

Transformers are vital components of electrical power systems and the choice of insulating and cooling oil can have a significant impact on their performance, safety and environmental footprint. Palm-based transformer oil (Figure 1), a biodegradable dielectric fluid, has emerged as a promising alternative to conventional mineral oil for several compelling reasons. Firstly, palm-based transformer oil offers superior fire safety, with a flash point over 280°C and a fire point exceeding 300°C, significantly higher than that of mineral oil (Mohd *et al.*, 2021). This enhanced fire safety, reduces the risk of transformer fires, contributing to a safer electrical infrastructure. In addition, palm-based transformer oil exhibits excellent moisture tolerance and is readily biodegradable, making it an environmentally friendly option. Its high moisture tolerance ensures better performance and longevity. Furthermore, this oil can extend the lifespan of the insulating paper in transformers, enhancing reliability and reducing maintenance costs.

From an economic perspective, retro-filling transformer with palm-based transformer oil and installing new transformers with this bio-based oil can lead to substantial cost savings. These savings arise from reduced maintenance requirements, longer equipment life and potentially lower insurance premiums due to reduced fire risk. Malaysia, the world's second-largest producer of palm oil, stands to benefit significantly from this innovation. The country's abundant palm oil resources present a unique opportunity to become a key player in the bio-based transformer oil market, fostering economic growth and promoting environmental sustainability in the electricity industry.

According to Future Market Insights (2022), the global transformer oil market reached USD4.02 billion in 2022. Global demand for transformer oil is expected to grow at a compound annual

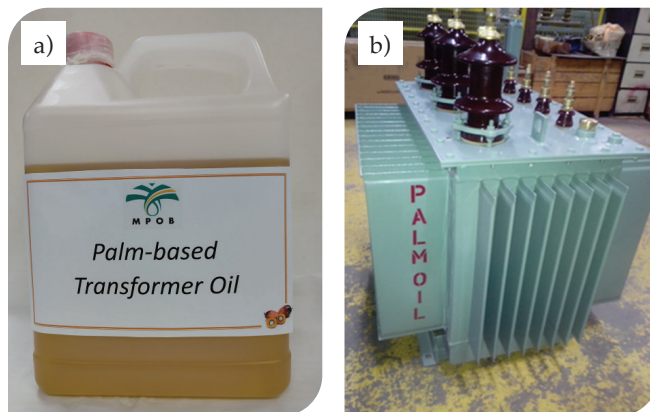


Figure 1. a) Palm-based transformer oil, b) palm-based transformer oil was tested in 100 kVa, 11/0.433 kV transformer for field trial.

growth rate (CAGR) of 8.8% during the forecast period 2023 to 2033. The total market value is predicted to rise from USD4.35 billion in 2023 to USD10.14 billion in 2033. Kline Company (2024), reported that ester-based oils currently account for less than 5% of the market and it offers tremendous growth opportunities. The demand for bio-based products is also expected to increase due to the growing installation of transformers worldwide, driven by their superior safety, efficiency, and sustainability. Safety considerations, operational challenges, and the increasing importance of sustainability in the market are all strong factors fuelling demand for ester-based transformer oils.

NOVELTY OF THE TECHNOLOGY

Palm-based transformer oil with a major content of palm oil products is formulated as a readily biodegradable oil with a high flash point and excellent water tolerance. This oil is an excellent choice for use in oil-filled transformers. The technology involves mixing base oil with additives and a treatment process to meet the required technical specifications. The technical specifications for palm-based transformer oil are shown in Table 1.

TABLE 1. TECHNICAL SPECIFICATION

Characteristics	Method	Palm-based transformer oil
Flash point (°C)	ASTM D92	296.00
Fire point (°C)	ASTM D92	324.00
Pour point (°C)	ASTM D97	-3.00
Density at 20°C (g/cm ³)	ASTM D4052	0.92
Viscosity (mm ² /s) 100°C	ASTM D445	6.90
Viscosity (mm ² /s) 40°C		32.40
Biodegradation	OECD 301F	Readily biodegradable
Dielectric breakdown (kV)	IEC 60156	>70.00
Water content (ppm)	ASTM D1533	<150.00

BENEFITS AND ADVANTAGES



Reduce fire risk
 • High flash point



Environmental protection
 • Readily biodegradable



Value addition



Cost savings
 • Lower insurance premium
 • Substation area reduction of 90% for new installation.



Non-toxic



Locally available feedstocks

ECONOMIC ANALYSIS

An investment of RM2.29 million with a production capacity of 260 tonnes/year and a selling price of RM18/kg brings the following economic benefits (Table 2).

TABLE 2. ECONOMIC ANALYSIS

Economic analysis	Value
Net present value (NPV) @10%	RM7 753 132
Internal rate of return (IRR)	59%
Discounted payback period	2.9 years
Discounted benefit: cost ratio (B:C)	1.41
Return of investment	48.8%

IP STATUS

This technology has been patented in Malaysia (PI 2010003594), Singapore (201105323-8), Thailand (1101001196), Philippines (12011000250) and Indonesia (1002011000460).

REFERENCES

Future Market Insight (2022). Transformer oil market outlook from 2023 to 2033. <https://www.futuremarketinsights.com/reports/transformer-oil-market>, accessed on 10 June 2024.

Kline Company (2024). Transformer oils market sees increasing use of ester-base oils. <https://klinegroup.com/transformer-oils-market-sees-increasing-use-of-ester-base-oils>, accessed on 10 June 2024.

Mohd, N K; Wen-Huei, L; Abu Hassan, N A and Shoot-Kian, Y (2021). Potential application of palm oil products and their blends for use as electrical insulating medium in oil-immersed transformers. *Environ. Prog. Sustain. Energy* 40(6): e13728.

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