

Plasticisers are additives that increase elasticity and flexibility of a material. They are known for their effectiveness in producing flexible plastics for applications in many industries such as automotive, medical and consumer goods (Benecke *et al.*, 2004). Plasticisers are one of the highly sought chemicals. They improve the properties of plastics, paints and varnishes, rubber, and adhesives. At present, the most commonly used plasticisers worldwide are phthalate based *e.g.* di(2-ethylhexyl) phthalate (DEHP) or commonly known as dioctyl phthalate (DOP), diisodecyl phthalate (DIDP), diisotridecyl phthalate (DITDP) and diisononyl phthalate (DINP). The DOP is by far the most widely used. Recent reports reveal that these petroleum-derived products have caused undesirable migration of the substrates. This has raised significant concerns on toxicity, especially after phthalate plasticisers have been found to leach out of medical plastics (Matthews, 1996; Chen *et al.*, 2011 and Zhou *et al.*, 2010). Hence, there is a need for plasticiser as an alternative to phthalates.

Nowadays, there is increasing interest in the use of natural or bio-plasticisers that are characterised by low toxicity and low migration. These are based on natural sources such as epoxidised triglyceride vegetable oils from soyabean, linseed, castor bean, sunflower, and fatty acid esters (FAE) (Baltacioğlu and Balköse, 1999). The epoxidised products were reported to be potential non-phthalate plasticiser (Rao *et al.*, 2012). Technology of epoxidised palm-based methyl oleate as plasticisers (*Palm-flexi Chem*) is a potential replacement for phthalate plasticisers.

THE TECHNOLOGY

Novelty

The process for *Palm-flexi Chem* has been filed for patent (PI 2016702567). The product fulfilled the industrial standard quality requirement. *Palm-flexi Chem* and DOP as control have been formulated into plasticiser. Plasticiser performance data were obtained on a 12 μm blown PVC thin film. The

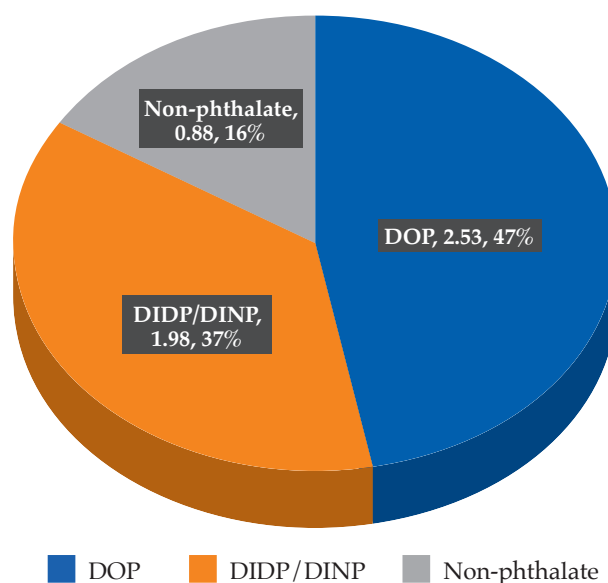
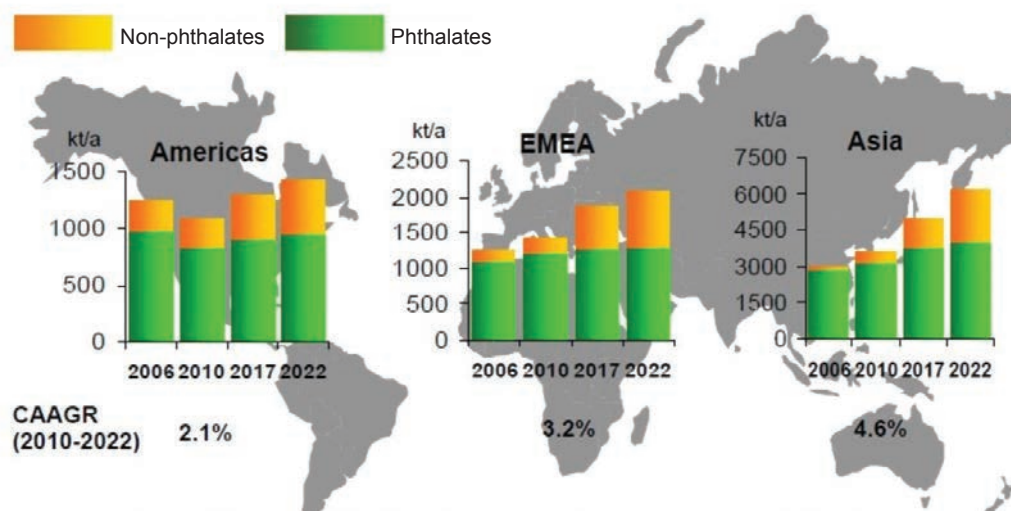


Figure 1. Market share of different plasticisers in million tonnes per year.



Demand for non-phthalate plasticisers will increase around the globe.

Figure 2. Phthalates and non-phthalates market demand in different region.

Source: Emanuel (2011).

resulting films from *Palm-flexi Chem* have had higher clarity than the commercial DOP film, and reduced static decay by half due to the primary ester linkage that actively interacts with air humidity. The hardness shore, tensile strength and elongation break of the PVC thin films increase with the content of *Palm-flexi Chem* compared to DOP. The plasticising effect of *Palm-flexi Chem* was higher because of its lower molecular weight and high compatibility with PVC. Despite the PVC thin film from *Palm-flexi Chem* has a higher tensile modulus than the PVC thin film from DOP, the plasticising effect was preserved. Moreover, the specific gravity of PVC thin film from *Palm-flexi Chem* was closer to that of the host polymer PVC.

Advantages

- Use renewable resources as feedstock.
- Non-toxic.
- Can replace DOP which is carcinogenic and banned in certain countries.
- Reduce migration of chemicals into plastic packed for food and beverages.

Market Analysis

The total market size of plasticiser worldwide in 2016 was 5.4 million tonnes. Phthalate based plasticiser has major market share of 84%. Non-phthalate plasticiser has accounted for about 16% market share. Bio-plasticiser and other

miscellaneous plasticiser have market share of about 5%-10%. The market share of various plasticisers is depicted in *Figure 1* (Melkeri, 2017).

The DOP plasticiser market in Europe and North America is decreasing, and non-phthalate-based plasticiser is replacing the conventional plasticiser. This is because of the ban imposed on the product by the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). This may not only lead to the growth in the non-phthalate plasticiser market, but may also result in many manufacturers switching to non-phthalate plasticiser and bio-plasticiser products. The non-phthalate plasticiser market is expected to witness substantial growth in the near future as compared to the DOP plasticiser (*Figure 2*).

ECONOMIC ANALYSIS

The estimated investment cost for *Palm-flexi Chem* is given below:

Economic analysis	Value
Estimated cost of plasticiser plant, RM	1.7 million
Production capacity	2000 t yr ⁻¹
Internal rate of return (IRR), %	25
Net present value (NPV), RM	793 884
Payback period, years	1.2

REFERENCES

Baltacioğlu, H and Balköse, D M (1999). Effect of zinc stearate and/or epoxidised soybean oil on gelation and thermal stability of PVC-DOP plastigels. *J. Applied Polymer Science*, 74: 2488-2498.

Benecke, H P; Vijayendran, B R and Elhard, J D (2004). Plasticisers derived from vegetable oils.

Chen, T; Yang, W; Li, Y; Chen, X and Xu, S (2011). Mono-(2-ethylhexyl) phthalate impairs neuro development: Inhibition of proliferation and promotion of differentiation in PC12 cells. *Toxicology Letters*, 201: 34-41.

Emanuel, C (2011). Plasticiser Market Update. *22nd Annual Vinyl Compounding Conference*.

Matthews, G (1996). PVC: Production, properties and uses, Woodhead Pub Limited.

Melkeri, T (2017). Plasticiser - A market scenario. Mumbai: Trademill Technologies Pvt. Ltd. <https://www.chemarc.com/content/plasticiser---a-market-scenario/> accessed on 30 January 2018.

Rao, N; Kaujalgikar, S; Chaudhary, B I; Bhide, S; Morye, S and Agashe, S (2012). Epoxidized fatty acid alkyl ester plasticisers and methods for making epoxidised fatty acid alkyl ester plasticisers. Google Patents.

Zhou, D; Wang, H; Zhang, J; Gao, X; Zhao, W and Zheng, Y (2010). Di-n-butyl phthalate (DBP) exposure induces oxidative damage in testes of adult rats. *Systems Biology in Reproductive Medicine*, 56: 413-419.

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