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Interaction Between Palm Stearin and Milk Fat Fractions and Their Implication for the Preparation of Cold Spreadable Fats

Cho Mar Kyi

Abstract

The demand for convenience (e.g., spreadable at refrigeration temperature) and health (inclusion of polyunsaturated fat and absence of trans fatty acids) is reflected in the composition of the fat spreads available in the market today. Two types of fat spreads are available, i.e. butter and margarine. In the production of cold spreadable fat, different oils and fats are blended to make a product that is spreadable at refrigerated temperature. However, incompatibilities between fats limit the use of modified fat in confectionery products. To understand interaction between palm stearin and milk fat fraction, the effects of blending and interaction on the physicochemical characteristics of the blends were studied. Anhydrous milk fat (AMF) was fractionated by two-stage acetone fractionation process to produce three fractions: high melting (HMF), middle melting (MMF) and low melting (LMF) fractions. To study purity, laboratory milk fat fractions were compared with commercial milk fat fractions. Then palm stearin and milk fat fractions were blended in various ratios. The characteristics of the palm stearin based blends were tailored to resemble oil blends extracted from commercial soft margarine. It was found that the purity of laboratory fractions were better than the commercial fractions. Eutectic interaction was observed in the bends, indicating the limited compatibility between two fats. Results showed that eutectic interactions could be eliminated by interesterification. However a bigger increase in slip melting point (SMP) and solid fat content (SFC) restrict its use in cold spreadable fat. Formulation diagrams showed that cold spreadable fat could be produced by blending of 16.7% of soft palm oil stearin, (sPOs), 16.7% of MMF and 66.6% of LMF before interesterification. Similarly, uninteresterified ternary blend containing 9% of hard palm oil stearin (hPOs), 15% of MMF and 76% of LMF could be used to produce the cold spreadable fat. However, the texture of the product may change during storage due to eutectic effect. Interesterification of these blends results in increase SFC>32% at 10˚C in all ternary mixture. This increase caused reduction in spreadability and hence rendered them less suitable as cold spreadable fats.

Demonstrator, Industrial Chemistry Department, University of West Yangon

Introduction

Customers always choose their foods according to their palatability and for their nutritional values. Cold spreadable fat has become one of the leading foods consumed in many countries because of its good qualities and nutritional values. In addition, the demand for convenience (e.g. spreadable at refrigeration temperature) and health (inclusion of polyunsaturated fat and absence of trans fatty acids) is reflected in the composition of the fat spreads available in the market today. Spreadable fats are water in oil emulsion. They are composed of liquid oil, fat crystals and water. Fat crystals provide the key structural functionality in cold spreadable fat and liquid oil provides spreadability.

In the formulation of cold spreadable fat, different oils and fats are blended to make a product that is spreadable at refrigerated temperature and its spreadability resembles that of butter. On formulating oil blends, for making margrine, the food processor has a number of oil and his choice will depend on various factors. Among which are cost, availability, functionality and requirement of consumers. Palm stearin is cheaper fraction obtained from fractionation of palm oil and this raw material is available locally in Malaysia. Milk fat provides excellent sensory and physical properties in many applications (Chrysam, 1996).

However, the composition of butter oil varies greatly according to the seasonal variation, the composition of feed, stage of lactation, genetic variation and other factors. Its variable physico-chemical properties and lack of functionality restrict its use in food industry. Recently it is suggested that by combining multistep fractionation and blending with other fats, it would be possible to overcome the functionality problems and seasonal variaions of butter oil. (Defense, 1998).

Therefore, palm stearin and milk fat fractions are possible raw material for cold spreadable fat. However blending of certain oils and fats can cause eutectic mixture. Eutectic mixture is a term normally used to describe margarine melting point of which is lower than its components. It is too soft at the beginning and later separates into layers of oil, usually unsatisfactory products.

The formation of eutectic mixture in a fat blend result of dissimilarity in glyceride composition among these fats and oil. Eutectic mixture indicates certain limit of compatibility (inhomogenity). (Talbot, 1995)

Intereasterification process is rearrangement of fatty acid distribution on glycerol backbone. Interesterification process will be used to minimize the inhomogenity among these fats and oils. However, interesterified products can cause an increase in melting point and solid fat content changes. Melting point and solid fat content of product is very important for cold spreadable fat. This increase caused reduction in spreadability. (Grvriilidou, 1991)

A solid fat content (SFC) of not greater than 32% at 10˚C is essential for good spread ability at the refrigeration temperature. (Norrlida, 1998)

Therefore, the objective of this research is to study the interaction between milk fat fractions and palm stearin before and after chemical interesteification and to decide whether formulating oil blends (palm sterarin and milk fat fractions) are suitable or not for cold spreadable fat.

Materials and Methods

Hard palm oil stearin (hPOs), middle melting milk fat fractions (MMF) and low melting milk fat fraction (LMF) were used in formulation (1) and soft palm oil stearin (sPOs), MMF and LMF were also used in formulation (2).

Preparation of HMF, MMF and LMF of Milk Fat

Commercial anhydrous milk fat (AMF) was fractionated on the basic temperature (20, 10 and 5 ˚C) by acetone fractionation process to provides three milk fat fractions i.e. high melting milk fat fraction (HMF), middle malting milk fat fraction (MMF), and low melting milk fat fractions (LMF).

Simple Blending

Commercial sample of hard palm oil stearin (hPOs) and soft palm oil stearin (sPOs) were obtained from Lam Soon Malaysia San Bhd. Petaling Jaya, Malaysia. MMF & LMF were obtained from acetone fractionations of milk fat.

These oils and fat were blended in various ratios in a ternary system of hPOs: MMF: LMF and SPOs: MMF: LMF. Blending in different ratios produced a matrix of 16 samples. Each blend was prepared in duplicate.

Their solidification and melting character, solid fat content (SFC), crystal habit and polymorphism were studied by using differential scanning calorimetry (DSC), nuclear magnetic resonance (NMR) and X-ray diffraction.

Chemical Interesterification of Fat Mixture

The blends were subjected to chemical interesterification (I.E) under the following conditions: temperature, 110 ˚C, catalyst , 0.2% sodium methoxide; reaction time, 30 min; and stirring speed, 500 rpm. The blends were then studied for their physico-chemical properties such as fatty acid composition (FAC), slip melting point (SMP), polymorphic behaviour, and solid fat content (SFC). Melting characteristics of the blends were also studied.

Results and Discussion

Melting Behavior of Anhydrous Milk Fat Fractions

First, the melting characteristic of laboratory milk fat fractions were studied by using differential scanning calorimeter (DSC) which directly measure the energy needed to melt a crystal.

In the DSC melting thermogram, the temperature that indicate melting of first crystals is called on-set temperature, while the temperature at the end of melting curve is called the off-set temperature. The area between the enthalpy curve and base line indicates the specific melt enthalpy, which is necessary for melting the existing crystal. Peak temperature is the major melting point of triglyceride. To study the purity, laboratory milk fat fractions were compared with commercial milk fat fractions. DSC melting diagram of commercial and laboratory milk fat fractions showed that the purity of laboratory milk fat fractions were better than the commercial fractions shown in Fig.1 (a,b,c)

Melting Behavior in Ternary System

Fig (2) showed DSC melting diagram of high, middle and low melting fractions of sPOs: MMF: LMF(1:1:4) and hPOs: MMF:LMF (1:1:4). Figure showed that Chemical interesterification of the blend resulted in an increased in proporiton of high melting fraction. The shift of the middle melting fraction to high melting fraction was pronounced after interesterification. This showed that all these modified blends were harder than the native blends.

Changes in slip melting point and solid fat content of different ternary blends shown in Table (1) and (2).

Table (1) Changes in slip melting point of different ternary blends before and after chemical interesterification

Set	% W/W	Slip Melting point (SMP˚C)		SMP difference
		Before interesterification	After interesterification	
A	hPOs: MMF: LMF (1:1:4)	42.5	50	+7.5
B	sPOs: MMF: LMF (1:1:4)	33	40.1	+7.1

Table (2) Changes in solid fat content (SFC%) BY NMR of different ternary blends before and after chemical interesterification

Set	% W/W	Solid Fat Content (SFC) %		SMP difference
		Before interesterification	After interesterification	
A	hPOs: MMF: LMF (1:1:4)	29.5	47.34	+ 17.84
B	sPOs: MMF: LMF (1:1:4)	21.19	46.0	+ 24.81

Table 1 and 2 showed that the SMP & SFC for blend set A & B had a bigger increase in SFC & SMP after chemical interesterification. This bigger increase in SFC upon interesterification with sodium catalyst was probably due to the replacement of low melting unsaturated fatty acid with saturated fatty acid in the triglyceride molecule.

Eutectic Behaviour in Ternary Blends

Figure 3. (a,b,c) showed SFC data analysis of isosolid diagrams of sPOs: MMF: LMF (1:1:4) and hPOs: MMF: LMF (1:1:4) before & after chemical interesterification. Talbot (1995) suggested that if the lines in isosolid diagram are parallel then the two component exhibit good compatibility. These isosolid diagrams showed that eutectic interaction was observed in the blends before interesterification, indicating that the limited compatibility be two fats.

Interesterification of these blends results bigger increase in SFC at all ternary mixture. It was also found that interesterification process could be minimized the eutectic effect, indicating that good compatibility.

Palm Stearin Based Formulation

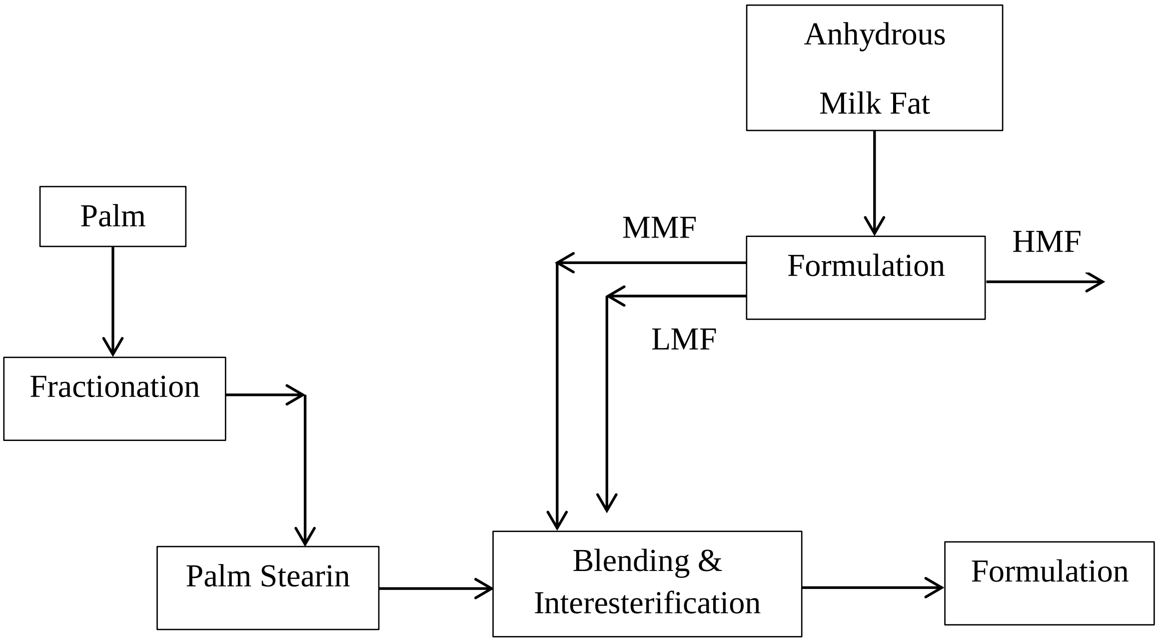
The formulation of fat/oil phase is based primarily on the relationship between specific physical measurements in particular the solid fat content (SFC), (SMP) and the composition of the fat/oil blend. The SFC, i.e. the amount of fat crystals in the blends is responsible for texture properties in many products. Noor Lida and Ali (1998) reported that SFC between 4 and 10˚C determines the ease of spreading of the product refrigeration temperature. A SFC of not greater than 32% at 10˚C is essential for good spreadability refrigeration temperature. (Noorlida, 1998)

Based on both SMP and SFC profiles, it can be concluded that in order to produce a soft margarine, the points within shaded areas were used to indicate the possible formulation blends. The common area obtained when the SFC data was superimposed on SMP (Fig. 4a & b) indicated that the suitable formulation for sPOs: MMF: LMF blend was located sPOs 16.6%, MMF 16.6% LMF 66.6% for middle point. Similarly, in the ternary hPOs based blends, the A' point for hPOs, MMF and LMP were 9%, 15% and 70%, while B' point were 13%, 14%, 7% and 78% respectivity were obtained before interesterification. However, the texture of the product may change during storage due to eutectic effect.

Fig.3 (c & d) showed the isoline of SFC diagram for interesterified, sPOs: MMF: LMF: and hPOs: MMF: LMF blends. There was a bigger increase in SFC>32% in both type of palm stearin based blends after interesterification. Therefore SFC isoline diagrams of these mixtures showed that none of them were suitable for soft margarine formulation.

Conclusion

It was found that the chemical interesterification could promote a greater homogeneity in the physical properties of the finished products compared to unmodified blend. However, the interesterification of these blends resulted an increased SFC>32% at 10˚C in all ternary mixture. This result indicated that none of palm stearin based blends were suitable for soft margarine but new fats with different ranges in plasticity for specification can be produced by employing this modification process.



Flow Diagram for the Preparation of Cold Spreadable Fat

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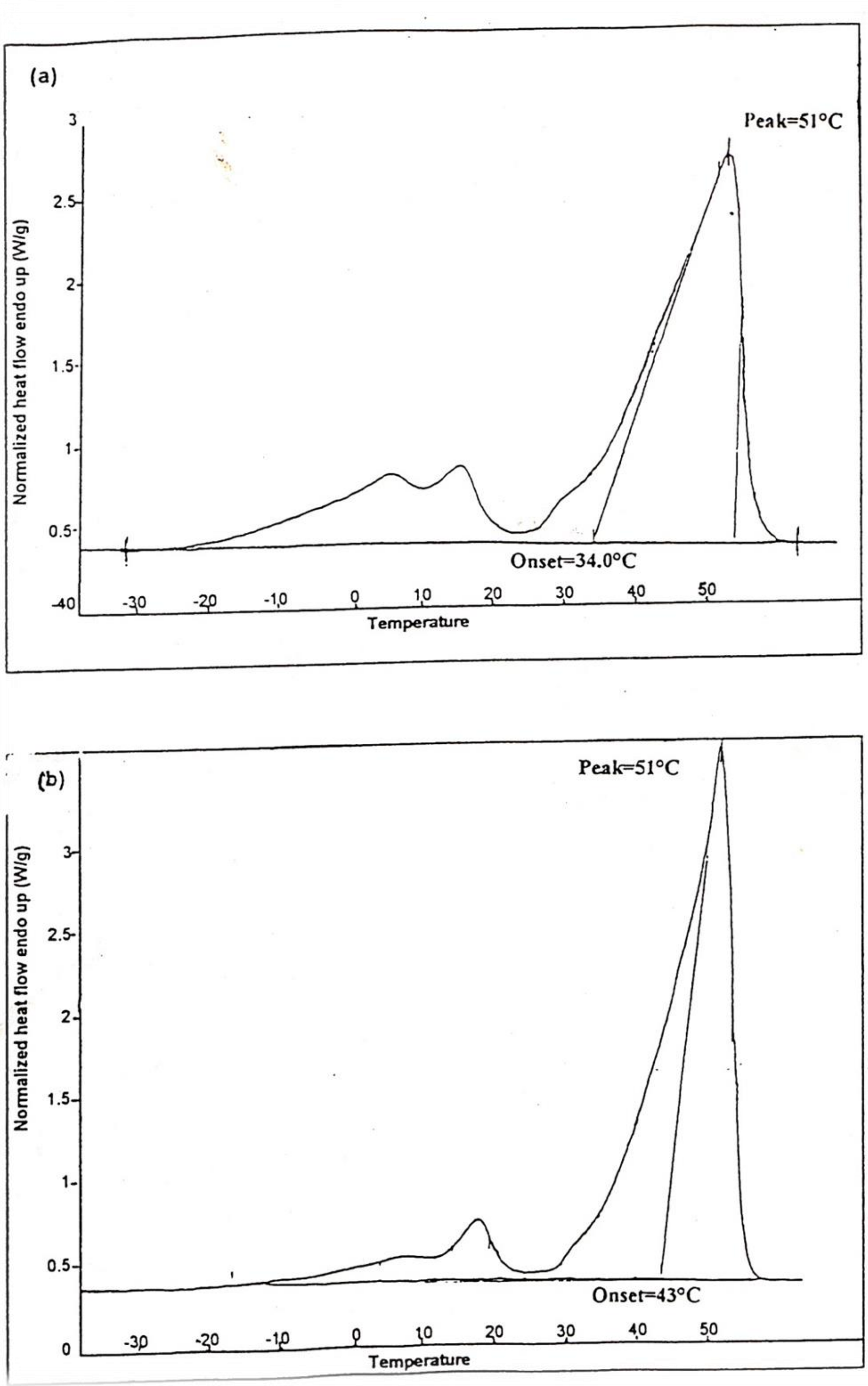

Figure 1.a DSC melting profile of (a) commercial (b) laboratory HMF

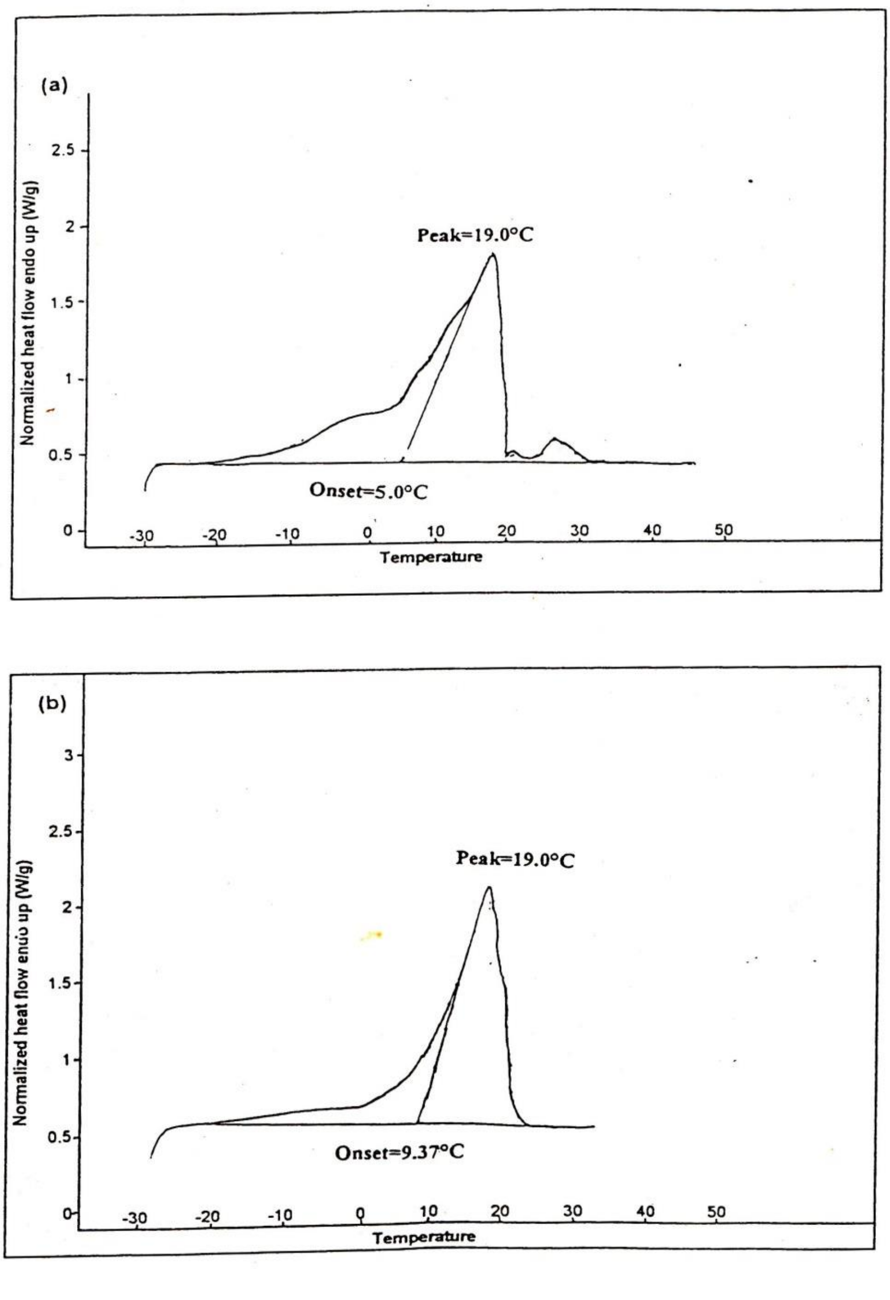

Figure 1b. DSC melting profile of (a) Commercial (b) laboratory MMF

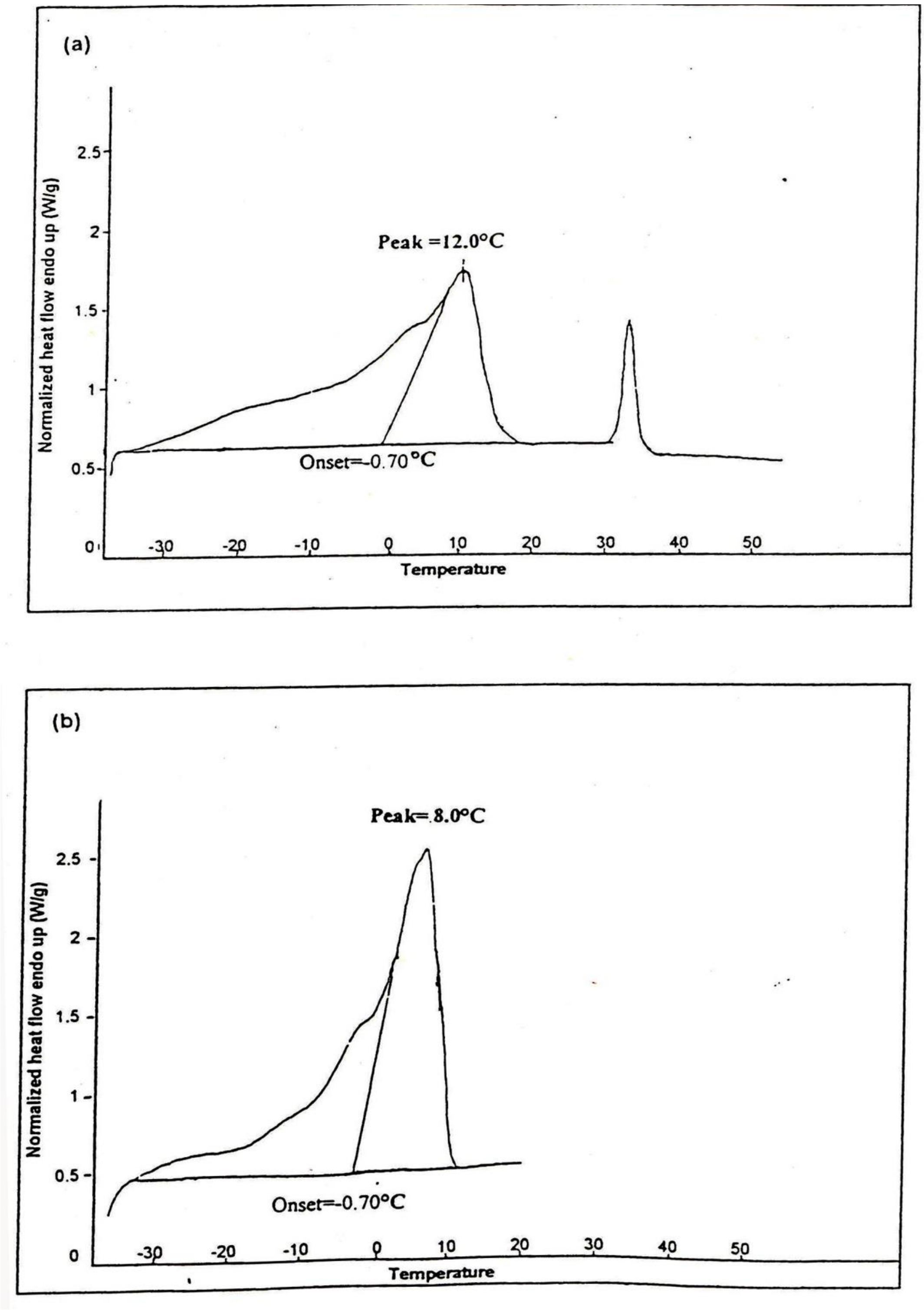

Figure 1c. DSC melting profile of (a) Commercial (b) laboratory LMF

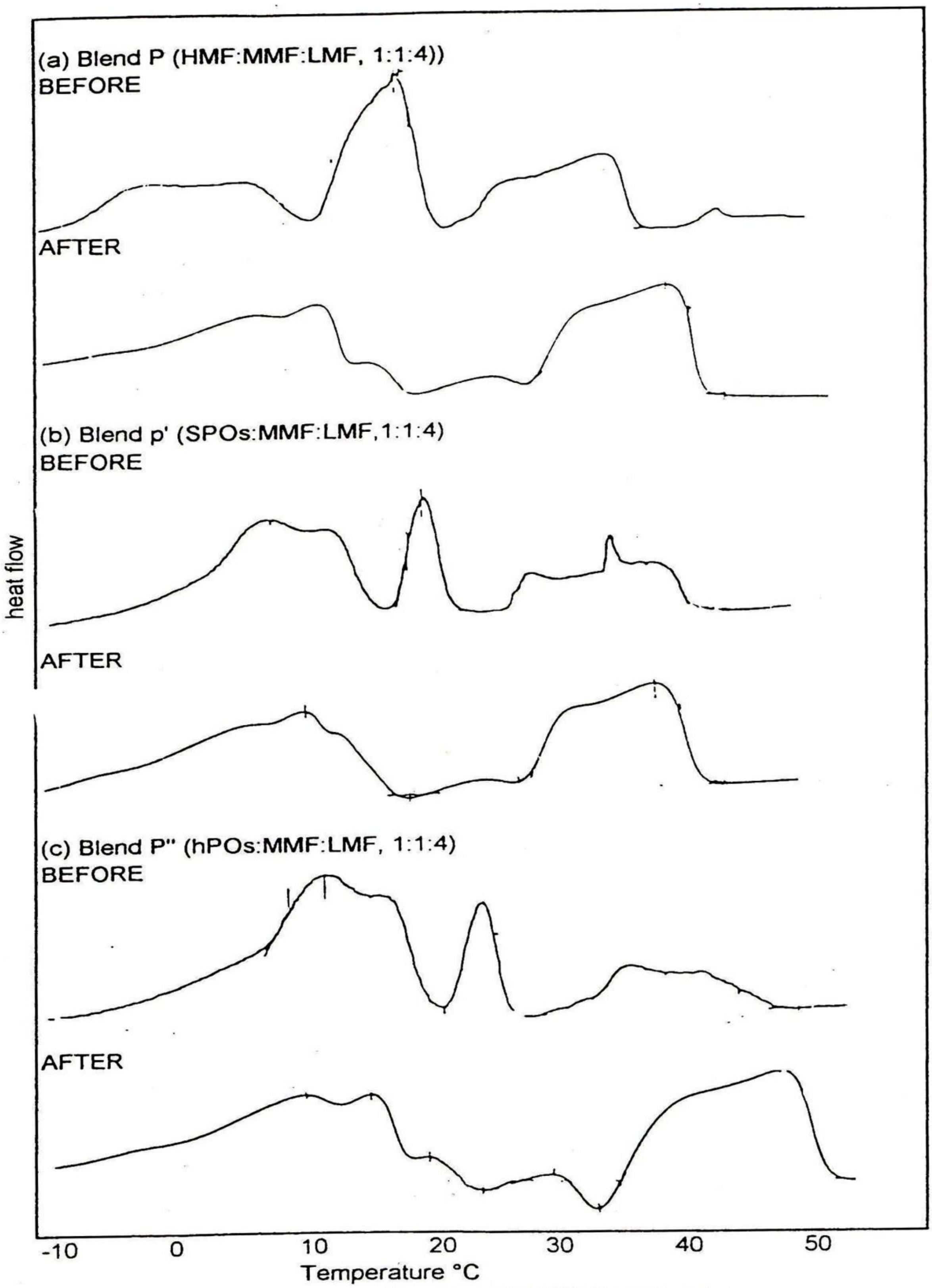

Figure 2 DSC melting profile of (a) HMF: MMF: LMF 1:1:4

(b) SPOs MMF LMF 1:1:4 (c) hPOs MMF: LMF, 1:1:4

Before and after chemical interesterification

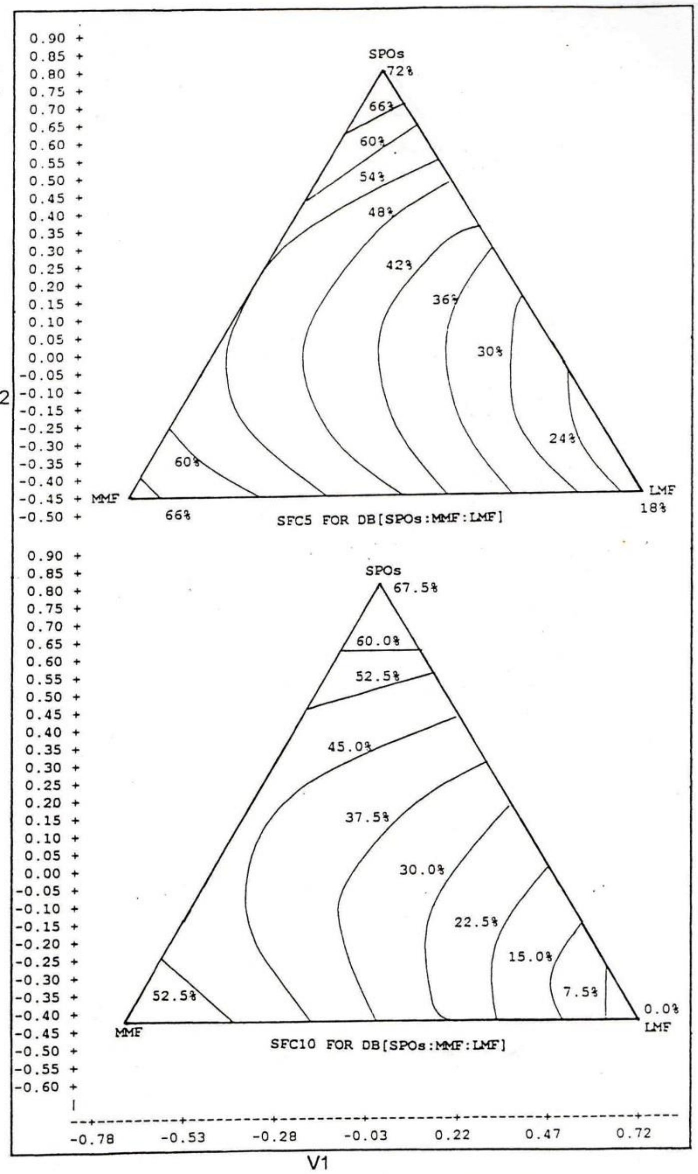

Figure 3a Iso-solid diagram of blends SPOs MMF:LMF at 5˚C and 10˚C before chemical interesterification

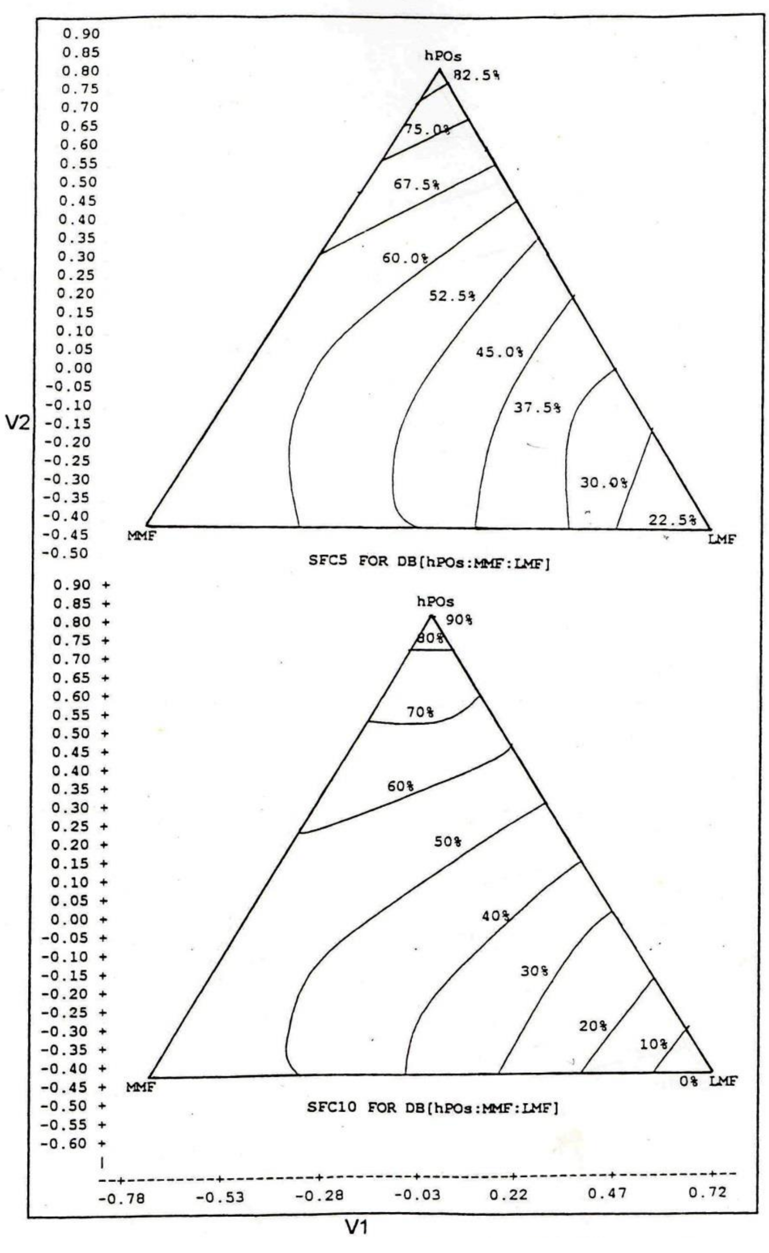

Figure 3b Iso-solid diagram of blends SPOs MMF:LMF at 5˚C and 10˚C before chemical interesterification

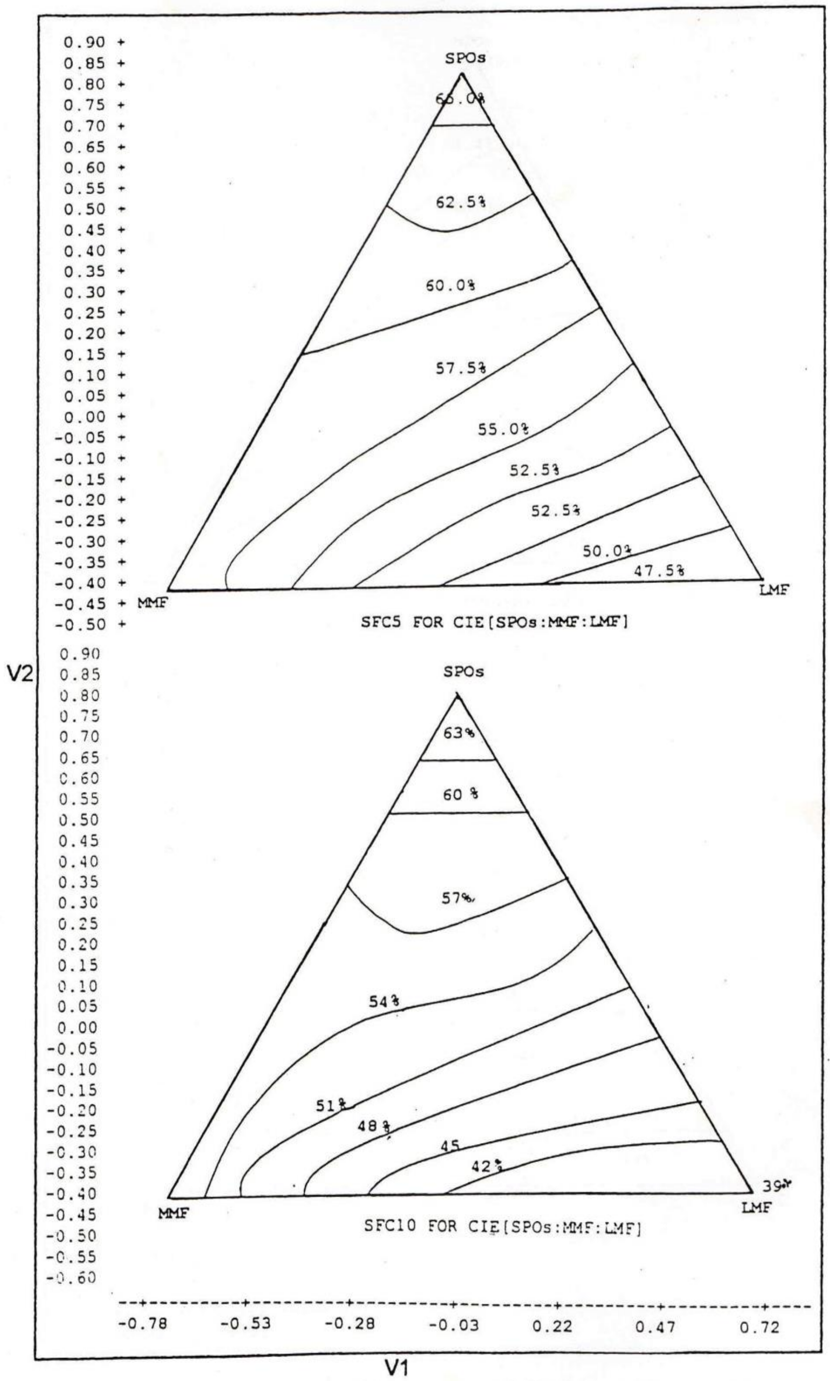

Figure 3c Iso-solid diagram of blends SPOs MMF:LMF at 5˚C and 10˚C before chemical interesterification

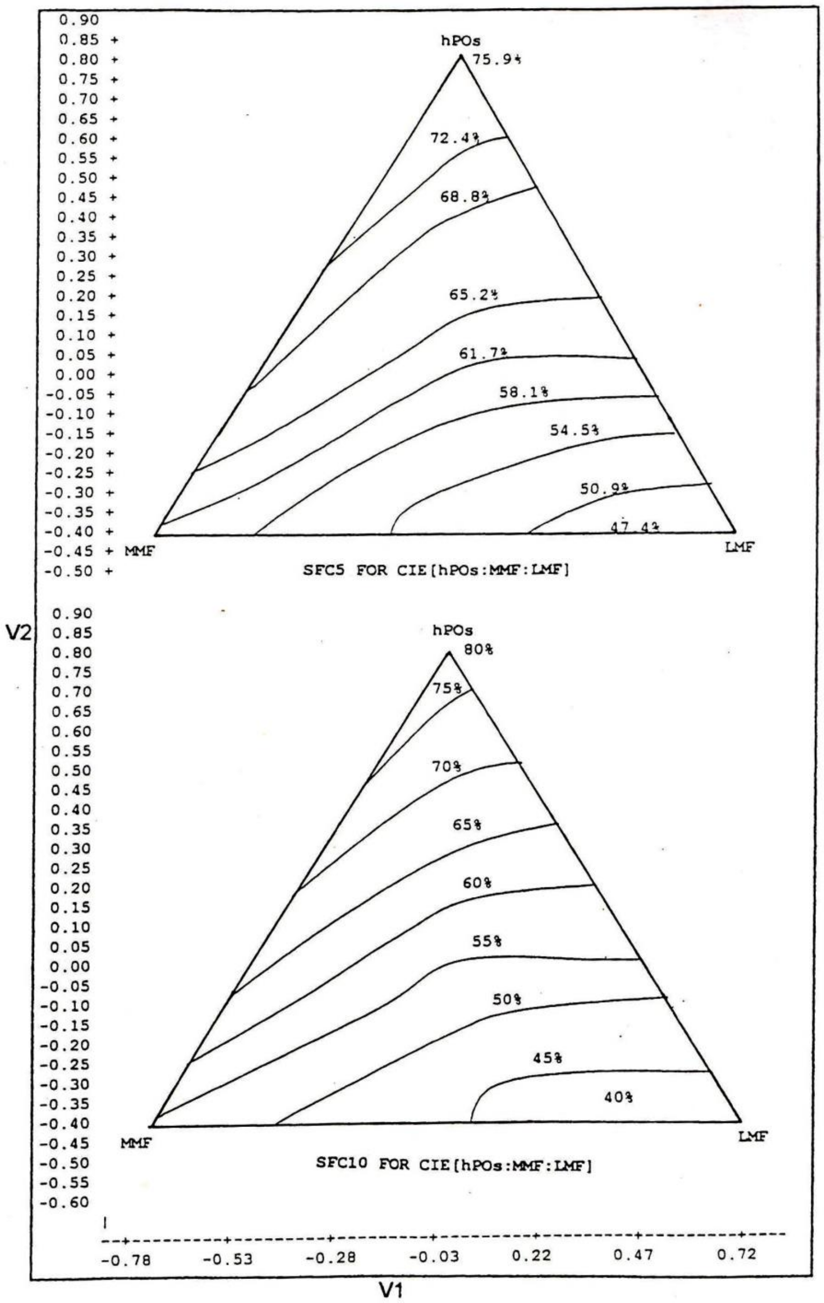

Figure 3d Iso-solid diagram of blends hPOs: MMF:LMF at 5˚C and 10˚C after chemical interesterification

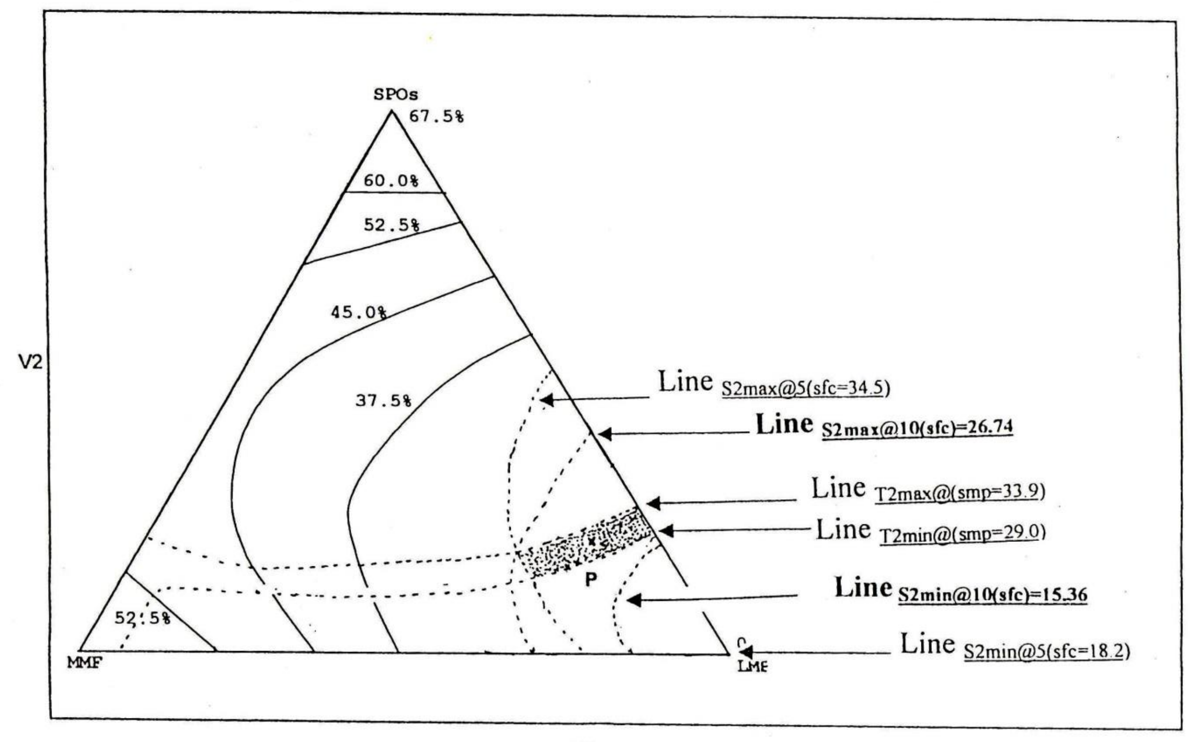

Figure 4a Superimposed iso-line diagram of solid fat content at 5˚C and 10˚C with slip melting point of unreacted SPOs:MMF:LMF blends

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