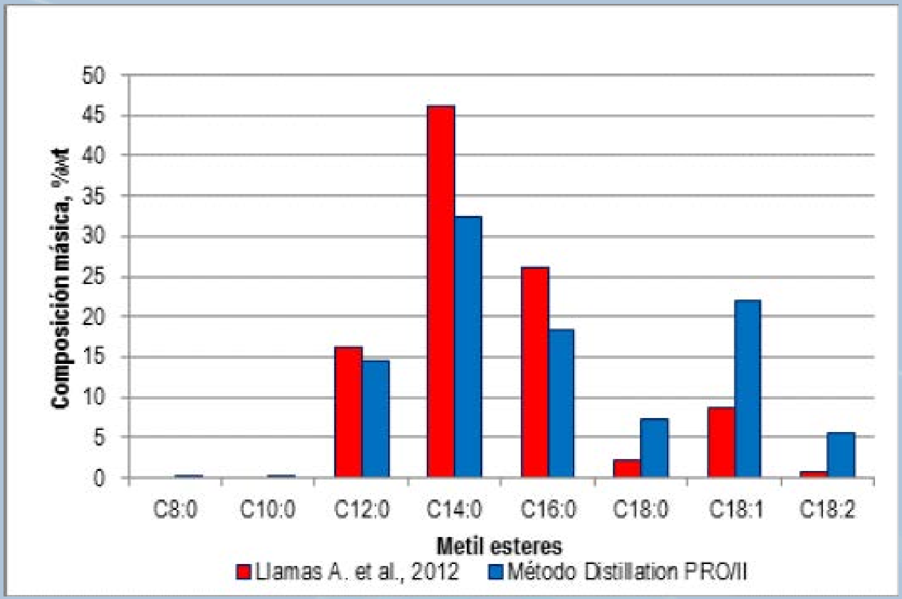
Distillation

	Coconut	Palm Kernel	Babassu
Distillate temperature (°C)	108.35	105.96	80.9
Bottom temperature (°C)	148.13	130.88	144.19
Column diameter (mm)	610	610	610
Tray Spacing (mm)	610	609	610

Distillation

Coconut FAME





Distillate

Bottom

Fuel Characterization

Heating Value

	Babassu	BK_0	BK_5	BK_10	BK_20	BK_100
		JET A1_ 100	JET A_95	JET A1_90	JET A1_80	JET A1_0
LHV *		42.9	43.12	42.74	42.04	34.93
LHV (ASTM D 4809)		42.93	43.14	42.76	42.07	34.96
HHV*		46.04	45.95	45.54	44.75	37.41
	Palm Kernel					
LHV *		42.9	42.64	42.18	41.19	34.89
LHV (ASTM D 4809)		42.93	42.66	42.21	41.22	34.92
HHV*		46.04	45.68	45.17	44.21	37.57
	Coconut					
LHV *		42.9				35.06
LHV (ASTM D 4809)		42.93				35.09
HHV*		46.04				37.66

$$LHV \text{ (net, 25 ºC)} = HHV \text{ (gross, 25 ºC)} - 213.65\, H - 0.77\, O$$

Fuel Characterization

Density

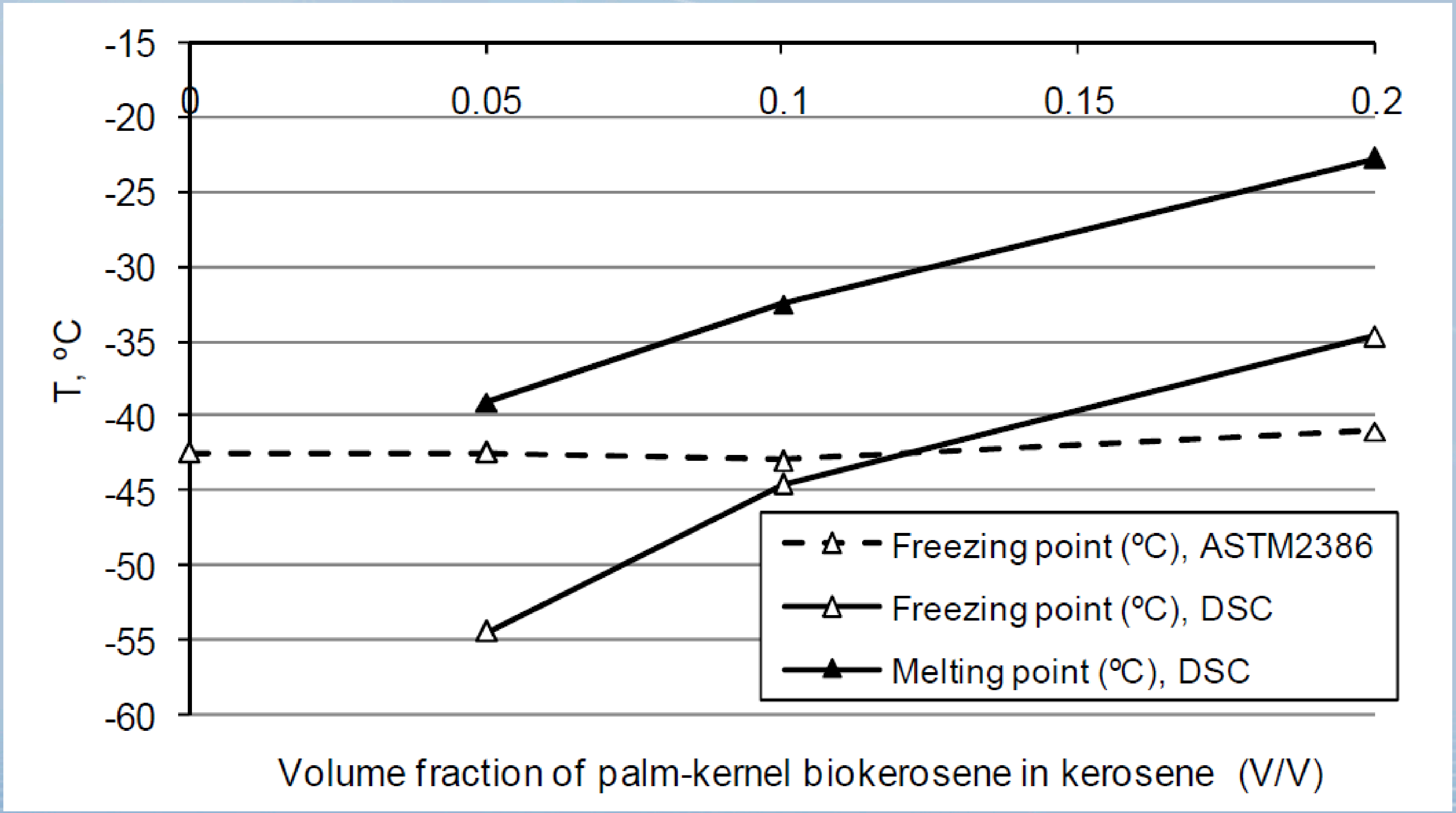
	BK_0	BK_5	BK_10	BK_20	BK_100
Density at 15 °C, kg/m^3	JET A1_ 100	JET A_95	JET A1_90	JET A1_80	JET A1_0
Babassu	791	804	807.7	814.9	874.5
Palm Kernel	791	802.3	805.5	811.8	

	BK_0	BK_5	BK_10	BK_20	Bk_100
Energy Density, GJ/m^3	JET A_100	JET A1_95	JET A1_90	JET A1_80	JET A1_0
Babassu	33.93	34.67	34.52	34.26	30.55
Palm kernel	33.94	34.21	33.98	33.44	

FT-SPK, *LHV* = 44.2 MJ/kg, *d* = 759 kg/m^3 and *ED* = 33.55 GJ/m^3;
HEFA, *LHV* = 44.3 MJ/kg, *d* = 770 kg/m^3 and *ED* = 34.11 GJ/m^3

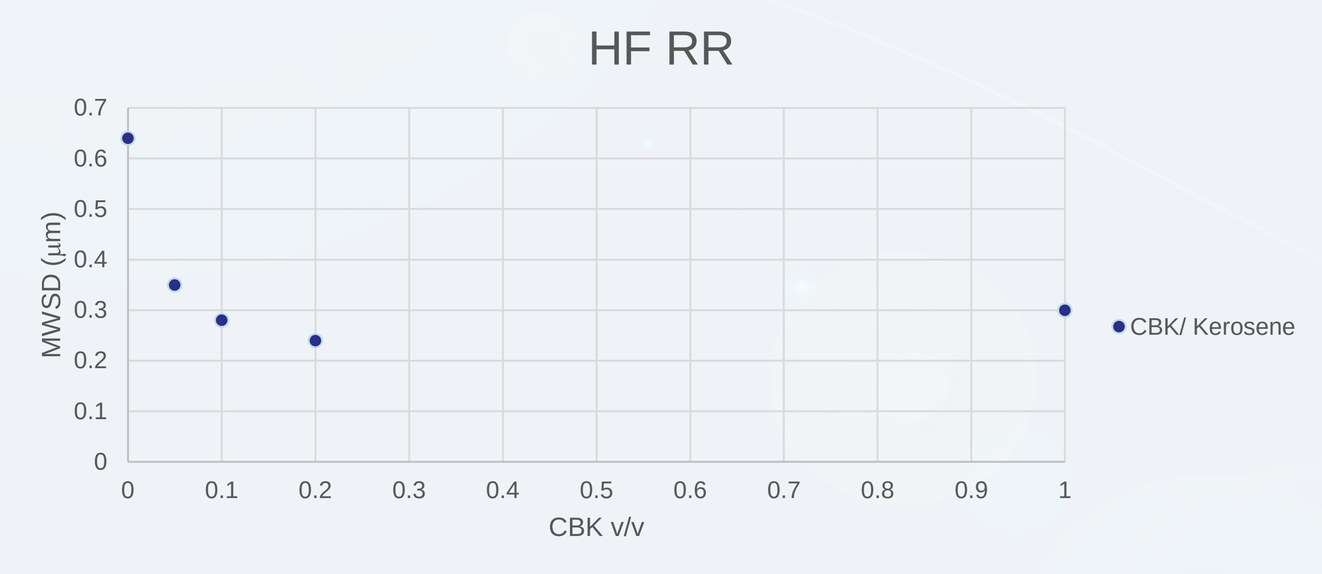
Fuel Characterization

Freezing point



Fuel Characterization

Lubricity: HF RR max. 0,85 mm And Flash point min 38 ºC

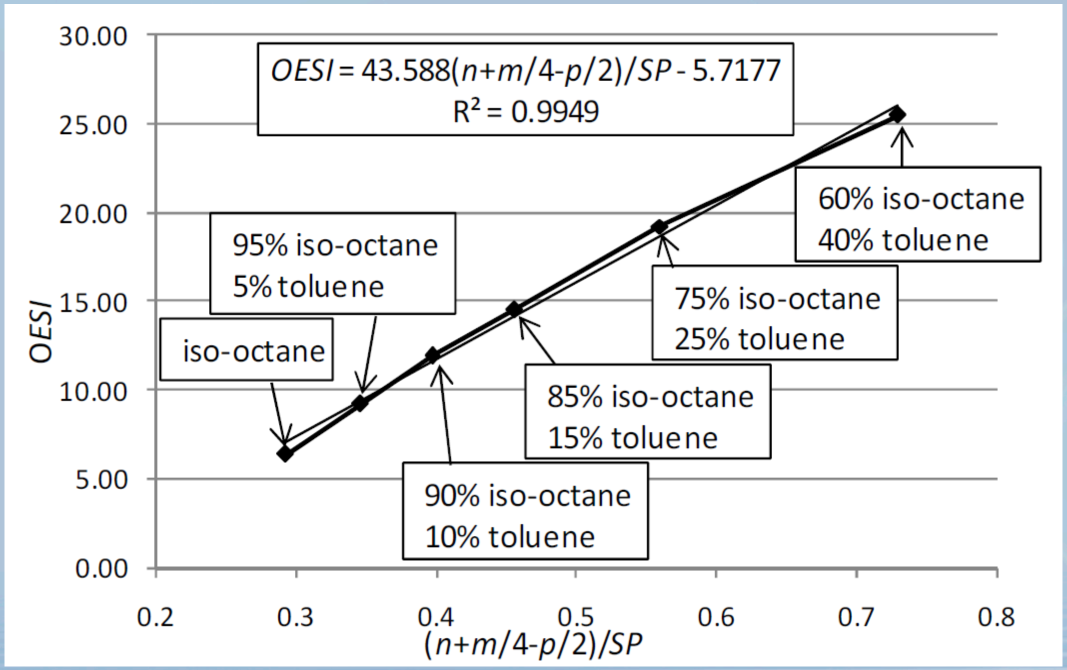


Flash point	BK_0	BK_5	BK_10	BK_20
	JET A1_ 100	JET A_95	JET A1_90	JET A1_80
Palm Kernel	43	43.5	45	45.5

Oxygen Extended Sooting Index

$C_nH_mO_p$

$$OESI = a'\left(\frac{n+\frac{m}{4}-\frac{p}{2}}{SP}\right)+b'$$



Oxygen Extended Sooting Index

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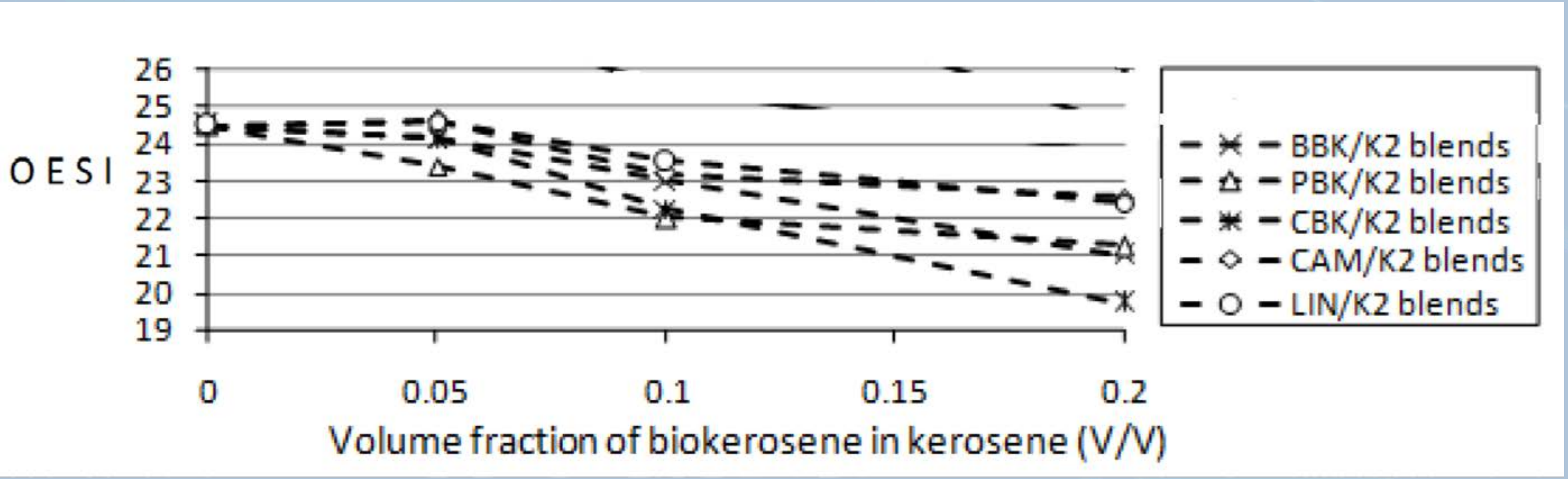
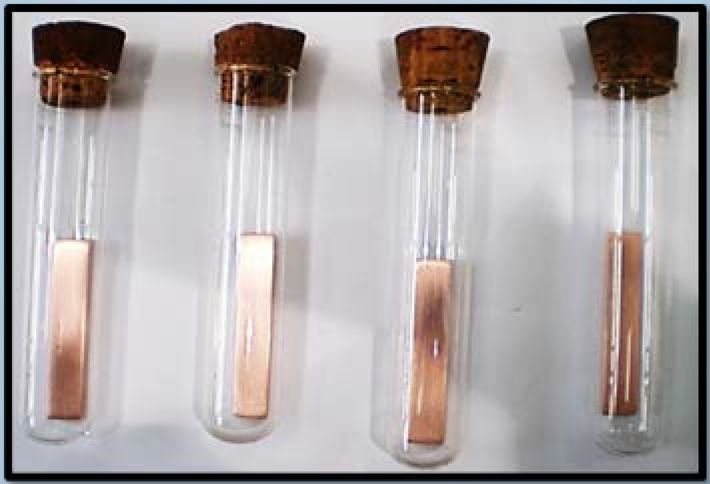
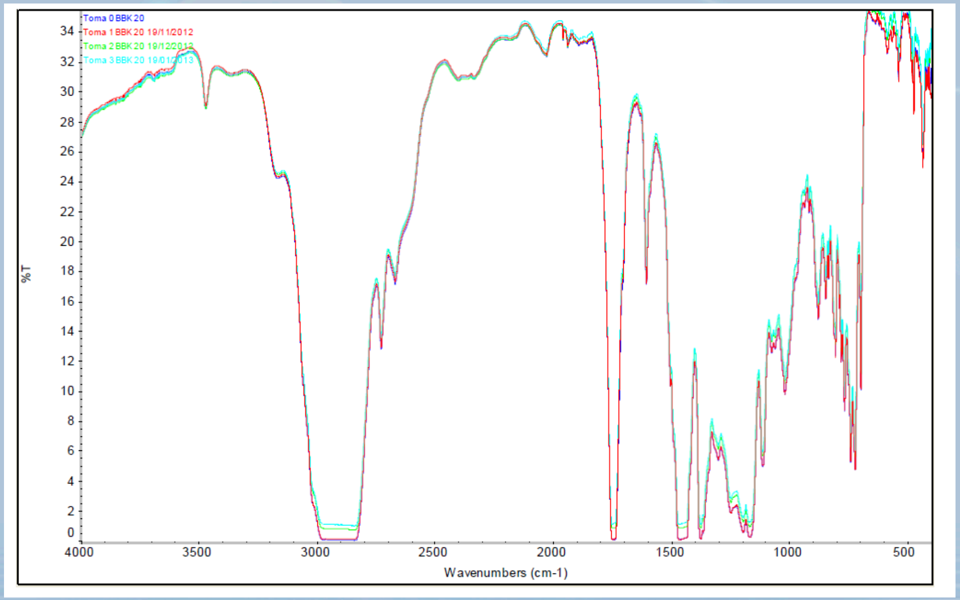


Fuel compatibility tests.

Every 20 % v/v sample: class 1a



Tested at 50 ºC
90 days



Babassu 20 % Jet A 1 80 %

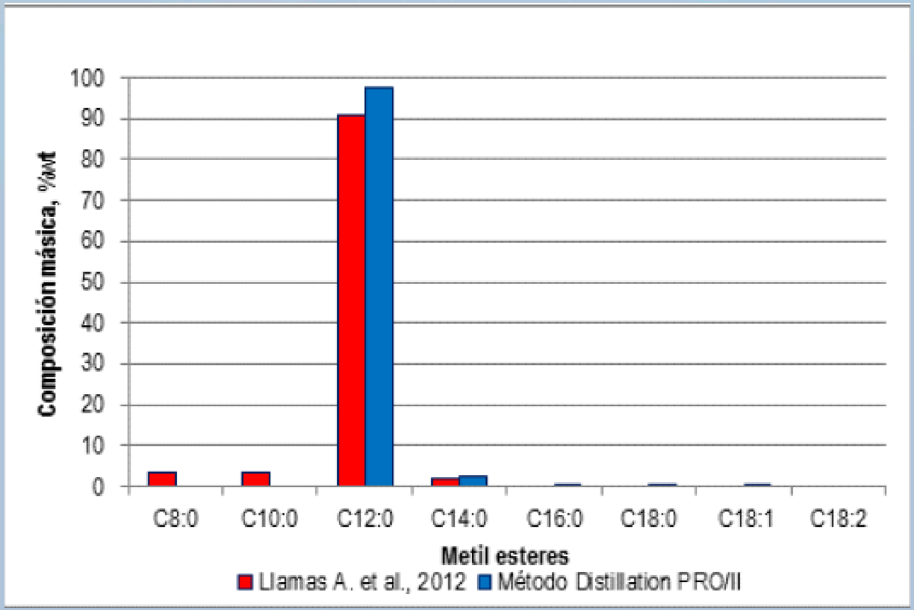
Conclussions

- FAME From three different vegetable oils have been produced and distillated, obtaining a low carbon number blend.
- A simulation of an industrial distillation has been carried out, leading to the design of possible distillation columns.
- Although some of the blends do not meet the LHV, they are close to the lower limit and have greater density.
- The fuel blends do meet the flash point specification. And some of them meet the freezing point to.

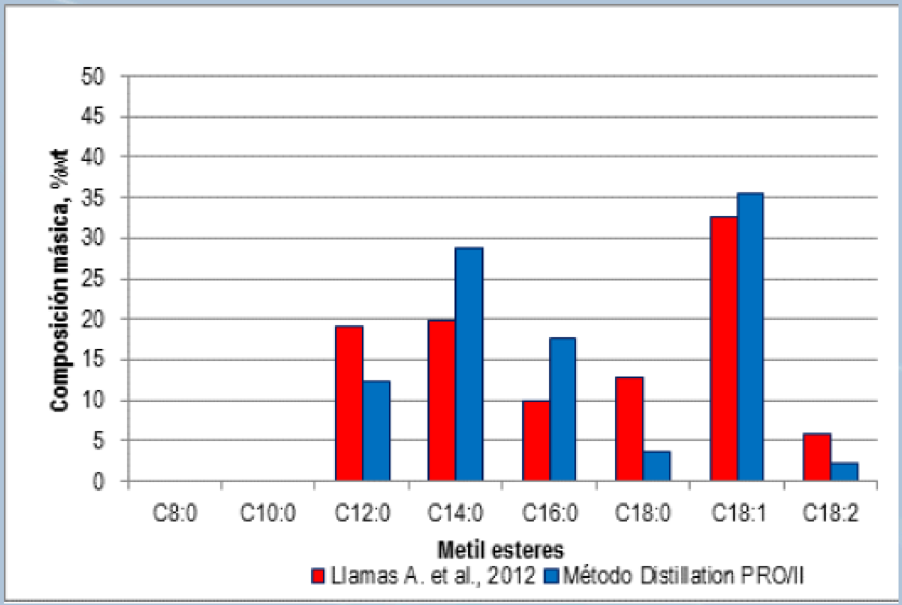
Conclussions

- The blends show a lower tendency in soot formation.
- Every 20 % v/v blend met the copper strip corrosion specification.
- Land use, concurrence with food production for such crops and price are still an issue. However, some coconut crops do not interfere in food markets, neither do esters from SCO processing and low carbon number esters blends could be reconsidered.

Palm Kernel FAME



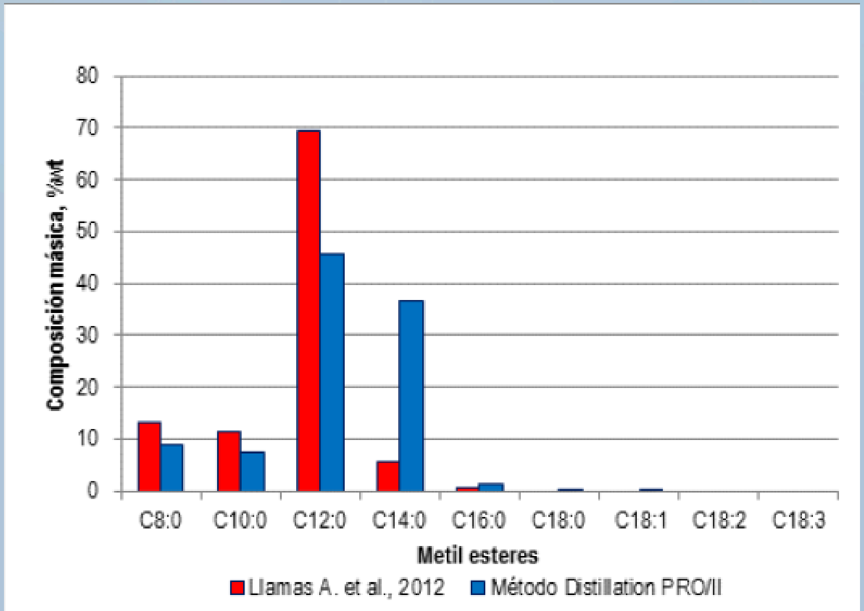
Distillate



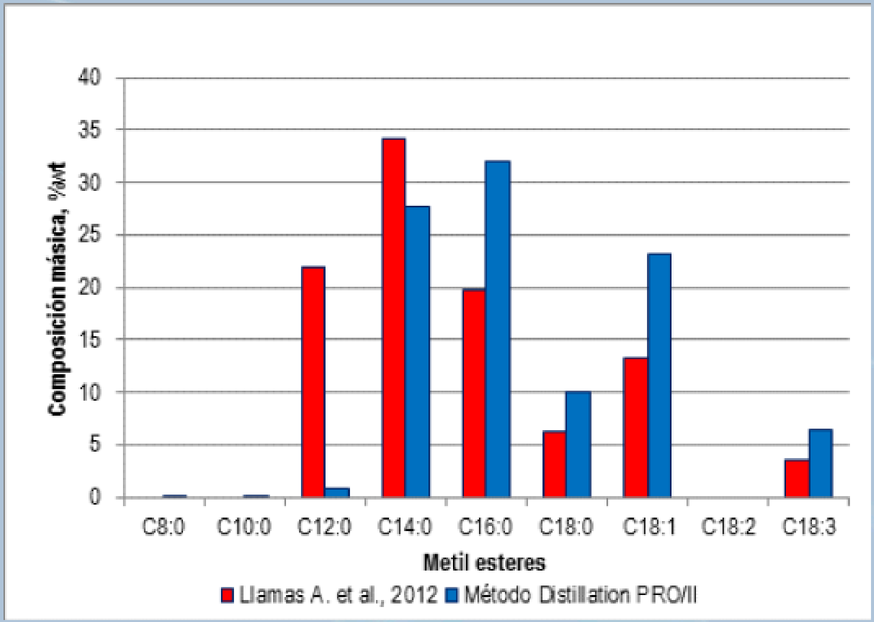
Bottom

Distillation

Babassu FAME



Distillate



Bottom