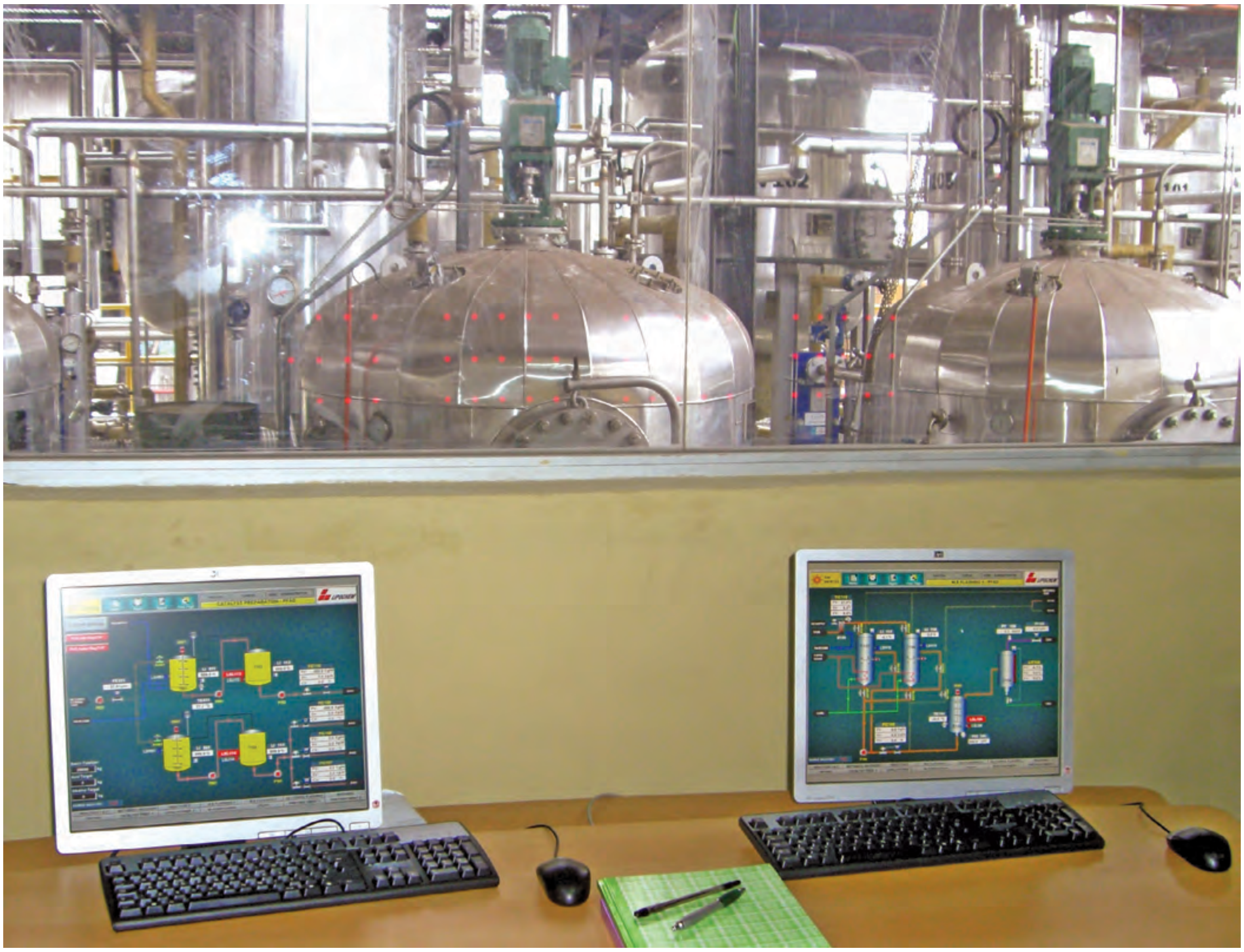
Palm fatty acid distillate biodiesel:

K.Y. Cheah, T.S.Toh, and P.M. Koh

Two years ago we looked at the challenges faced by the biodiesel industry (Building plants for biodiesel and co-products, *inform 19*:302–305, 2008) and also examined the co-products that could improve the economic viability of the industry. In the interval, the situation for the biodiesel industry has not improved, with the high cost of feedstocks continuing to be the bane of biodiesel producers. The promise of alternative low-cost non-food feedstocks such as jatropha has yet to materialize, and there seems to be, at the current moment, no light at the end of the tunnel in the search for low-cost feedstock alternatives.

Most biodiesel plants use the conventional sodium hydroxide/sodium methoxide-based transesterification process, which requires highly priced refined oil feedstock. Although palm oil is one of the more competitive feedstocks for biodiesel production, it can be expensive because its price is linked to that of crude petroleum (Fry, 2010). However, during the refining of palm oil, a lower-value by-product known as palm fatty acid distillate (PFAD) is generated in the fatty acid stripping and deodorization stages. PFAD is potentially a valuable, low-cost feedstock for the production of biodiesel. It also makes the much-debated "food vs. fuel" argument a non-issue as PFAD is generally sold as a source

A palm fatty acid distillate (PFAD) biodiesel plant as viewed from the control room.



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Next-generation palm biodiesel

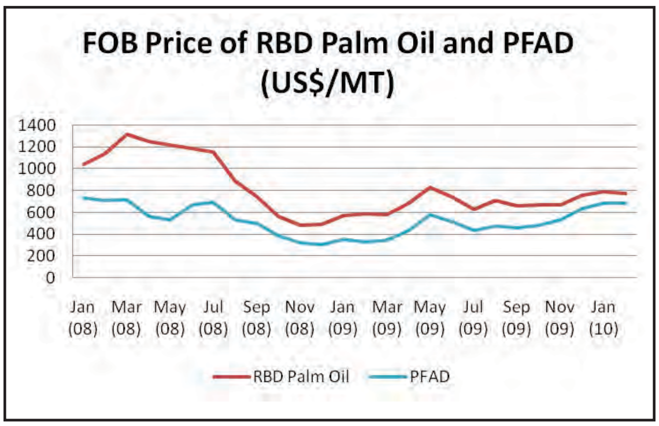

FIG. 1. FOB price of RBD palm oil and PFAD. Abbreviations: RBD, refined, bleached, deodorized; PFAD, palm fatty acid distillate; MT, metric ton. Source: Malaysian Palm Oil Board.

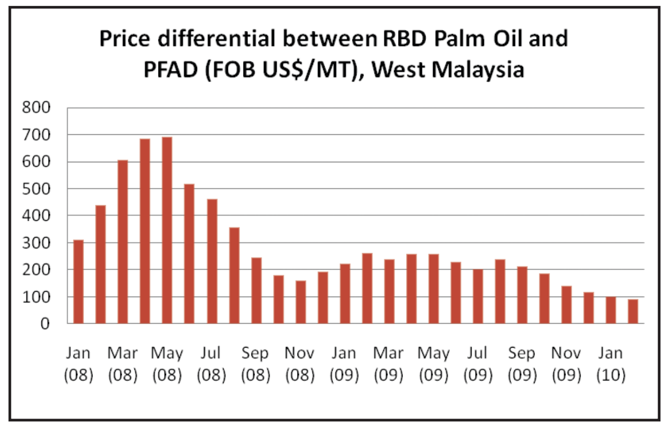

FIG. 2. Price differential between RBD palm oil and PFAD. For abbreviations, see Figure 1. Source: Malaysian Palm Oil Board.

of industrial fatty acids for non-food applications. It has also been used as a fuel in power plants and industrial boilers.

Malaysia and Indonesia are the largest producers of palm oil. In 2009, Malaysia and Indonesia produced about 17.5 and 20.9 million metric tons of crude palm oil, respectively (Mielke, 2010). In Malaysia, most of the crude palm oil is refined locally for export to overseas markets, mainly for food applications. Almost 700,000 metric tons (MT) of PFAD were produced in Malaysia as a by-product of the refining process (MPOB, 2010).

PFAD—THE LOW-COST FEEDSTOCK FOR BIODIESEL

The amount of readily available PFAD is not insignificant, and it presents biodiesel producers with excellent access to a low-cost, non-food source of feedstock. PFAD is always traded at a discount to crude or refined, bleached, and deodorized (RBD) palm oil (Fig. 1). Before October 2009, the discount typically exceeded $200/MT, and it was as high as $680/MT in May 2008. However, since November 2009, the price differential between PFAD and RBD palm oil has narrowed. In early 2010 the discount of PFAD over RBD palm oil was less than $100 per ton (Fig. 2).

PFAD BIODIESEL PLANTS

Although the basic process for the conversion of high-acid oil feedstock to biodiesel is well known, it has been carried out mainly in small-scale batch-type processes. A breakthrough came in October 2009 with the successful operation of the world's first continuous large-scale 200 MT/day PFAD biodiesel plant (in Sumatra, Indonesia). In this plant, owned by a large Asian-based multinational palm oil group, fresh PFAD from the refineries is sent directly to the PFAD biodiesel plant for conversion to biodiesel.

The benefits of a continuous PFAD biodiesel process include single person control room operations and a fully automated and tightly controlled management of all process parameters for consistent biodiesel product quality. The biodiesel yield from this plant approaches 100%, and it fully meets EN (European Standards) specifications. After distillation, the PFAD biodiesel also passes the ASTM Cold Soak Filtration Test, introduced in 2008.

Two more PFAD biodiesel plants using the above process technology will be operational in Pasir Gudang, Malaysia, and Kalimantan, Indonesia by May 2010. These plants can also operate using refined oil feedstocks.

NEW GENERATION MULTIPLE FEEDSTOCK BIODIESEL PLANTS

By incorporating a continuous esterification section, a biodiesel producer with a conventional sodium hydroxide/sodium methoxide-based transesterification process now has the opportunity to possess a new, truly multiple feedstock plant able to handle different raw materials including PFAD. By using the above processes, combined with pretreatment and other processes, the variety of feedstock can be further expanded to include low-quality and high free-fatty-acid (FFA) oils, thereby ensuring that a very wide range of low-cost feedstocks are available to the biodiesel processor, thus ensuring the profitability of the plant.

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TABLE 1. *General characteristics of Malaysian PFAD*[a]

	Mean	Range
FFA—palmitic (%)	86.4	72.7–92.6
Unsaponifiable matter (%)	1.61	1.0–2.5
Saponification value (mg KOH/g)	209.5	200.3–215.4
Titer (°C)	46.7	46.0–48.3
Specific gravity @ 50°C (g/cc)	0.8725	0.8640–0.8880
Water content (%)	0.104	0.03–0.24
Iodine value, Wijs (g/100 g)	54.8	46.3–57.6

[a]PFAD, palm fatty acid distillate; FFA, free fatty acids. Source: Bonnie and Mohtar (2009).

PHYTOCHEMICALS FROM PFAD

PFAD also provides a source of value-added co-products for the biodiesel producer. PFAD contains 72.7–92.6% FFA, with a small amount of unsaponifiable components (1–2.5%) and the remainder neutral oil. The general characteristics of Malaysian PFAD are shown in Table 1. Modern palm oil refineries consistently produce PFAD with FFA content higher than 88%, and crude palm oil also contains non-glyceride minor components that have been associated with health benefits, some of which are distilled off together with the FFA as unsaponifiable components.

The unsaponifiable materials of PFAD have long been considered a potential source of highly valuable phytochemicals (Gapor, 2000). Vitamin E, phytosterols, and squalene are of particular interest, and their beneficial effects are well documented. In fact, tocotrienol from PFAD is being produced commercially. The vitamin E profile of Malaysian PFAD is 10.3 wt% α-tocopherol, 18.7 wt% α-tocotrienol, 49.8 wt% γ-tocotrienol, and 14.6 wt% δ-tocotrienol (Bonnie and Mohtar, 2009). Depending on the feedstock and processing conditions, some samples of PFAD can have as much as 0.5% vitamin E, 0.4% phytosterols, and 0.8% squalene. These high-value co-products further improve the profitability of PFAD biodiesel plants.

The initial step in the extraction of phytochemicals from PFAD is conversion of the fatty acids into a methyl ester, that is, biodiesel. The methyl ester is then distilled in a short-path evaporator where the phytochemicals are concentrated in the residues. The residues are further processed to produce the high-value-added phytochemicals. The distilled methyl ester is a high-quality biodiesel that will meet all biodiesel EN and ASTM specifications, including the Cold Soak Filtration Test. Furthermore, other parameters such as mono-, di-, and triglycerides content are reduced significantly, further enhancing the fuel properties of the biodiesel.

CONCLUSIONS

The challenge for biodiesel producers is to remain profitable, and one solution is to operate a new-generation biodiesel plant that is truly multiple-feedstock capable. PFAD is one alternative low-cost feedstock that is available today. PFAD also gives a producer the ability to produce high-value co-products. Going one step further, these new-generation truly multiple-feedstock biodiesel plants can be designed to accept low-quality and high-FFA oil feedstocks using proven process technologies that are already operational in several plants today.

information

FOR FURTHER READING:

- Fry, J., Is it smooth sailing or choppy waters ahead? Paper presented at the Palm and Lauric Oils Conference & Exhibition Price Outlook (POC), Kuala Lumpur, Malaysia, March 8–10, 2010.
- Mielke, T., The price outlook of palm and lauric oils and impacts from the global vegetable oil markets–A fundamental approach, Paper presented at the Palm and Lauric Oils Conference & Exhibition Price Outlook (POC), Kuala Lumpur, Malaysia, March 8–10, 2010.
- Malaysian Palm Oil Board, 2010. Website: www.mpob.gov.my.
- Gapor, A.M.T., A study on the utilization of PFAD as a source of squalene, *Proceedings of the 2000 National Seminar on Palm Oil Milling, Refining Technology, Quality and Environment*, Malaysian Palm Oil Board, Selangor, 2000, pp. 146–151.
- Bonnie, T.Y.B., and Y. Mohtar, Characteristics and properties of fatty acid distillates from palm oil, *Oil Palm Bulletin 59*:5–11 (2009).

K.Y. Cheah is technical director, Lipochem Bio-Tech Sdn. Bhd. He has worked as a petroleum refining technologist in the Shell Petroleum Company (Singapore), a research officer for the Malaysian Palm Oil Board (MPOB), and as head of Palm Oil Milling and Palm Oil Processing Unit for MPOB. T.S. Toh, general manager of Lipochem Pte. Ltd. (Singapore), has more than 18 years of experience in the oils and fats industry as a project engineer and engineering manager in Scandinavian and Singaporean multinational companies where he managed the design, construction, and commissioning of edible oil refining plants in Southeast Asia. P.M. Koh is managing director of Lipochem (M) Sdn. Bhd. & Lipochem Bio-Tech Sdn. Bhd., Malaysia. He worked for over 20 years in various European multinational fats and oils engineering companies in the areas of design, project management, plant start-up and commissioning before moving into management of these companies. For more information, visit www.lipochem.com.

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