PALM OIL METHYL ESTERS AS FUEL: PALM DIESEL

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INTRODUCTION

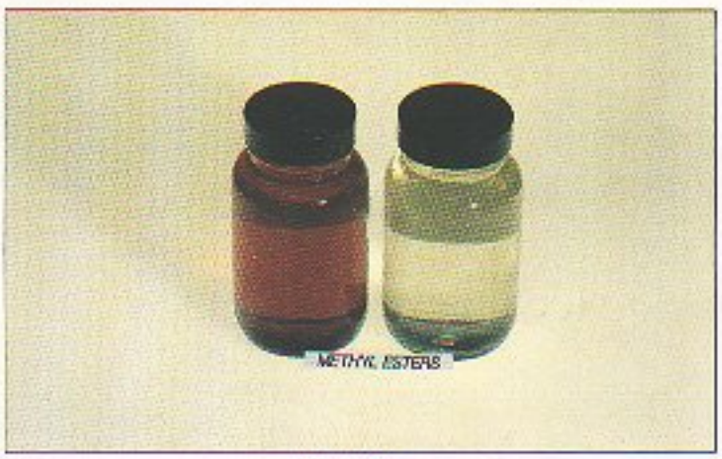
Palm diesel consists of methyl esters of crude palm oil or crude palm stearin prepared from reaction with methanol using a suitable catalyst. Crude oils of free fatty acids content up to 30% can be used as the feedstock, as the process provides pretreatment stage (esterification) to handle the free fatty acids. The process has been shown to be technically feasible on a pilot plant scale. The product, palm diesel, has been thoroughly evaluated as a diesel substitute.

PRINCIPLES OF THE PROCESS

The process for the conversion of crude palm oil into methyl esters consists of two steps: (1) esterification of the free fatty acids present in palm oil into methyl esters, and (2) transesterification of the neutral glycerides directly into methyl esters. In this process the washing stage after esterification is obviated and this is an economic advantage. The esterification step is carried out in a column of solid catalyst. The resultant reaction mixture, which is neutral, is then transesterified in the presence of an alkali catalyst. This process is run continuously. The separation of glycerol from methyl esters is effected in the presence of methanol. Methanol is recovered from both fractions and then recycled. The esters are washed and dried before being used as diesel substitute. The complete process is illustrated in the flow diagram as shown in *Figure 1*.

The process has also been extended to the conversion of crude palm stearin and crude palm kernel oil into methyl esters in the pilot plant scale. The compositions of the esters from these feedstocks are given in *Table 1*.

The glycerol obtained from the transesterification process can be refined on an industrial scale to a purity of 99.6%.



Methyl Esters

Palm Diesel Pilot Plant

Table 1. Fatty Acid Composition of Methyl Esters of Crude Palm Oil (CPO), Crude Palm Stearin (CPS) and Crude Palm Kernel Oil (CPKO)

	Fatty Acid Composition (%)											
	C6	C8	C10	C12	C14	C16:0	C16:1	C18:0	C18:1	C18:2	C18:3	C20
CPO	–	–	–	0.3	0.8	44.3	0.2	5.0	39.1	10.1	0.1	–
CPS	–	–	–	0.4	1.9	52.0	–	4.1	32.7	7.9	0.1	–
CPKO	0.5	3.0	2.8	44.9	16.0	10.1	–	2.4	17.1	2.8	0.2	0.2

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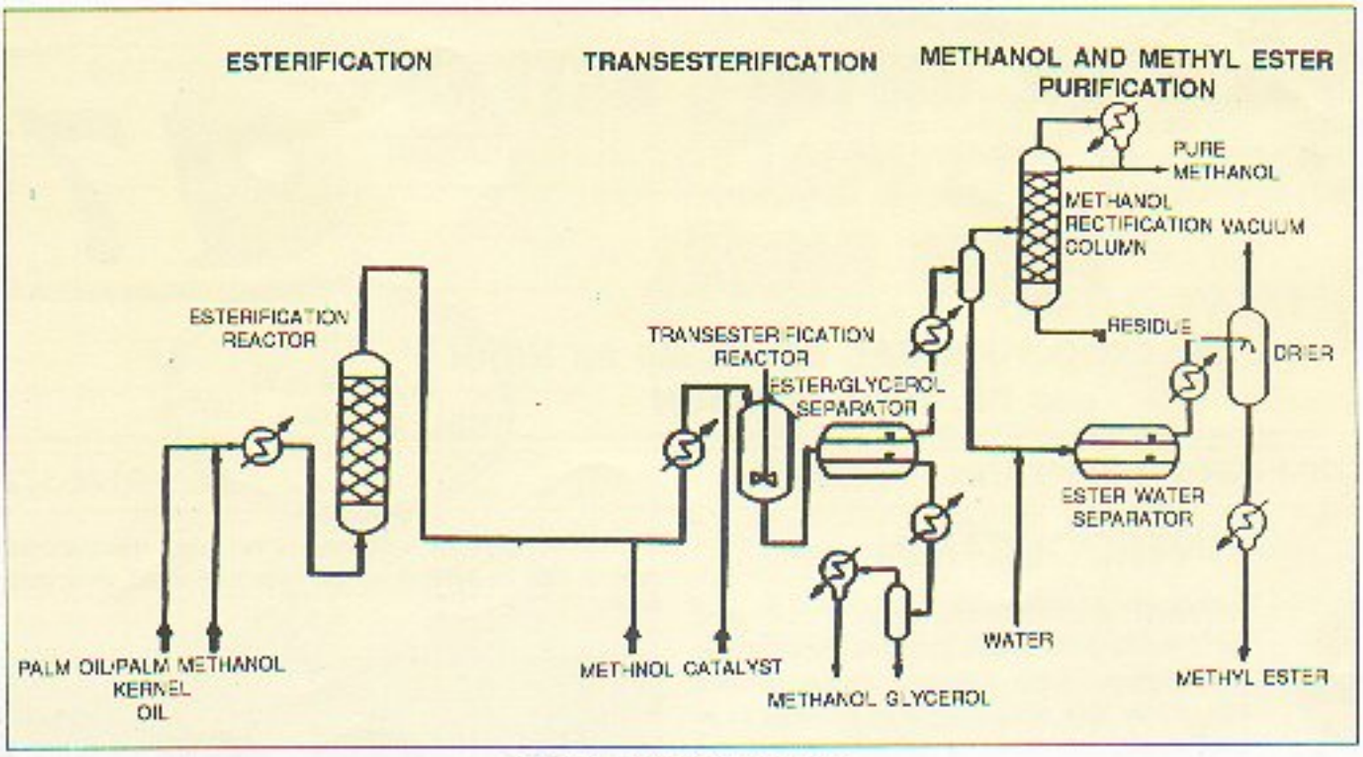

Figure 1. Methyl esters pilot plant

FUEL CHARACTERISTIC

Laboratory evaluation of these esters has been carried out including the determination of cetane number and the results, as shown in *Tables 2* and *3*, indicate that palm oil methyl esters could perform better than petroleum diesel. This is borne out by results obtained in stationary engine tests and field trials. The results of the field trials permit the following conclusions to be made:

Table 2. Fuel Characteristics of Methyl Esters of Crude Palm Oil and Crude Palm Stearin

Product Test Conducted		Methyl Esters of CPO	Methyl Esters of CPS	Malaysian Diesel
Specific Gravity ASTM D1290°F		0.8700 @ 74.5	0.8713	0.8330 @ 60.0
Colour (Visual)		Reddish	Orange	Yellow
Sulfur Content % WT. IP 242		0.04	0.002	0.10
Viscosity @ 40°C ASTM D445 (cST)		4.5	4.6	4.0
Pour Point/°C ASTM D97		16.0	17.0	15.0
Distillation D86				
I.B.P	°C	324.0	320.0	228.0
10%	°C	330.0	331.0	258.0
20%	°C	331.0	332.0	270.0
50%	°C	334.0	335.0	298.0
90%	°C	343.0	343.0	376.0
F.B.P	°C	363.0	349.0	400.0
Final Recovery ml		98.0	98.5	–
Gross heat of Combustion ASTM D2382 kJ/kg		40,135	39,826	45,800
Flash Point/°C P'S cc ASTM D93		174	165	98
Conradson Carbon Residue ASTM D198 % wt		0.02	0.05	0.14

Table 3. Cetane Number of Crude Palm Oil (CPO) Methyl Esters, Petroleum Diesel (from Europe) and their Blends

Samples		Cetane Number (ASTM D613)
CPO Methyl Esters (%)	Petroleum Diesel (%)	
100	0	62.4
0	100	37.7
5	95	39.2
10	90	40.3
15	85	42.3
20	80	44.3
30	70	47.4
40	60	50.5
50	50	52.0
70	30	57.1

- No modification of the engines is required.
- The performance of engines is generally good. The engines are easy to start with no knocking and with smooth running.
- The exhaust gas emission of the engines is much cleaner with reduction of hydrocarbon, NOx, CO, and SO_2 contents, therefore it is more environmentally friendly.
- The engine oil is still usable at the recommended mileage.
- Palm diesel does not produce explosive air/fuel vapour. It also offers enhanced safety characteristic with higher flash point (174°C compared to 96°C of petroleum diesel).
- Carbon build-up on engine nozzles is normal except that the nature of carbon is different.
- The fuel consumption of palm diesel is comparable to petroleum diesel (e.g. 3-4 km/L for the buses under trial).

The second phase of the exhaustive field trial, which commenced in 1990 and involved 36 Mercedes Benz engines mounted on 36 buses, is in its final phase of testing. Some buses have already clocked in 300,000 km, the targeted mileage. Observations made to date in the trial confirm the positive findings on palm diesel obtained earlier. Meanwhile, crude palm stearin methyl esters have also been successfully tested in PORIM vehicles with no deleterious effects on the engines.

OTHER APPLICATIONS

Besides being a useful diesel substitute, palm oil methyl esters have other applications. One of these is the conversion of methyl esters into alpha-sulphonated derivatives (alpha-SME) that could be used as active ingredients in detergent formulation.

Before their conversion into α-SME, the methyl esters should first be distilled to recover the bulk of minor components originally present in palm oil, namely the carotenoids, tocopherols and tocotrienols. From the residue a carotenoid concentrate of > 80,000 ppm was obtained. The carotenoid concentrate was found by chromatographic analysis to contain 11 different carotenoids and xanthophylls. A toxicological study in rats has shown that the carotenoid concentrate is safe for consumption. Its specification as food colourant has also been accepted by the Food & Agriculture Organization (FAO) recently. The carotenoid concentrate has also been successfully presented in different forms i.e. soft and hard capsules, powder and emulsion, for possible pharmaceutical applications.

Methyl esters have also been used to manufacture premium soap products. Other applications include conversion of esters into fatty alcohols for detergent and cosmetic industries; conversion to fatty amines used in textile industry, isolation of methyl oleate that could be converted to synthetic lubricant or to civetone (a perfumery material).

Vehicle using palm diesel.

PRELIMINARY ECONOMIC VIABILITY STUDY

The technology developed by PORIM offers an alternative route to the production of palm methyl esters (palm diesel). This has the advantages of utilizing low temperature and low pressure reactions compared to traditional methods using the splitting of fatty acid route.

The economic equation for palm methyl ester production is shown below:

$$Ppo + 0.112\ Pm + Pc + Np = 0.96\ P_{ME} + 0.1\ Pg$$

where:
Ppo is the price of palm oil (RM/tonne)
Pm is the price of feedstock methanol (RM/tonne)
P_{ME} is the price of palm methyl esters (RM/tonne)
Pg is the price of glycerol (RM/tonne)
Pc is the processing cost (RM/tonne of palm oil feed)
Np is the net profit (RM/tonne of palm oil feed)
Pc + Np is the gross profit (RM/tonne of palm oil feed)

The plot of the parameters of the equation shows that the improved viability of the palm diesel is obtained if petroleum diesel price is increased, glycerol price is increased, and if the

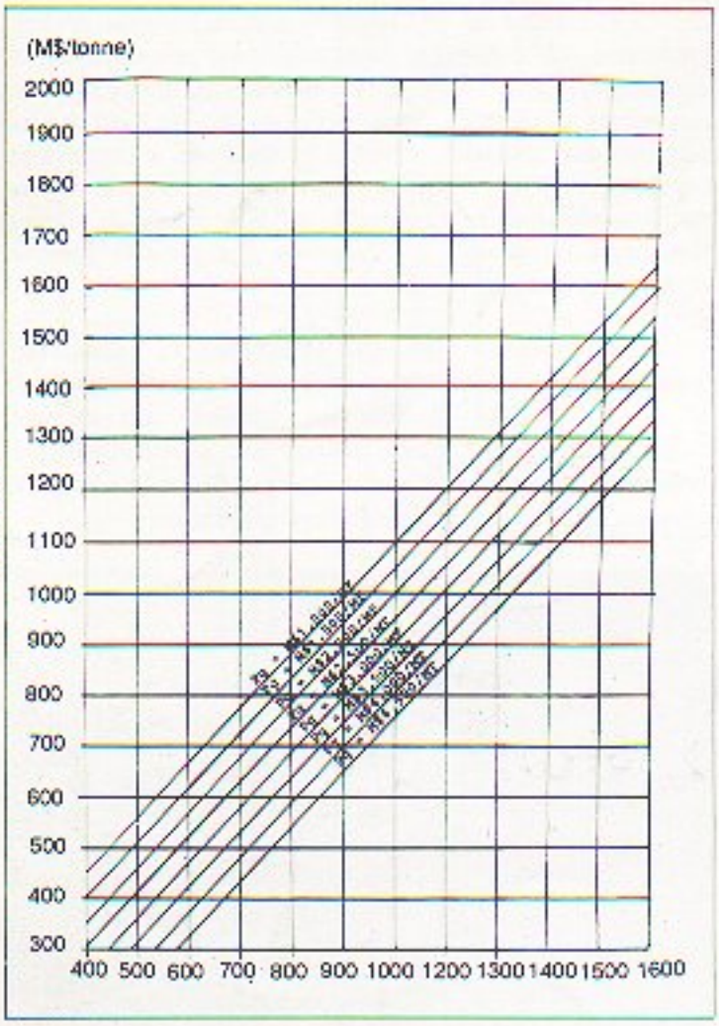

Figure 2. Sensitivity Analysis

Note: 1. Methanol price assumed fixed at M$400/MT
2. Gross profit assumed at M$120/MT of palm kernel oil/palm oil feed.

crude palm oil price is reduced (see *Figure 2*). For example, the price of crude palm oil has to be below RM650 per tonne given the correct price of glycerol and diesel, for the project to be viable. Nevetheless, the economic of the project would be very much improved if methyl esters are sold as oleochemicals and carotenoids as well as vitamin E are recovered from the esters.

BENEFITS OF THE PALM DIESEL PROJECT

The benefits of the palm diesel project can be envisaged to be as follows:

- It provides a safety net for the Malaysian Palm Oil Industry in time of glut in the market;
- It contributes to the quality enhancement of palm oil by utilizing palm oil products of low quality;
- It provides a chemical feedstock for other chemicals and other biodegradable detergents;
- It provides high valued minor components and by-product glycerol; and finally,
- It provides an alternative fuel for diesel engines.

COMMERCIALIZATION

PORIM is in the process of commercializing the palm methyl ester technology for large scale production to interested customers.

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