

PILOT PLANT SERVICE FOR CONTINUOUS ENZYMATIC INTERESTERIFICATION OF OILS AND FATS

NOOR LIDA HABI MAT DIAN; MISKANDAR MAT SAHRI; RAFIDAH ABD HAMID and MOHAMAD RODDY RAMLI



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In their native form, most edible oils have limited application in food products. They are often modified, chemically and/or physically, to alter their textural properties and enhance their functionality in food applications. Interesterification (IE) is a powerful tool for modification of the textural properties of oils and fats, and is currently the perfect alternative to hydrogenation. IE involves redistribution and interchange of fatty acids (FA) within and between the triacylglycerol (TAG) molecules of the oils and fats by means of an appropriate catalyst (Augustin and Versteeg, 2006). The result is a significant change in the physicochemical properties of the oils and fats, such as melting and crystallisation behaviour, viscosity and functionality (Lee *et al.*, 2012; Noor Lida *et al.*, 2007; 2006; 2002). No change to the FA composition occurs, and no formation of either *trans* or geometrical isomers of FA. Nowadays, the production of many textural foods such as margarines, shortenings and confectionery fats, rely heavily on the success of the IE process to produce tailor-made fats, which are free of *trans* FA. This is because IE can offer a real synergy between the textural properties and melting properties of the two constituting fats. IE fats are typically used for food applications such as margarines, shortenings and confectionery fats where the plasticity or texture of the fat is of utmost importance to the general appreciation of the product.

Two types of IE are available, namely chemical and enzymatic IE. Enzymatic IE, a lipase-catalysed process, has several advantages over chemical IE. This process is more specific, especially with the use of 1,3-specific lipase, resulting in custom-made fats which have the desired physical and nutritional properties that chemical IE is unable to attain (Zhang *et al.*, 2000). Enzymatic IE is carried out at low temperatures (normally at 55°C - 70°C), thus reducing cost and energy consumption. Enzymes are neither hazardous to the environment

nor dangerous to handle (Chen *et al.*, 2007; Desmet Ballestra, 2004). Furthermore, the stability of the oxidation-prone FA, minor components such as vitamin E, shelf-life and quality of products are preserved due to the lower operating temperatures (Marangoni and Rousseau, 1995). Enzymatically interesterified products are more natural than chemically interesterified products as if the process is catalysed by 1,3-position specific lipase, the FA at the 2-position, which is generally rich in essential unsaturated FA is preserved, and does not produce *trans* FA which are bad for health (Gunstone and Harwood, 2007). This is useful from a nutritional aspect, and is the reason why enzymatically interesterified oils are more acceptable to the health-conscious consumer (MacKenzie and Stevenson, 2000). If a non-specific lipase is used as catalyst, the enzymatic IE produces fats with physical properties similar to fats produced by chemical IE (Desmet Ballestra, 2004). Enzymatic IE is a simple and cost-efficient process. A specific melting profile of the fat is achieved by passing the oil once through the enzyme column. Neither washing nor bleaching of the interesterified fat is required as the low temperature enzymatic process produces no side-products. The amount of catalyst used is low, typically 0.2-0.4 kg enzyme/t oil. Oil loss is also much lower than with chemical IE. Continuous enzymatic IE process can be accurately controlled, which allows specific melting profiles to be achieved. This means that products with new and improved melting profiles can be produced (Desmet Ballestra, 2004).

DESCRIPTION OF CONTINUOUS MULTI-COLUMN ENZYMATIC INTERESTERIFICATION PILOT PLANT

The Continuous Multi-column Enzymatic Interesterification Pilot Plant at the Malaysian Palm Oil Board (MPOB) (Figure 1) is a four-column reactor. Each column can be filled with

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Malaysian Palm Oil Board, Ministry of Plantation Industries and Commodities, Malaysia

6 Persiaran Institusi, Bandar Baru Bangi, 43000 Kajang, Selangor, Malaysia.

Tel: 03-8769 4400

Fax: 03-8925 9446

Website: www.mpo.gov.my



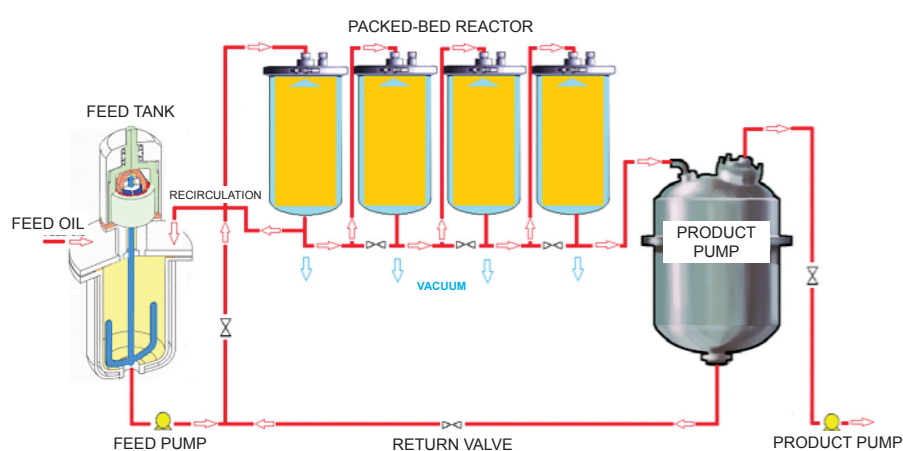


Figure 1. Continuous Multi-column Enzymatic Interesterification Pilot Plant at the Malaysian Palm Oil Board.

10 kg of enzyme (lipase). The Continuous Multi-column Enzymatic Interesterification Pilot Plant comprises:

- A temperature-controlled stainless steel feed tank (of 150 kg capacity).
- Four temperature-controlled enzyme columns (each packed with 10 kg enzyme).
- A temperature-controlled stainless steel product tank (of 150 kg capacity).

CONTINUOUS ENZYMATIC INTERESTERIFICATION PROCESS

Enzymatic IE modifies the physical properties of oils and fats by the interchange of FA between and within the different TAG molecules. The reaction

is catalysed by lipase at reaction temperature of about 60°C - 70°C. The continuous enzymatic IE process involves the following steps:

- Moisture-free oil at a temperature of 60°C - 70°C is continuously pumped (at a rate of 1.5 to 2.5 kg oil/ kg enzyme/ hr) from a feed tank into the reaction columns which are packed with 10 kg of lipase each. The temperature of the packed columns is kept at 60°C - 70°C by a hot water circulation system.
- The interesterified oil exiting from the reaction columns is collected in a product tank.
- A light post-deodorisation step is carried out (if necessary) to remove residual free fatty acid (FFA), which is normally less than 1.0%.

CHARACTERISTICS OF THE ENZYMATICALLY INTERESTERIFIED OIL

The interesterified oil produced by the Continuous Multi-column Enzymatic Interesterification Pilot Plant is of good quality with a very low FFA content (< 1.0%), thus, requiring only mild refining. The solid fat content profile of interesterified oil produced using the Continuous Multi-Column Enzymatic Interesterification Pilot Plant is shown in Figure 2. Enzymatic IE can produce fats with physical properties similar to fats produced by chemical IE.

ADVANTAGES OF CONTINUOUS MULTI-COLUMN ENZYMATIC INTERESTERIFICATION PILOT PLANT

- Uses simple, clean, safe and continuous process. Enzymatic IE of oils and fats is achieved by passing the oil continuously and only once through the enzyme columns.
- It operates at low temperatures (60°C - 70°C) depending on the type of enzyme used to catalyse the reaction.
- No or very mild post-treatment (bleaching and deodourisation) of the interesterified oil. The Continuous Enzymatic Multi-column Interesterification Pilot Plant produces a natural and good quality interesterified oil with FFA content of <1.0%.
- It has a wide range of production capacity, *i.e.* from 1.5-2.5 kg oil/ kg lipase/ hr, which means

that the pilot plant is able to produce 60 - 100 kg of interesterified oil per hour if it is run at full capacity using all four columns.

- Low oil losses.

SERVICE OFFERED

MPOB offers a service of a continuous enzymatic IE process for oils and fats using the Continuous Multi-column Enzymatic Interesterification Pilot Plant. The service is offered at a minimal fee, depending on the type of catalyst used, production capacity and post-treatment involved. The service fee includes the IE and post-treatment (if necessary) processes, sample analyses before and after IE [FFA content, solid fat content, differential scanning calorimetry (DSC) melting and crystallisation properties and slip melting point], and consultation.

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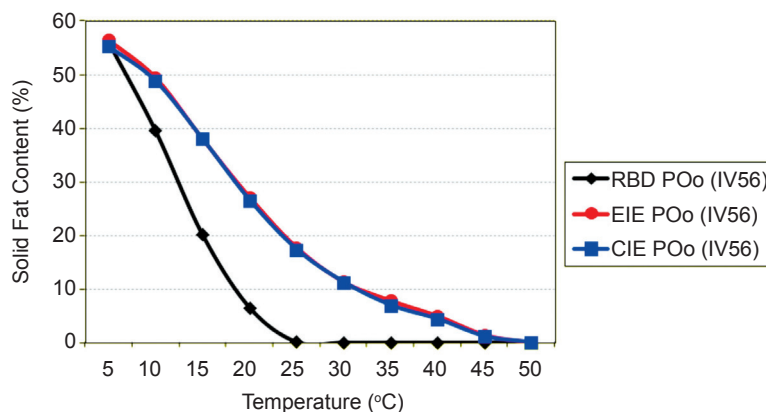


Figure 2. Solid fat content profile of palm olein with iodine value of 56 before interesterification (RBD POo IV56), after enzymatic interesterification (EIE POo IV56) catalysed by non-specific lipase using Continuous Enzymatic Interesterification Pilot Plant, and after chemical interesterification (CIE POo IV56) catalysed by sodium methoxide.

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For more information, kindly contact:

Director-General
MPOB

6 Persiaran Institusi, Bandar Baru Bangi,
43000 Kajang, Selangor, Malaysia.

Tel: 03-8769 4400

Fax: 03-8925 9446

www.mpob.gov.my