PALM-BASED SPECIALTY CHEMICAL FOR LUBRICANT

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Increasing environmental and climate change awareness have shifted the market trend from petroleum-based materials to more biodegradable and renewable chemicals. Stringent regulations by government have accelerated the adoption of bio-based lubricants (Sharma and Biresaw, 2016).

High biodegradability (Luna *et al*., 2015; Siti Afida *et al*., 2015), low toxicity and availability of palm-based esters chemicals have made them a lucrative alternative for lubricant feedstock. Excellent lubricity properties of palm-based esters are demonstrated based on the ester configuration in the triglyceride molecule. In general, some of the lubricant properties of vegetable oil are more superior compared to mineral oil such as high viscosity index, high flash point, high lubricity performance, and low evaporation loss.

Dimerate esters which can be produced by esterification of dimer acid and alcohol generally have good thermal and oxidative stability which make them excellent lubricant. Furthermore, the stability can be improved by hydrogenation of the double bonds. This diester is commonly used in two-stroke engine, predominantly in marine application as it provides low smoke properties and biodegradability for spilled or combusted oil. The degree of biodegradability of esters are generally higher than corresponding hydrocarbons (Buenemann *et al*., 2003).

NOVELTY

The production of dimerate esters were previously reported by esterification of dimer acid or esterification of fatty acid followed by dimerisation of the respective fatty esters. The esterification are commonly mediated by organic acid catalyst such as sulfuric acid (Zeki *et al*., 2010).

The technology eliminates the need of acid catalyst and organic solvent to produce hydrogenated dimerate esters with acid value as low as 0.06 mg KOH g^{-1} of sample. This technology emphasised on the green and sustainable energy approach which is one of Malaysia's economic growth key drivers. It is also aligned with MPOB's strategy for the production of dimerate esters for application as lubricant base oil.

In addition of excellent yield of product, as high as 96% per batch of reaction, this technology requires only removal of excess alcohol (reactant) by vacuum distillation for purification of product. Thus eliminate the need of acid neutralisation or additional work-up procedure applied as compared to that of using acid catalyst in the process. This technology also produces only water as by-product. Consequently, this will result in lower manufacturing and maintenance cost. The summary of the technology is illustrated in *Figure 1*.

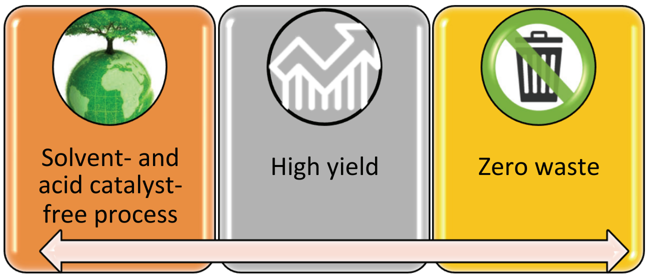

Figure 1. Highlights of solvent- and catalyst-free production of dimerate esters technology.

METHODOLOGY

This invention describes the production of a range of C_{36} dimerate esters for application as biolubricant base stock from C_{36} dimer acid, which can be derived from renewable fatty acid. This invention involves heating of dimer acid and alcohol for 24 hours at temperature between 150°C-200°C under atmospheric pressure with addition of up to 15 wt% of drying agent (Noor Armylisas *et al*., 2017). This invention disclosed the efficiency of water removal from the reaction process to obtain C_{36} dimerate esters with low acid value (as low as 0.06 mg KOH g^{-1} of sample) and excellent yield of product of can be obtained, as high as 96%.

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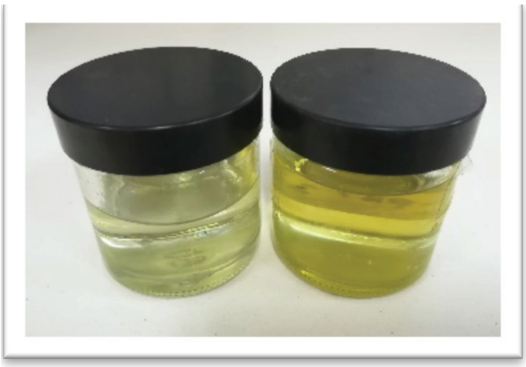

Figure 2. Image of two dimerate ester products with different chain length obtained by our technology.

ADVANTAGES

Advantages of esterification technology for production of dimerate esters are:

Elimination for need of acid catalyst and solvent by selection of right reaction temperature and efficient water removal set-up.

Sustainable and energy efficient process:
- by-product is water and unreacted alcohol which could be recycle.
- implies atom economy principles (as high as 98% atom economy) which considered as green synthesis.
- neither washing nor tedious work-up procedure is required.

Water and excess of alcohol can be **retrieved and reused** upon purification of the product by vacuum distillation.

Low production cost:
- No work-up/neutralisation process required.
- Only dimer acid, alcohol and drying agent required for this process.

In addition of production of dimerate esters, this technology could also be applied in other similar esterification process. Wide range of dimerate esters could be produced with excellent low temperature properties (*Figure 3*).

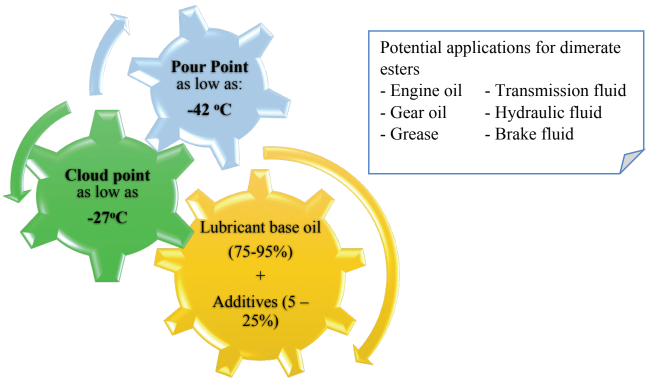

Figure 3. Low temperature properties of dimerate esters.

ECONOMIC ANALYSIS

The estimated investment cost for the production of dimerate esters using our technology is given below based on a plant capacity of 300 000 t yr^{-1} with capital investment of RM 3.4 million and RM 2.8 million yr^{-1} average operating expenditure (OPEX):

TABLE 1. ECONOMIC ANALYSIS OF OUR ESTERIFICATION TECHNOLOGY

Economic analysis	Value
Net present value (NPV)	RM 6.1 million
Internal rate of return (IRR)	32.87%
Payback period	4 yr
Benefit cost ratio (B:C)	1.31

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