RESIDUAL OIL FROM SPENT BLEACHING EARTH (SBE) FOR BIODIESEL AND BIOLUBRICANT APPLICATIONS

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In refining palm oil, bleaching earth is used to remove colour, phospholipids, oxidized products, metals and residual gums from the oil. It also absorbs approximately 0.5% by weight of the oil in the process. Spent bleaching earth (SBE) is usually disposed of in landfills, normally, paid for by the refinery. Due to the increasingly high cost of disposal, it is desirable to use the material instead. The oil in SBE (*Figure 1*) can be recovered via solvent or supercritical fluid extraction (SC-CO_2) with a yield of up to 30% by weight of the SBE. The SBE generated annually by Malaysian palm oil refineries is estimated to be approximately 120 000 t. The potential oil that can be recovered is estimated to be approximately 36 000 t. The recovered oil would have high free fatty acids and peroxide value, and would not be suitable for food application. But it can be: (1) a cheap feedstock for conversion to biodiesel; (2) used as a lubricant base and lubricant auxiliary for biolubricants.

Figure 1. Residual oil from SBE (WAC and NC).

TECHNOLOGY

SBE was extracted using hexane under reflux conditions, or by SC-CO_2 extraction. The yellow oil obtained was (1) subjected to transesterification to convert to methyl esters; (2) pre-treated and used for formulating a bio-lubricant.

PRODUCT CHARACTERISTICS AND APPLICATIONS

The characteristics (*Table 1*) and lubrication properties (*Table 2*) of the residual oil, and composition of the resulting methyl esters are shown (*Table 3*). The oil has good lubricity; *i.e.* suitable viscosity range and high viscosity index for use as a lubricant base. The methyl esters (*Figure 2*) have comparable fuel properties to commercial petroleum diesel (*Table 4*), hence; can be used as a diesel substitute. Besides, the methyl esters can also be used as a lubricant auxiliary to provide and maintain a thin film over the metal parts of machines and the oil contact surface to smoothen and lubricate them. The SBE (*Figure 3)* can be recycled for use (Cheah *et al*., 2004) or used as fuel (*Table 5*).

Figure 2. Methyl esters from SBE (biodiesel).

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TABLE 1. CHARACTERISTICS OF RESIDUAL OIL[a] FROM SBE
(acid activated clay – WAC and neutral clay - NC)

Characteristics	Solvent extraction		$SC\text{-}CO_2$ extraction	
	WAC oil	NC oil	WAC oil	NC oil
FFA (%)	11.5	12.6	11.5	12.6
PV (meq kg^{-1})	3.1	3.4	2.8	2.2
Phosphorus (ppm)	19.3	18.7	18.1	15.8
Fe (ppm)	0.22	1.24	N.D.[b]	N.D.
Cu (ppm)	0.32	0.38	N.D.	N.D.
Carotene content (ppm)	3	6	7	7
Total vitamin E (ppm)	0	0	0	38.8
Fatty acid composition, (FAC) (wt% as methyl esters)				
C14:0	1.1	1.0	1.2	1.3
C16:0	45.2	44.4	44.5	43.6
C18:0	4.9	4.7	5.1	4.9
C18:1	37.9	39.4	38.6	39.7
C18:2	10.9	10.5	10.6	10.5
Oil recovery (%)[c]	30	21	27	20

Notes: [a] Only for one particular sample (batch).
[b] Not detected.
[c] Dry weight basis.

TABLE 2. LUBRICATION CHARACTERISTICS OF RESIDUAL OIL FROM SBE
(WAC and NC) FOR USE AS LUBRICANT BASE AND LUBRICANT AUXILIARY

Characteristics	WAC oil	NC oil
Specific gravity @ 25°C (g cm^{-3})	0.9160	0.9496
Kinematic viscosity, ASTM D445 @ 40°C, cSt	38.32	42.56
@100°C, cSt	7.78	9.25
Viscosity index, ASTM D2270	179.2	180.1
Moisture content, ASTM D1744 (%)	0.086	0.427
Total acid number (TAN), ASTM D664 (mg g^{-1})	1.06	1.89
Pour point, ASTM D97 (°C)	10.0	9.0
Cloud point, ASTM D2500 (°C)	26.1	25.8
Rancimat stability, pr EN 14112 (hr)	15.25	30.16

TABLE 3. COMPOSITION OF METHYL ESTERS (ME) PRODUCED FROM RESIDUAL SBE OIL

Composition	WAC ME (%)	NC ME (%)
Esters	99.5	98.9
Monoglycerides	0.45	1.0
Diglycerides	0.05	0.1
Triglycerides	0.00	0.0
Fatty acid composition (FAC) (wt% as methyl esters)		
C14:0	0.9	0.8
C16:0	44.8	43.8
C18:0	5.1	4.9
C18:1	38.6	39.3
C18:2	10.6	11.2

TABLE 4. FUEL PROPERTIES OF METHYL ESTERS (ME) PRODUCED FROM RESIDUAL SBE OIL

Property	WAC ME	NC ME	Malaysian diesel
Density at 25°C (kg $litre^{-1}$) ASTM D4052	0.8700	0.8723	0.8310
Viscosity @ 40°C (cSt) ASTM D445	4.6	5.2	4.0
Sulphur content (wt%) IP 242	0.04	0.04	0.10
Pour point (°C) ASTM D97	15	15	15
Flash point (°C) ASTM D93	172	164	98
Gross heat of combustion (kJ kg^{-1}) ASTM D240	38 080	39 470	45 800
Oxidative stability (hr) pr EN 14112	14.59	29.36	NA

Figure 3. Types of SBE (with or without residual oil).

TABLE 5. CALORIFIC VALUES OF SBE (WAC and NC)

Type of SBE	Calorific value (J g^{-1})
WAC	9 620.7
WAC (de-oiled)	3 141.0
NC	10 543.0
NC (de-oiled)	2 731.7

NOVELTY OF INVENTION

Recovery of residual oil from SBE is a unique solution to the environmental problem of disposing it in landfills. The oil can be developed to substitute unsafe and toxic petroleum-based fluids in lubricant formulations used in and around food processing and other environmentally-sensitive areas. It can also be an economical feedstock for the production of biodiesel. The recovery of residual oil and re-use of SBE offer a great potential cost saving to the palm oil processing industry.

ECONOMIC ANALYSIS

Annual production of CPO: 15.9 million tonnes (2006).
Estimated SBE generated (based on ~0.8% of BE used in palm oil refining): 120 000 t.
Amount of oil recovered from SBE (based on 30% of oil absorbed in SBE): 36 000 t.
Average price of CPO: RM 2500 t^{-1}.
Recovery of residual oil from SBE offers revenue of RM 90 million to the palm oil processing industry.
Estimated production cost of biodiesel from residual SBE oil: RM 2.80 kg^{-1}.
Estimated production cost of biolubricant from residual SBE oil: RM 3.1 kg^{-1}.

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