GAIN #1: SCALABLE PRODUCTION TECHNOLOGY FOR BIO-BASED MONOPROPYLENE GLYCOL (MPG)

AHMAD SYAFIQ AHMAD HAZMI; WAN NUR FATIHAH WAN MUHAMMAD ZULKIFLI; MOHD AZMIL MOHD NOOR; NUR AZREENA IDRIS; NOOR KHAIRIN MOHD; ARNIZA MOHD ZAN; NORHAYATI MOHD NOOR; ZAFARIZAL ALDRIN AZIZUL HASAN; SHAHMIL SINWAN; MOHD FAZDLI ABD RAZAK; MOHD RIDZUAN ZAKARIA and BAHRIAH BILAL

870

MPOB INFORMATION SERIES • ISSN 1511-7871 • JUNE 2026 MPOB TT No. 701

Malaysia was a dominant force in oleochemical processing throughout the 1980s. Since then, Indonesia has steadily eroded that lead, recording a Compound Annual Growth Rate (CAGR) of 13.5% between 2015 and 2022, compared to Malaysia's modest 2.3% (*Figure 1*). While Indonesia has aggressively expanded into downstream oleochemical activities, Malaysia remains confined to basic oleochemical production, ceding both market share and technological ground.

The MPOB Glycol-Alkene Intensified Technology (GAIN) represents a strategic pivot from costly, restrictive foreign-licensing technology toward sovereign ownership of a high-performance, sustainable industrial asset. By retaining full control over both the supply chain and unrestrictive export markets, GAIN will position Malaysia as an independent player in the global oleochemical value chain. At its core, GAIN Platform 1 converts basic oleochemical glycerol, an abundant byproduct, into bio-based monopropylene glycol (MPG), a versatile compound with broad industrial and consumer applications.

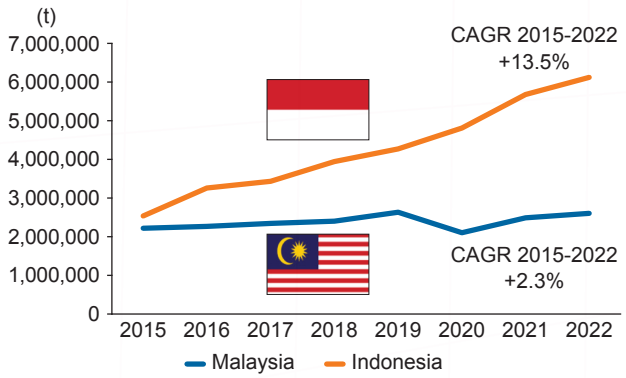


Figure 1. Compound annual growth rate (CAGR) for Indonesia and Malaysia in the oleochemical sector.

PROBLEM STATEMENT

Malaysia has established monoethylene glycol (MEG) production capabilities but remains entirely dependent on imports for MPG, with annual import volumes ranging from 20-50 kTA (estimated value at RM0.360 billion/year). This gap represents a critical vulnerability in the nation's oleochemical value chain. Malaysia must develop proprietary downstream technology to convert glycerol into MPG, a higher-value intermediate chemical.

Establishing local ownership of the inside battery limits (ISBL) of the process is critical to ensure process sovereignty, reduce dependence on costly foreign licensing fees, reduce exposure to supply disruptions, and mitigate risks associated with export restrictions imposed by technology holders (Malaysian Palm Oil Board, 2019). Nevertheless, the key challenge lies in catalytic and process engineering, which governs reaction efficiency, selectivity, and overall process performance. Limitations in catalyst design and process optimisation represent a major bottleneck, directly impacting productivity and long-term profitability.

OBJECTIVES

Develop an Applied Catalytic Engineering Ecosystem

To build a practical catalytic engineering framework that brings together materials science, reaction engineering, and process design. This includes selecting and developing suitable catalysts, designing appropriate reactor systems, and establishing clear protocols for testing and scale-up, ensuring that laboratory findings are successfully translated into industrial applications.

ISSN 1511-7871
9 771511 787001

Head of Innovation Commercialisation Centre, Malaysian Palm Oil Board. 6, Persiaran Institusi, Bandar Baru Bangi, 43000 Kajang, Selangor, Malaysia.
Tel: 03-8769 4575 E-mail: tot@mpob.gov.my Website: www.mpob.gov.my

Develop the MPG Process

To design and refine the MPG process from initial concept through to commercial-scale implementation. This involves defining the reaction chemistry, optimising key operating conditions, selecting suitable equipment, and conducting validation trials to confirm that the process is technically sound, safe, and reproducible.

Process Economy and Profitability

To assess and demonstrate the commercial viability of the technology by conducting cost analyses, estimating capital and operating expenditures, and identifying revenue opportunities. This ensures that the technology is not only technically feasible but also financially competitive and capable of delivering sustainable long-term returns.

METHODOLOGY

Process Development

During the planning stage, we finalise the reaction and catalyst package. Pre-run will establish the integrity operational window (IOW), the critical process parameters (temperature, pressure, flow rate, feed composition) within which the catalyst and reactor system are expected to operate safely and reliably without degradation of performance or mechanical integrity, followed by continuous reactor operation for more than 150 hr. The produced product shall be subjected to quality control and meet the certificate of analysis.

a) **Process Quality Control (QC)**
Quality control underpins the reliability of all analytical data generated throughout process development and performance testing.
   i. Reference material such as a chemical standard.
   ii. Primary detection using gas chromatography.

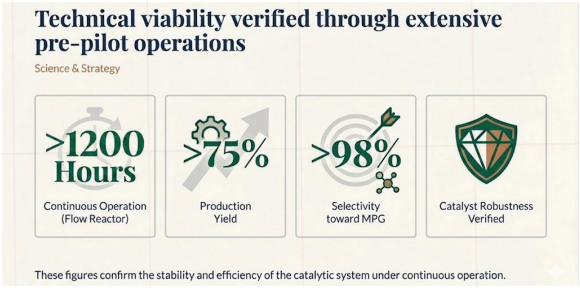
b) **Process Performance**
Catalyst performance evaluation is conducted using a dedicated flow reactor system, which enables controlled delivery of feed gases or liquids over the catalyst bed under variable temperature and pressure conditions. The reactor effluents are subjected to QC to identify product composition and to determine conversion and selectivity.

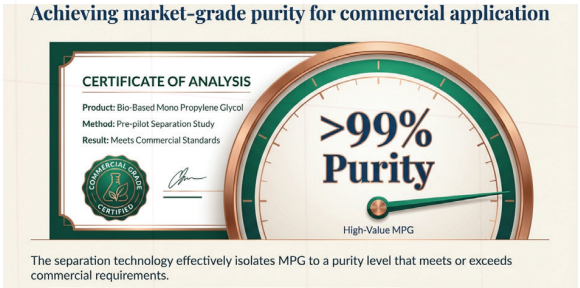
c) **Economic Analysis**
Net Present Value (NPV) is calculated at a discount rate of 8%, which reflects the minimum acceptable return on investment. The following financial indicators are determined: The break-even period and the Internal Rate of Return (IRR).

NOVELTY OF THE TECHNOLOGY

- Sustainable process technology enabling the production of bio-based MPG from glycerol through an inherently carbon-deficient process.
- First-of-its-kind in Malaysia, featuring a Malaysian-owned process and proprietary catalyst.
- Excellent catalytic-based production process delivering high yield and high selectivity toward MPG.
- Establishing local ownership of the process ensures national sovereignty, reduces dependence on costly foreign licensing, and mitigates risks associated with export restrictions.

BENEFITS AND ADVANTAGES





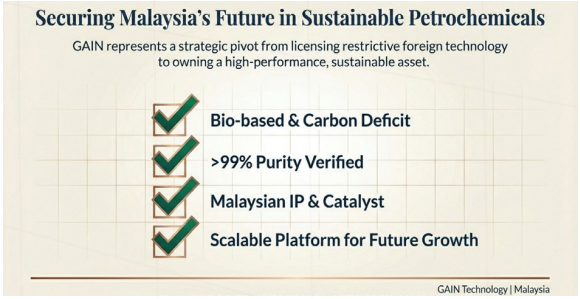


TABLE 1. ECONOMIC ANALYSIS OF BIO-BASED PRODUCTION

Economic analysis		Scenario 1 (Mass export-oriented)	Scenario 2 (Local consumption + few export-oriented)	Scenario 3 (Local consumption)	Scenario 4 (Startup)
Plant capacity		50,000 t/year (50 kTA or 150 t/day)	10,000 t/year (10 kTA or 30 t/day)	5,000 t/year (5 kTA or 15 t/day)	2,500 t/year (2.5 kTA or 7.5 t/day)
Typical capital expenditures (CAPEX)		RM400 million	RM80 million	RM40 million	RM20 million
Plant operating level		100% capacity	100% capacity	100% capacity	100% capacity
Cumulative net cash flow analysis (discounted factor at 8%)	Internal rate of return	39%	36%	34%	31%
	Net Present Value (NPV)=0 (breakeven)	Year 3	Year 3	Year 3	Year 3
	NPV (in 20 years)	RM3.6 billion	RM0.675 billion	RM0.320 billion	RM0.150 billion

IP STATUS

- Proprietary catalytic-based process and purification technology for the production of high-purity MPG including process operational parameters, scale-up know-how, and engineering design package protected through trade secrets and confidential technical know-how (*Figure 2*).
- Scale-up at Pulau Carey, Selangor.
- Trade secrets filing.
- Technology Readiness Level (TRL 7) - Detailed engineering design >80% completed.

Figure 2. Purified MPG and its application as a biobased coolant.

ECONOMIC ANALYSIS AND COMMERCIALISATION POTENTIAL

Net Present Value (NPV) is calculated at a discount rate of 8%, which reflects the minimum acceptable return on investment. The following financial indicators are determined: The break-even period and the Internal Rate of Return (IRR).

CONCLUSION

GAIN #1 (Glycol-only technology production) is well-positioned for early technology transfer, preferably as a technology collaborator (TC) at Pulau Carey, Selangor.

REFERENCES

Malaysian Palm Oil Board (MPOB). (2019). *JKPO development of palm-based oleochemical derivatives*. Kuala Lumpur, Malaysia. MPOB.