Biokerosene from coconut, babassu, camelina and palm kernel oils: production and properties of their blends with fossil kerosene

A. Llamas[a], A.M. Al-Lal[a], M. Hernandez[b], Magín Lapuerta[c], Laureano Canoira[a]
[a] Department of Chemical Engineering & Fuels, Escuela Técnica Superior de Ingenieros de Minas, Universidad Politécnica de Madrid. Ríos Rosas 21, 28003 Madrid, Spain.
[b] Laboratory of Fuels & Petrochemistry, Tecnogetafe Scientific Park, Universidad Politécnica de Madrid. Erik Kandel s/n, 28906 Getafe, Spain.
[c] Grupo de Combustibles y Motores, Escuela Técnica Superior de Ingenieros Industriales. Universidad de Castilla La Mancha. Avda. Camilo José Cela s/n, 13071 Ciudad Real, Spain.
**Corresponding author: laureano.canoira.lopez@upm.es*

Introduction

On December 20th 2006 the European Commission approved a law proposal to include the civil aviation sector in the European market of carbon dioxide emission rights [European Union Emissions Trading System, EUETS). On July 8th 2009, the European Parliament and Conseil agreed that all flights leaving or landing in the EU airports starting from January 1st 2012 should be included in the EUETS. On November 19th 2008, the EU Directive 2008/101/CE [1] included the civil aviation activities in the EUETS, and this directive was transposed by the Spanish law 13/2010 of July 5th 2010 [2]. Thus, in 2012 the aviation sector should reduce their emissions to 97 % of the mean values registered in the period 2004-2006, and for 2013 these emission reductions should reach 95 % of the mean values for that same period. Trying to face this situation, the aviation companies are planning seriously the use of alternative jet fuels to reduce their greenhouse gas emissions and to lower their costs. However, some US airlines have issued a lawsuit before the European Court of Justice based in that this EU action violates a long standing worldwide aviation treaty, the Chicago convention of 1944, and also the Chinese aviation companies have rejected to pay any EU carbon dioxide tax [3]. Moreover, the USA Departments of Agriculture and Energy and the Navy will invest a total of up to $150 million over three years to spur production of aviation and marine biofuels for commercial and military applications [4]. However, the jet fuels should fulfill a set of extraordinarily sensitive properties to guarantee the safety of planes and passengers during all the flights.

Experimental

Transesterification of coconut, babassu, palm kernel and camelina oils were carried out following an experimental procedure previously described in the literature [5]. The biokerosene fraction of coconut, babassu and palm kernel FAME's was obtained by fractional distillation at 2 torr (2.67 hPa) [6] of the biodiesel fuel using a 41 cm long x 3.5 cm od Vigreux column. The camelina FAME was used without previous distillation. Kerosene of fossil origin has been used to prepare the blends with biokerosene: K1 was a straight-run atmospheric distillation cut (hydrotreated) kerosene without any additives and K2 was commercial Jet A1 kerosene and it contains additives. The blends of fossil kerosene (K1 and K2) and 5, 10 and 20 % vol of biokerosenes from coconut (CBK100), babassu (BBK100), palm kernel (PBK100) and camelina (CAM100) have been prepared by standard volumetric procedures. These amounts were established in order to foresee a progressive incorporation of this renewable fuel into the aviation jet fuels.

Only the specifications considered essential among those required by the standard ASTM D1655-09a [7] were tested.

Results and Discussion

Tables 1 list the values of the properties measured for the blends of babassu biokerosene and Jet A1. In this table, the standard procedure and the equipment used to measure each property are also shown. Similar tables could be obtained from the authors upon request for the blends of coconut, palm kernel and camelina with both types of fossil kerosene.

Table 1. Properties of the blends of babasu biokerosene (BBK) and Jet A1 (K2).

		BBK_0/ K2_100	BBK_5/ K2_95	BBK_10/ K2_90	BBK_20/ K2_80	BBK_100/ K2_0	Method	Equipment
Colour and aspect		Clear[1]	Clear[1]	Clear[1]	Clear[1]	Clear[1]	ASTM D1500	Visual
Acidity (mg KOH/g)		0.0112	0.0112	0.0112	0.0336	0.0330	EN ISO 14104	Manual
Water content (mg/kg)		-	138.6	113.7	346.4	595.3	ASTM D1774	Karl-Fischer Methrom 831KF
Elemental Composition	C(%)	84.12	85.81	84.13	78.35	73.38		LECO CHNS-932
	H(%)	14.67	13.25	13.08	12.64	11.55		
	N(%)		0.11	0.13	0.15	0.11		
	S(%)		0.10	0.10	0.20	0.10		
Density at 15 ºC (kg/m^3)		791.0	804.0	807.7	814.9	874.5	ASTM D1298	Digital DM48
Density at 23 ºC (kg/m^3)		-	804.7	807.0	814.7	874.2	ASTM D1298	Digital DM48
Viscosity at 40ºC (mm^2/s)		-	1.27	1.31	1.32	2.13	ASTM D445	Cannon Fenske
High calorific value (MJ/kg)		46.04	45.95	45.54	44.75	37.41	ASTM D240	LECO AC-300
Low calorific value (MJ/Kg)		42.90	43.12	42.74	42.04	34.93	ASTM D240[2]	
Flash point (ºC)		43.0	43	44	46	50	EN ISO 3679	Petrotest PMA4
Cloud point (ºC)		-62.0 (3)	-43	-42	-32	-7	ASTM D2500	ATPM
Pour point (ºC)		-	-39	-38	-33	-23	ASTM D2500	ATPM
Smoke point (mm)		27.1	24.7	25.9	25.1		ASTM D1322	Analis 47551
Copper strip corrosion, class		1a	1a	1a	1a	1a	ASTM D130	M. Belenguer 534.01
Oxidative stability (h)		-	> 140	> 140	> 140	> 140	EN 14112	Rancimat Methrom 743

[1]Clear and colourless. [2]ASTM D240 modified for oxygenated fuels. [3]Freezing point

References

1. European Directive 2008/101/CE on Aviation Gas Emission.
2. Spanish Law 13/2010, BOE 6th July 2010, 163: 59586-627.
3. C. Hogue. Unfriendly skies, Chemical & Engineering News October 17 (2011) 48.
4. Administration pushes biofuels production. Chemical & Engineering News August 22 (2011) 30.
5. L. Canoira, M. Rodríguez-Gamero, E. Querol, R. Alcántara, M. Lapuerta, F. Oliva. Biodiesel from Low-Grade Animal Fat: Production Process Assessment and Biodiesel Properties Characterization. Ind Eng Chem Res 47 (2008) 7997.
6. M. Lapuerta, L. Canoira, J. Raez. Improved method for determining the atmospheric distillation curve of biodiesel fuels from reduced pressure. Ind Eng Chem Res 50 (2011) 7041.
7. Standard specification for aviation turbine fuels. Standard ASTM D1655-09a. ASTM International: West Conshohocken, Pennsylvania, 2009.