Palm Biodiesel: Gearing Towards Malaysian Biodiesel Standards

Cheng Sit Foon*; Choo Yuen May*; Yung Chee Liang*; Ma Ah Ngan* and Yusof Basiron*

INTRODUCTION

As biodiesel is gaining considerable global attention and market, standards are vital for its commercialization and market introduction. It is necessary for the authorities to evaluate the safety risks and environmental impact, while giving quality assurance to the users. Vehicle manufacturers would also need a standard to approve vehicles to be operated using biodiesel. Therefore, an approved biodiesel standard is important to the producers, suppliers and users.

According to International Standard Organization (ISO), a standard is a written document approved by a recognized body (Nicolas and Repussard, 1994). Besides that, a standard is also available to the public and drawn up by consensus from all the parties concerned and to the benefit of all. It is intended for repeated or continuous application and normally not mandatory, except for being explicitly referred to in regulations.

There are two major biodiesel standards that are most referred to, namely, the European Standard for Biodiesel (EN 14214) and the American Standard Specifications for Biodiesel Fuel (B100) Blend Stock for Distillate Fuels (ASTM 6751) (*Tables 1* and *2*). The European EN 14214 includes most of the parameters specified in the US ASTM D6751 and the limits in both standards are the same or very close. The major differences between these standards are their intended applications and the preferred test methods.

The European EN 14214 sets the specifications and test methods for fatty acid methyl esters to be used neat as automotive fuel for diesel engines, or as an extender for automotive fuel for diesel engines, in conformation with the European Automotive Diesel Standard (EN 590). The US ASTM D6751 specifies the standards for biodiesel (100%, or denoted as B100) for use as a blend component with diesel fuels. The other major difference between these standards is the preferred testing methods. The testing methods preferred are the standard methods published by European Committee for Standardization (CEN) and American Society for Testing and Materials (ASTM), respectively.

* Malaysian Palm Oil Board,
P. O. Box 10620,
50720 Kuala Lumpur,
Malaysia.
E-mail: sfcheng@mpob.gov.my

FUEL PROPERTIES OF NORMAL AND LOW POUR POINT PALM DIESEL vis-á-vis EUROPEAN AND AMERICAN STANDARDS ON BIODIESEL

The properties of biodiesel depend very much on the nature of its raw material as well as the technology or process used for its production. In this respect, the aforementioned standards have specified relevant parameters to govern the quality of biodiesel. Inherent properties from vegetable oils or animal fats that have an effect on the performance of biodiesel as diesel substitute, such as iodine value (I.V.), density, viscosity, cetane number, copper strip corrosion, linolenic acid methyl esters content, polyunsaturated (more or having four double bonds) methyl esters content and phosphorus content, have been included. On the other hand, the properties of biodiesel related to the production technology are, namely, the contents of ester, sulphated ash, water, partial glycerides (mono-, di- and tri-glycerides), alkali, free and total glycerol, flash point and the acid value.

The fuel properties of all palm diesels, namely, normal palm diesel and low pour point palm diesel (*Figures 1* and *2*), were evaluated vis-à-vis EN14214 and

TABLE 1. EUROPEAN STANDARD FOR BIODIESEL (EN 14214)

Property	Unit	Limits		Test method
		Minimum	Maximum	
Ester content	% (m m^{-1})	96.5	-	pr EN 14103
Density at 15°C	kg m^{-3}	860	900	EN ISO 3675 EN ISO 12185
Viscosity at 40°C	mm^2 s^{-1}	3.5	5.0	EN ISO 3104
Flash point	°C	120	-	ISO/CD 3679
Carbon residue (on 10% distillation residue)	% (m m^{-1})	-	0.3	EN ISO 10370
Acid value	mg KOH g^{-1}	-	0.5	pr EN 14104
Cetane index	-	51.0	-	EN ISO 5165
Sulphur content	mg kg^{-1}	-	10	-
Sulphated ash content	% (m m^{-1})	-	0.02	ISO 3987
Water content	mg kg^{-1}	-	500	EN ISO 12937
Total contamination	mg kg^{-1}	-	24	EN 12662
Copper strip corrosion (3 hr at 50°C)	Rating	1	-	EN ISO 2160
Oxidation stability, 110°C	hr	6.0	-	pr EN 14112
Iodine value	-	-	120	pr EN 14111
Linolenic acid methyl ester	% (m m^{-1})	-	12	pr EN 14103
Polyunsaturated (≥4 double bonds) methyl esters	% (m m^{-1})	-	1	-
Methanol content	% (m m^{-1})	-	0.2	pr EN 14110
Monoglyceride content	% (m m^{-1})	-	0.8	pr EN 14105
Diglyceride content	% (m m^{-1})	-	0.2	pr EN 14105
Triglyceride content	% (m m^{-1})	-	0.2	pr EN 14105
Free glycerol	% (m m^{-1})	-	0.02	pr EN 14105 pr EN 14106
Total glycerol	% (m m^{-1})	-	0.25	pr EN14105
Alkaline content (Na + K)	mg kg^{-1}	-	5	pr EN 14108 pr EN 14109
Phosphorus content	mg kg^{-1}	-	10	pr EN14107

Source: European Committee for Standardization (CEN) (2003).

ASTM D6751. Laboratory evaluations were conducted using ASTM standard methods as practiced in this country. Generally, these palm biodiesels met the respective limits in the aforementioned standards (*Table 3*).

The flash point and methanol content in biodiesel are inter-related. The flash point is set at above 120°C and 130°C in the respective EN14214 and ASTM D6571 to ensure that the manufacturers have removed excess methanol used in the production. Residual methanol is a safety issue as even a very small amount will reduce the flash point greatly. Besides, methanol can also affect fuel pumps, seals and elastomers. All palm diesels have a flash point of about 150°C, well above the specified maximum in the standards.

An upper limit of 0.02% sulphated ash was set in both standards to ensure total removal of the catalyst used in the production. High sulphated ash may cause deposits and filter plugging while high acid number is normally associated with fuel system deposits on pumps and filters. In this respect, palm diesels have sulphated ash contents of not more than 0.01%.

The adverse effect of sulphur on diesel engines has resulted specified maximums of 10 and 15 ppm in EN14214 and ASTM D6751, respectively. Sulphur oxides produced from combustion of the fuel react with moisture present in the combustion chamber to form sulphuric acid which corrodes the cylinder liner and piston. Besides a negative effect on diesel engines, the sulphur content in fuel is also a concern towards the environment as it contributes to air pollution by forming acid rain. Palm diesel including low pour point palm diesel are derived from palm oil, a renewable resource of plant origin, the concerns of sulphur content in them should not arise and results have shown that they have negligible levels of sulphur (<0.001%).

TABLE 2. STANDARD SPECIFICATIONS FOR BIODIESEL FUEL (B100) BLEND STOCK FOR DISTILLATE FUELS (ASTM D6751)

Property	Unit	Grade S15	Grade S500	Test method
		Limits	Limits	
Kinematic viscosity at 40°C	$mm^2 s^{-1}$	1.9-6.0	1.9-6.0	ASTM D445
Flash point (closed cup)	°C	130.0 min	130.0 min	ASTM D93
Sulphur content	% mass (ppm)	0.0015 max (15)	0.05 max (500)	ASTM D5453
Carbon residue (on 100% distillation residue)	% mass	0.050 max	0.050 max	ASTM D4530
Acid number	mg KOH g^{-1}	0.80 max	0.8 max	ASTM D664
Cloud point	°C	Report*	Report*	ASTM D2500
Cetane number	-	47 min	47 min	ASTM D613
Sulphated ash content	% mass	0.020 max	0.020 max	ASTM D874
Water and sediment	% volume	0.050 max	0.050 max	ASTM D1796
Copper strip corrosion (3 hr at 50°C)	rating	No. 3 max	No. 3 max	ASTM D130
Free glycerol	% mass	0.020	0.020	ASTM D6584
Total glycerol	% mass	0.240	0.240	ASTM D6584
Phosphorus	% mass	0.001 max	0.001 max	ASTM D4951
Distillation temperature (90% recovered)	°C	360 max	360 max	ASTM D1160

Note: * The cloud point of biodiesel is generally higher than that of petroleum-based diesel fuel and should be taken into consideration when blending.

Source: ASTM International (2003).

Figure 1. Normal palm diesel (crude/distilled palm oil methyl esters).

Figure 2. Low pour point palm diesel.

The presence of acids or sulphur containing compounds can cause corrosion to the fuel system as certain parts of diesel engines are made of brass or bronze while a high acid number will cause deposits. In view of these, parameters such as the acid value and copper strip corrosion have been included. Both normal and low pour point palm diesel have acid and copper strip corrosion values that meet the specified limits in EN14214 (0.5%) and ASTM D6751 (0.8%).

Properties such as the methanol, monoglycerides, diglycerides, triglycerides, free glycerol and total glycerol contents are mainly related to the production technology used to produce the methyl esters. The methanol content is measured to ensure total removal of the excess methanol used in the production of methyl esters, while the contents of monoglycerides, diglycerides and triglycerides indicate the degree of conversion from oil to methyl esters or completion of the esterification/ transesterification process. In these respects, both normal and low pour point palm diesel meet the specifications in both standards.

In summary, both type of palm diesel (normal and low pour point palm diesel) meet all the specifications in EN14214 and ASTM D6751.

FUEL PROPERTIES OF PROCESSED LIQUID PALM OIL/PETROLEUM DIESEL BLENDS vis-á-vis MALAYSIAN STANDARD ON DIESEL FUEL

Besides research and development in palm diesel, MPOB's palm biofuel programme also includes using processed liquid palm oil (PLPO) and its blends with petroleum diesel (PD) (*Figure 3*). The physical and fuel properties of these palm biofuel samples in various ratios were evaluated and the results have shown that blends of PLPO/PD (up to 10% PLPO) can be used directly, without chemical modification, in conventional diesel engines. Actual engine trials using MPOB vehicles on B2, B5 and B10 of PLPO/PD blends (denoting 2%, 5% and 10% PLPO in PD) have been ongoing since 2002 (*Figure 4*). So far, no technical problems have been reported and the long-term effects on the engines are being studied.

As the global development of biodiesel is mostly focussed on the methyl esters of vegetable oil, there is currently no biodiesel standard for vegetable oil/diesel blends. Both the European and American Standards on Biodiesel are intended for methyl esters and, are thus, not suitable for evaluation of PLPO/PD blends. In addition, it was found that the fuel properties of these blends are very similar to the fuel properties of petroleum diesel from our evaluation of PLPO/PD blends (B2, B5 and B10). Thus, it is appropriate to use the Malaysian Standard for Diesel Fuel (MS123:1993) as the reference standard.

Generally, the fuel properties of PLPO/PD blends are very similar to those of petroleum diesel. Blending PLPO up to 10% in petroleum diesel does not change the fuel properties of petroleum diesel much with the resultant fuel properties of the blends still heavily dependent on the fuel properties of petroleum diesel. *Table 4* depicts the fuel properties of the blends from a study conducted using PLPO from different palm oil refineries in Malaysia. From this study, B2 and B5 of the PLPO/PD blends can meet all the requirements of MS123:1993.

TABLE 3. FUEL PROPERTIES OF NORMAL AND LOW POUR POINT PALM DIESEL

Property	Unit	Normal palm diesel	Low pour point palm diesel	EN14214	ASTM D6751
Ester content	% mass	98.5	98.0 to 99.5	96.5 (min.)	-
Density at 15°C	kg litre^{-1}	0.8783	0.87 to 0.89	0.86 to 0.90	-
Viscosity at 40°C	mm^2 s^{-1}	4.415	4 to 5	3.5 to 5.0	1.9 to 6.0
Flash point	°C	182	150 to 200	120 (min.)	130 (min.)
Cloud point	°C	15.2	-18 to 0	-	Report
Pour point	°C	15	-21 to 0	-	-
Cold filter plugging point	°C	15	-18 to 3	-	-
Sulphur content	% mass	<0.001	<0.001	0.001 (max.)	0.0015 (min.) (Grade S15) 0.05 (min.) (Grade S500)
Carbon residue (on 10% distillation residue)	% mass	0.02	0.02 to 0.03	0.3 (max.)	0.05 (max.)
Acid value	mg KOH g^{-1}	0.08	<0.3	0.5 (max.)	0.8 (max.)
Sulphated ash content	% mass	<0.01	<0.01	0.02 (max.)	0.02 (max.)
Basic sediment and water	% mass	<0.05	<0.05	0.05 (max.)	0.05 (max.)
Cetane number	-	58.3	53.0-59.0	51 (min.)	47 (min.)
Copper strip corrosion (3 hr at 50°C)	rating	1a	1a	1	3 (max.)
Iodine value	-	52	56 to 83	120 (max.)	-
Content of linolenic acid methyl esters	% mass	<0.5	<0.5	12 (max.)	-
Content of polyunsaturated fatty acid methyl esters (more than 3 double bonds)	% mass	<0.1	<0.1	1 (max.)	-
Methanol content	% mass	<0.2	<0.2	0.2 (max.)	-
Monoglycerides content	% mass	<0.4	<0.4	0.8 (max.)	-
Diglycerides content	% mass	<0.2	<0.2	0.2 (max.)	-
Triglycerides content	% mass	<0.1	<0.1	0.2 (max.)	-
Free glycerol content	% mass	<0.01	<0.01	0.02 (max.)	0.02 (max.)
Total glycerol content	% mass	<0.01	<0.01	0.25 (max.)	0.24 (max.)

Notes: ASTM D6751: Standard Specifications for Biodiesel Fuel (B100) Blend Stock for Distillate Fuels.
EN14214: European Standard for Biodiesel.

Figure 3. Processed liquid palm oil/petroleum diesel blends.

TABLE 4. FUEL PROPERTIES OF PROCESSED LIQUID PALM OIL (PLPO)/MALAYSIAN PETROLEUM DIESEL (PD) BLENDS

Property	Unit	PLPO/PD blends		Malaysian petroleum diesel	MS123:1993	
		B2	B5		Min.	Max.
Density at 15°C	kg litre^{-1}	0.8395 - 0.8448	0.8419 - 0.8459	0.8380 - 0.8420	-	-
Viscosity at 40°C	mm^2 s^{-1}	3.974 - 4.184	4.136 - 4.549	3.918 - 3.974	1.5	5.8
Flash point	°C	77.0 - 81.0	75.0 - 81.0	77.0	60	-
Cloud point	°C	14 - 16	14 - 16	14 - 16	-	18
Pour point	°C	9 - 12	9 - 12	12	-	15
Sulphur content	mg kg^{-1}	0.18 - 0.19	0.17 - 0.18	0.19 - 0.21	-	0.5
Carbon residue (on 10% distillation residue)	% mass	< 0.1 - 0.1	0.2	< 0.1	-	0.2
Cetane number	-	50.6 – 61.8	54.8 – 61.5	55.2 – 61.2	45	-
Cetane index	-	51 - 57	55 - 56	51 - 57	47	-
Ash content	% mass	0.001 - 0.007	<0.001 - 0.006	0.001 - 0.005	-	0.01
Basic sediment and water	mg kg^{-1}	< 0.01	< 0.01	< 0.01	-	0.01
Copper strip corrosion (3 hr at 100°C)	rating	1a	1a	1a	-	1
Distillation temperature at 90% recovery	°C	365.4 - 369.0	363.7 - 367.8	365.4 - 365.9	-	370
Water by distillation	% volume	< 0.05	< 0.05	< 0.05	-	0.05
Colour	-	1.0 - L1.5	1.0	L1.0 - 1.5	-	2.5
Gross calorific value	MJ kg^{-1}	45 - 47	44 - 47	45 - 47	-	-

Notes:
B2: 2% processed liquid palm oil + 98% petroleum diesel.
B5: 5% processed liquid palm oil + 95% petroleum diesel.
MS123:1993: Malaysian Standard for Diesel Fuel.

Figure 4. One of the MPOB Pajero participating in the exhaustive field trial using B5 processed liquid palm oil/petroleum diesel blend.

CONCLUSION

In view of the positive results obtained from the evaluation of palm biodiesels, namely, palm diesel, low pour point palm diesel and PLPO/PD blends, it is rational to establish individual standards for each of the palm biofuels that is acceptable to diesel engine manufacturers. It is important to have the standards to regulate the quality and give assurance to the engine manufacturers and end-users. The European and American Standards on Biodiesel are good references for palm biodiesel based on palm oil methyl esters while the Malaysian Standard for Diesel Fuel can be used as a close reference for the PLPO/PD blends in our effort in working towards Malaysian Biodiesel Standards.

It is timely for Malaysia to set-up its national biodiesel standards which harmonize with the European and American standards and which, at the same time, is practical for their intended applications. Due consideration should also be given on factors such as optimum vehicle performance, environmental impact, marketing as well as quality analysis infrastructure, in establishing the national biodiesel standards.

REFERENCES

ASTM INTERNATIONAL (2003). *Standard Specification for Biodiesel Fuel (B100) Blend Stock for Distillate Fuels (ASTM D6751)*.

EUROPEAN COMMITTEE FOR STANDARDIZATION (CEN) (2003). *European Standard for Biodiesel (EN14214).*

NICOLAS, F and REPUSSARD, J (1994). *Common Standards for Enterprise*. European Commission. Brussels, Luxembourg.