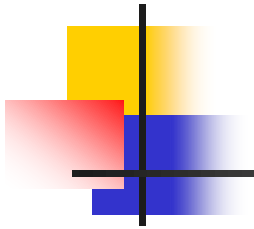


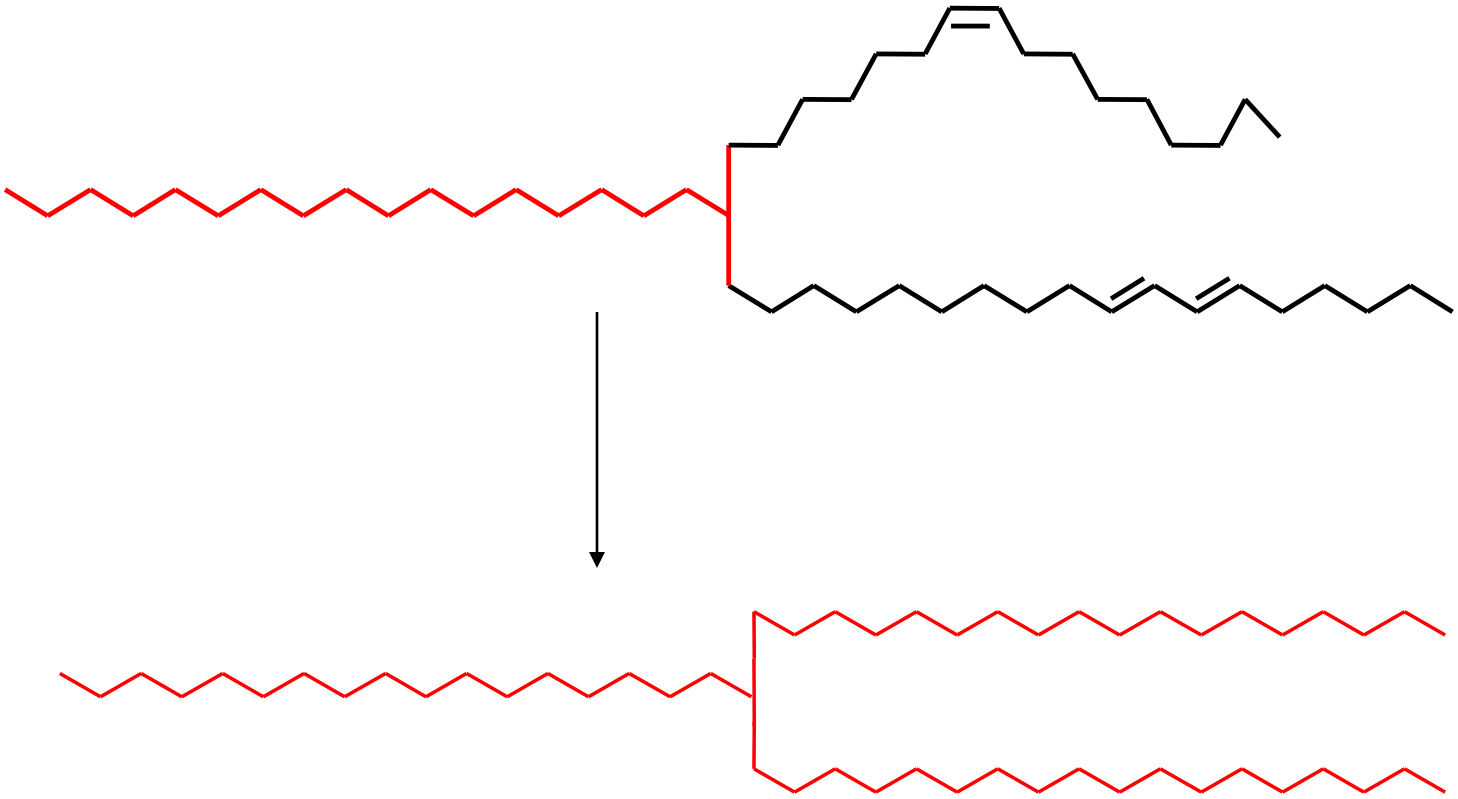
INTERESTERIFICATION

Interesterification

Interesterification involves an exchange of acyl group among triglycerides.

Acyl groups may exchange positions within a triglyceride or among triglyceride molecules.

Interesterification



Probablity of Different Triglycerides Formation

If A, B, and C are the molar percentages of fatty acids A, B, and C for a commercial oil,

Then, molar percentage of glycerides containing only 1 acid is:

$$\% \text{ AAA} = A^3 : 10{,}000$$

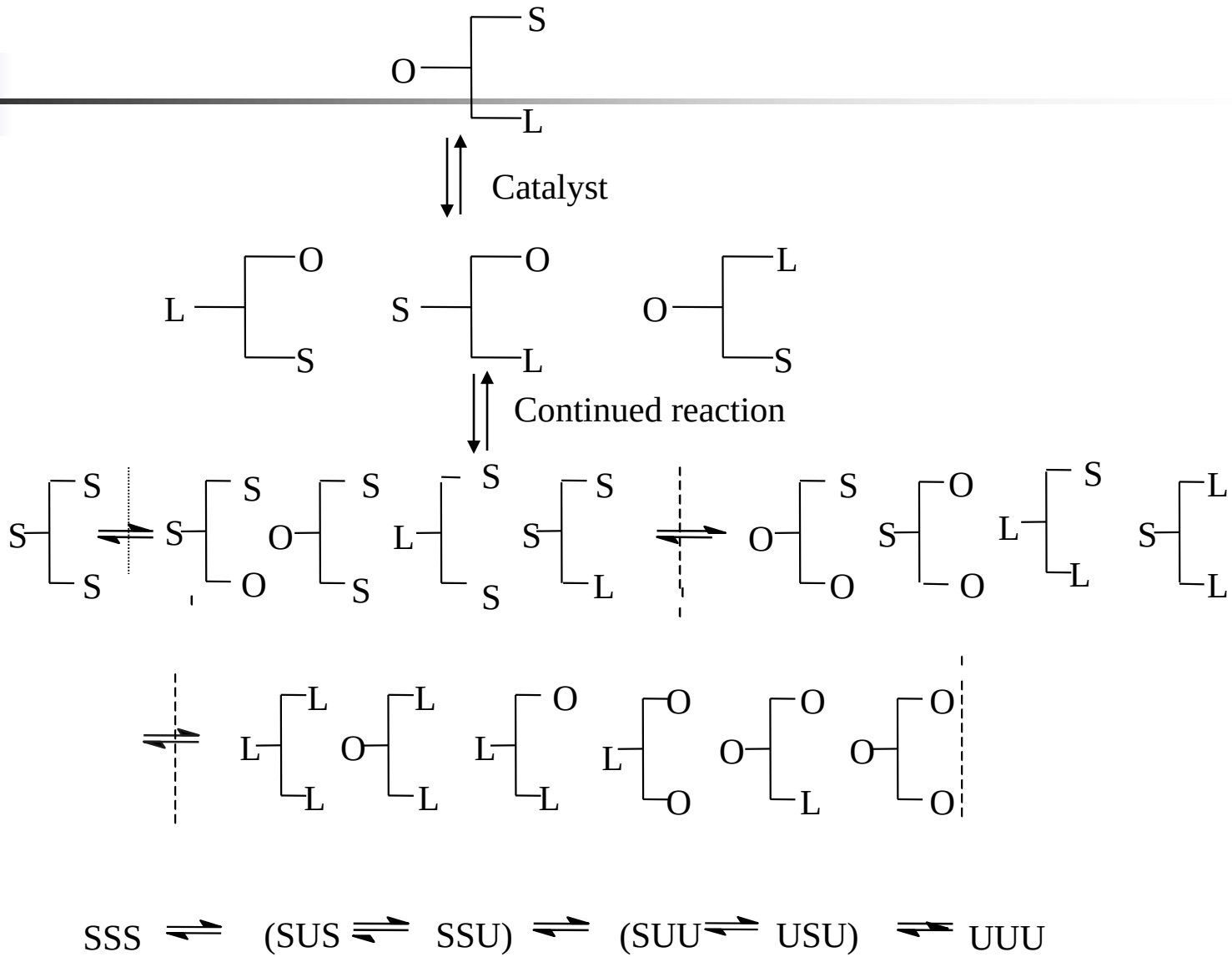
Molar percentage of glycerides containing 2 acids is:

$$\% \text{ AAB} = 3A^2B : 10{,}000$$

And molar percentage of glycerides containing 3 acids is:

$$\% \text{ ABC} = 6ABC : 10{,}000$$

Intraesterification, Interesterification and Equilibrium Mixture.



Random Interesterification

A. S (Stearic acid 35%)
O (Oleic acid 30%)
L (Linoleic acid 35%)

B. S (50%)
O (40%)
L (10%)

After random interesterification, the triglyceride compositions are:

Sample A		Sample B	
Triglyceride	%	Triglyceride	%
SSS	= 4.3	SSS	= 12.5
OOO	= 2.1	OOO	= 6.4
LLL	= 4.3	LLL	= 0.1
SSO	= 11.0	SSO	= 30.0
SSL	= 12.8	SSL	= 7.5
OOS	= 9.5	OOS	= 24.0
OOL	= 9.5	OOL	= 4.8
LLS	= 12.8	LLS	= 1.5
LLO	= 11.0	LLO	= 1.2
SOL*	= 22.0	SOL*	= 12.0

*Total triglycerides containing 3 different fatty acids.

Catalysts

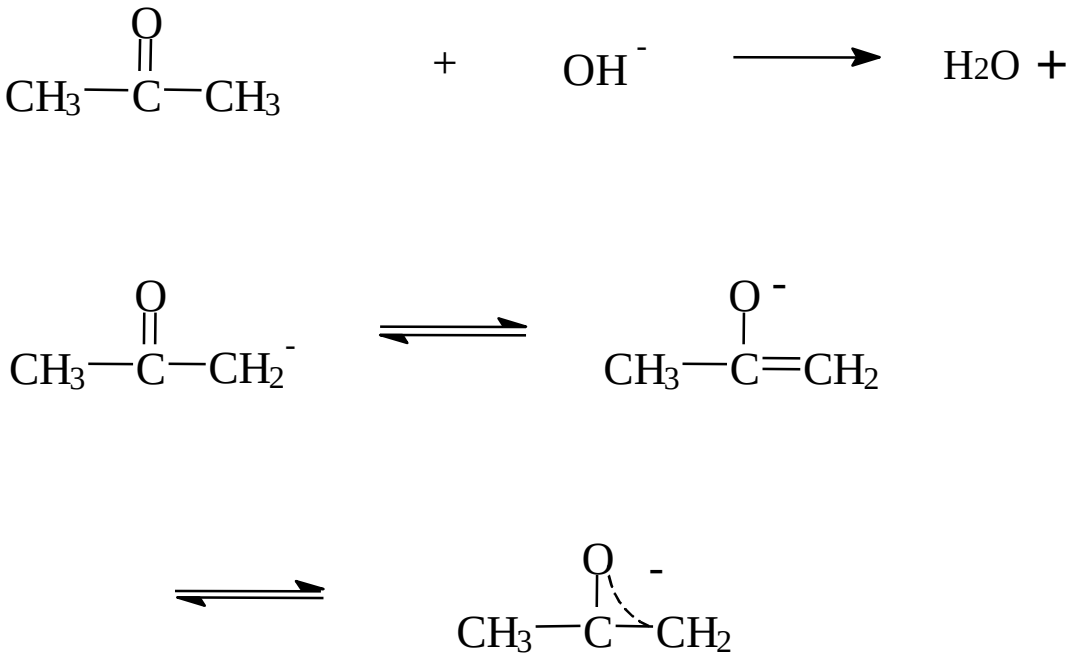
- High temperature catalysts: KOH and NaOH
- Low temperature catalysts: Sodium Methoxide ($NaOCH_3$)

Reaction Mechanisms

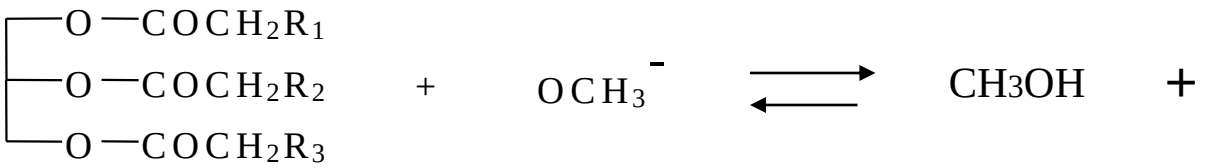
1. The formation of enolate ion
2. The formation of Beta-Keto ester
3. Interesterification

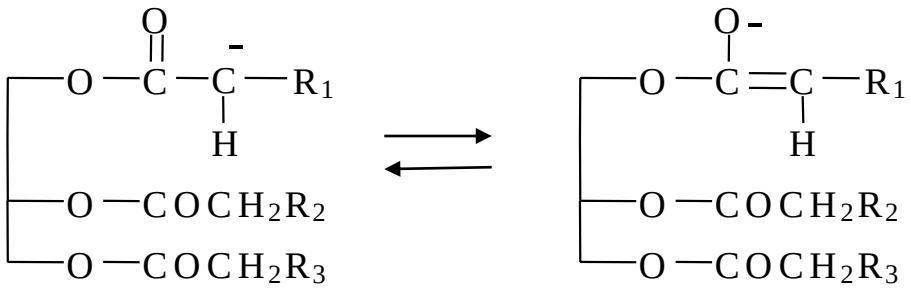
Catalyst Function in Interesterification

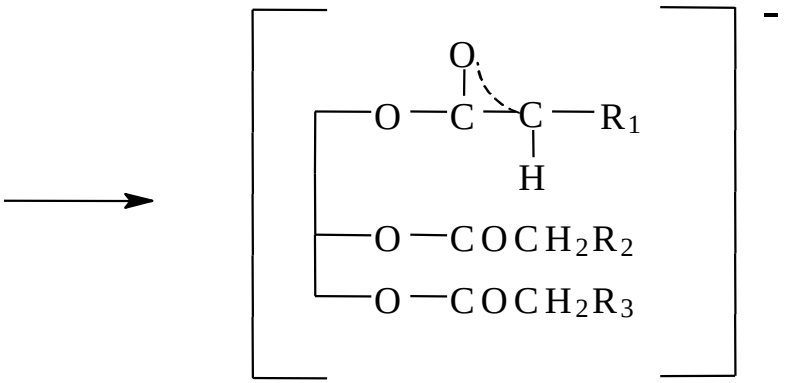
Initial removal of an α-proton by the base catalyst leads to the charge delocalized enolate anion.



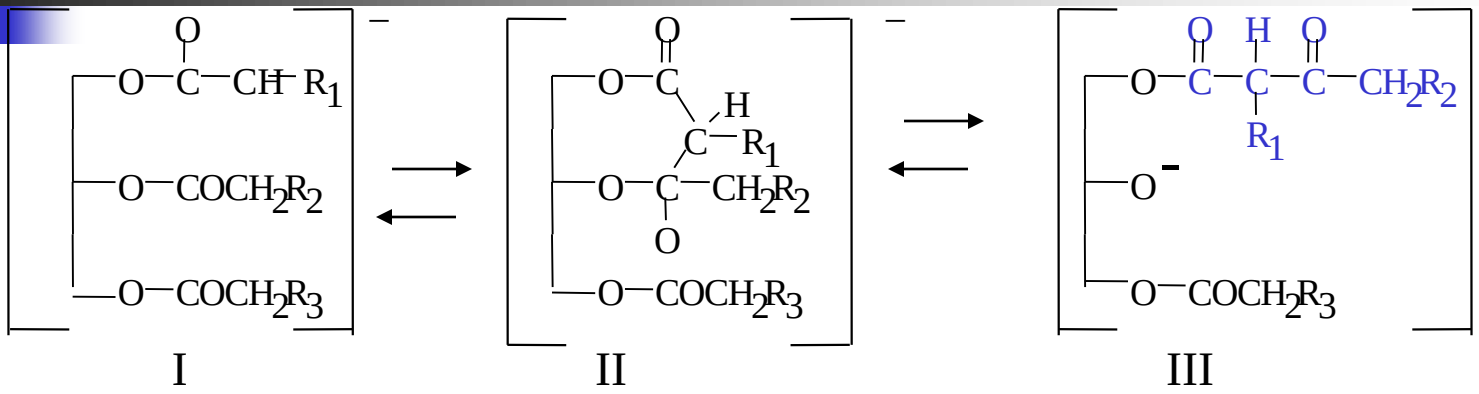
Enolate Ion Formation

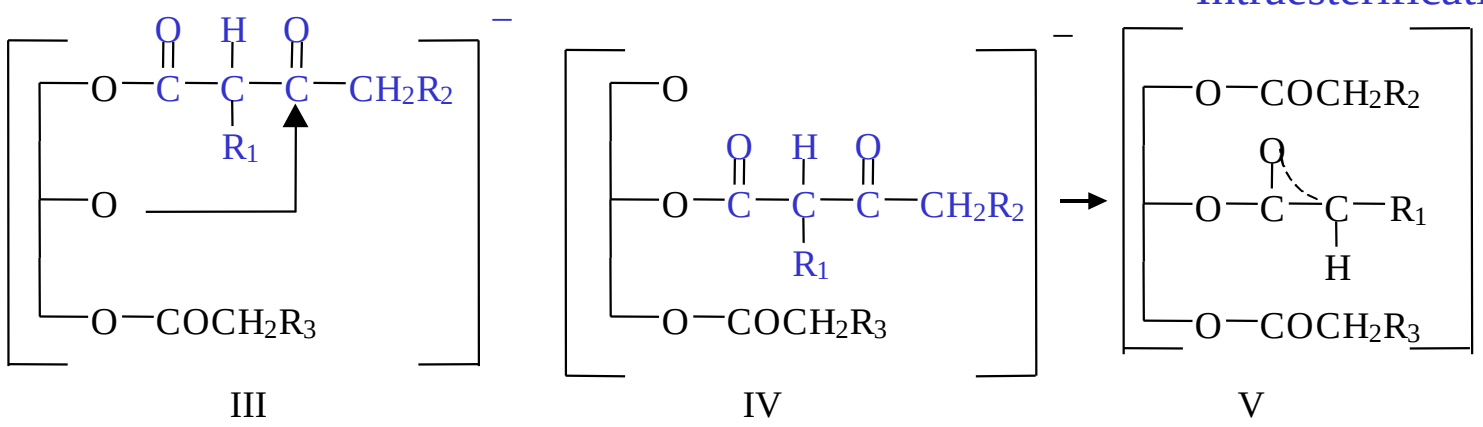




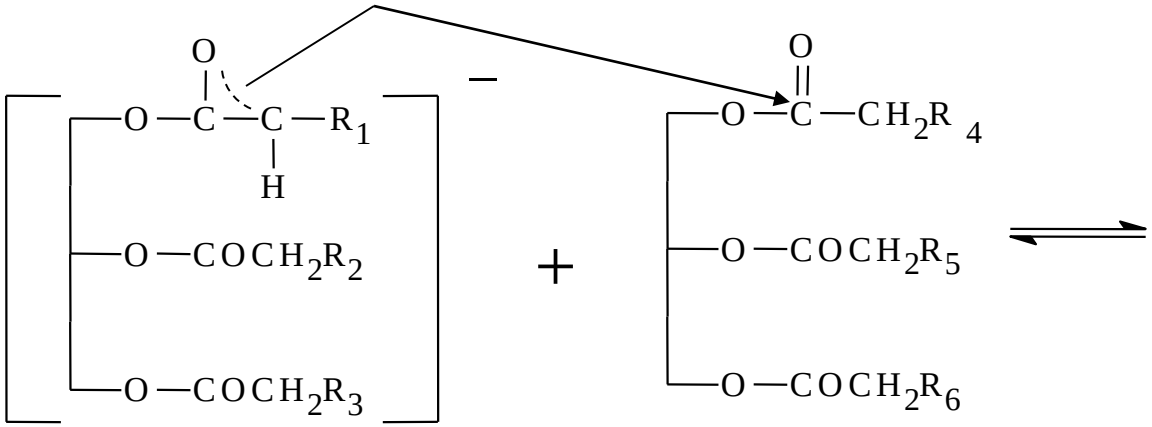


Mechanism for Intramolecular Ester-Ester Interchange



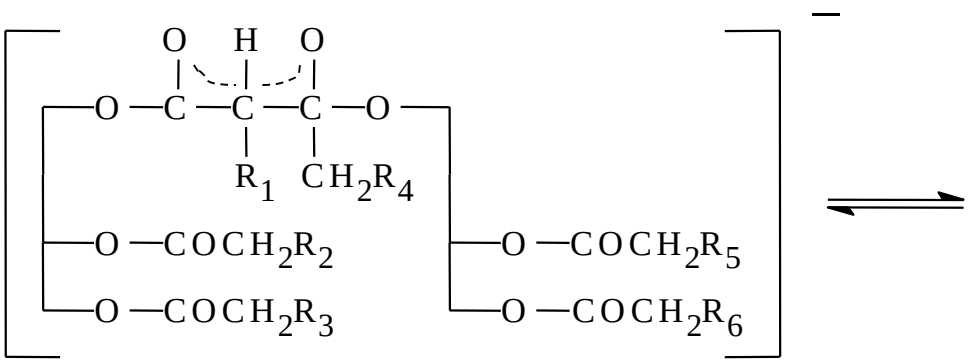


Mechanism for Intermolecular Ester-Ester Interchange

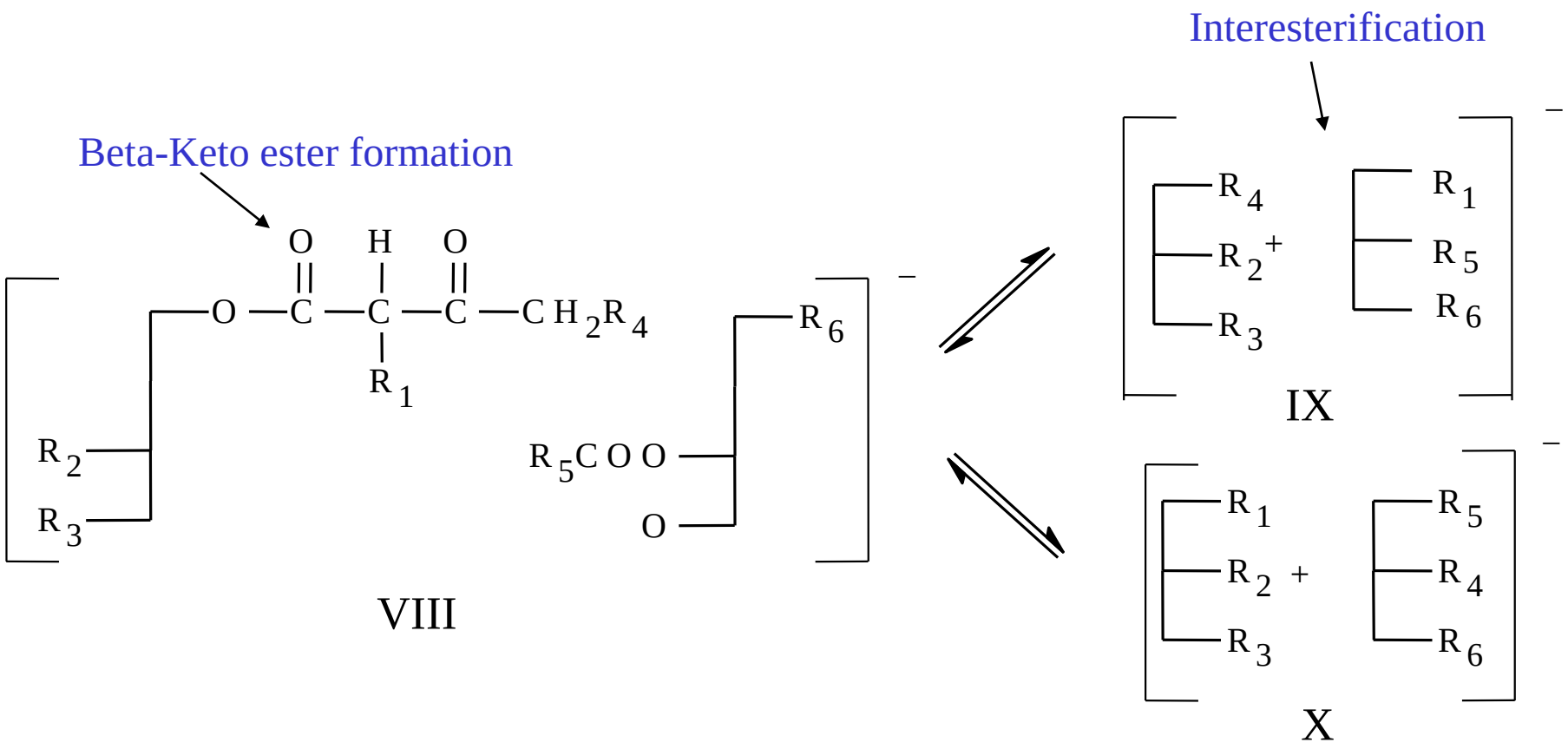


I VI

VII



Mechanism for Intermolecular Ester-Ester Interchange



Random Esterification

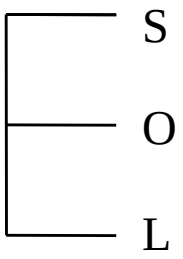
Interesterification can be carried out to an equilibrium condition, at which point the fatty acids assume an almost random distribution among triglycerides.

Direct Interesterification

Interesterification can be directed away from its usually random end-point if the fat is allowed to crystallize during reactions.

The trisaturated glycerides crystallize first.

Directed Interesterification



1.	Stearic-Stearic-Stearic	33.3 mole % solid
2.	Oleic-Oleic-Oleic	8.3 mole % liquid
3.	Linoleic-Linoleic-Linoleic	8.3 mole % liquid
4.	Oleic-Oleic-Linoleic	24.9 mole % liquid
5.	Oleic-Linoleic-Linoleic	24.9 mole % liquid

Applications

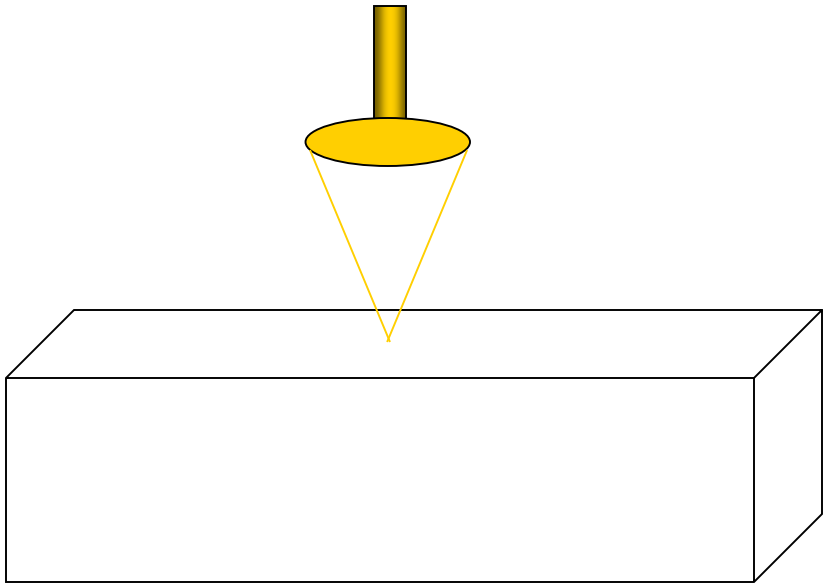
Shortenings: The proportion of palmitic acid in the 2-position is reduced from about 64% to 24% on random interesterification.

Randomization of lard improves its plastic range and thus makes it a better shortening than natural lard.

Plasticity and Consistency

Plasticity is the changes in consistency as a function of temperature.

Consistency is the apparent hardness at a temperature



Margarines – High Stability Margarine Blends

1. 75 % (co-randomized 40 % coconut oil / 60 % palm oil),
2. 10 % (co-randomized 50% coconut oil / 50 % hydrogenated canola oil) and
3. 15 % hydrogenated soybean oil

Good spreadability, high temperature stability, and good eating qualities.

Nutritional Margarine Blends

High polyunsaturated content and low-to-zero *trans*-acid containing margarines are produced by interesterifying a blend of liquid oil and a fully hydrogenated oil.

Confectionary Fats

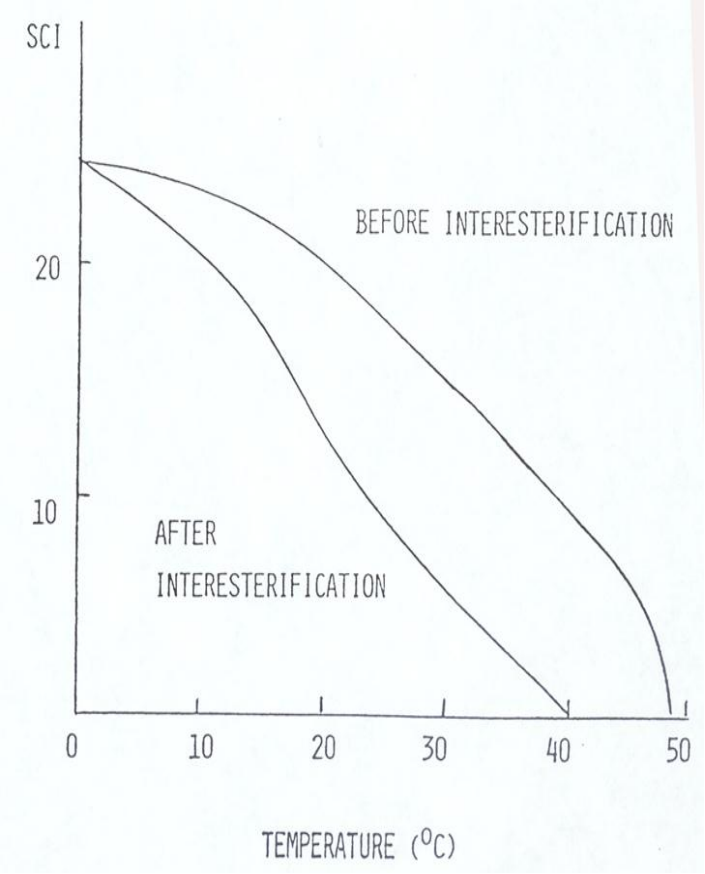
Hydrogenated palm kernel oil is a hard butter melting at 46°C and produces a waxy feel in the mouth.

On randomization, its melting point is reduced to 35°C. By blending hydrogenated palm kernel oil and its randomized product, a whole series of hard butters with highly desirable melting qualities (rapid melt in mouth) are obtained

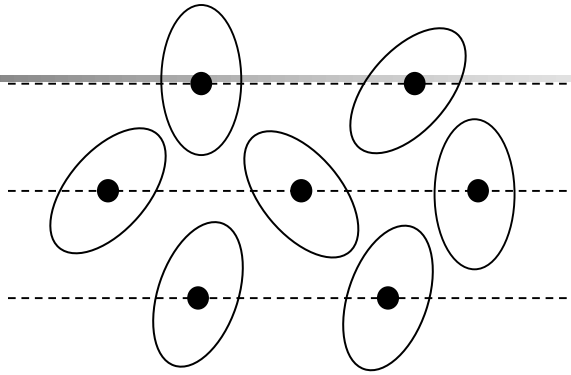
Confectionary Fats from Blend of Hydrogenated and Interesterified Hydrogenated Palm Kernel Oil

Fat	M.P.(°C)	SCI 10	SCI 20	SCI 35	SCI 38
Hydrogenated palm kernel oil (PKO)	46.8	74.2	67.0	15.4	11.7
Int. hydrogenated PKO	35.0	65.0	49.9	1.4	1.1
50% hydrogenated 50% int. hydrogenated	41.7	70.0	57.4	8.7	5.2

Effect of Randomization on SCI of an 80:20 Mixture of Lightly Hydrogenated Soybean Oil and Palm Stearine

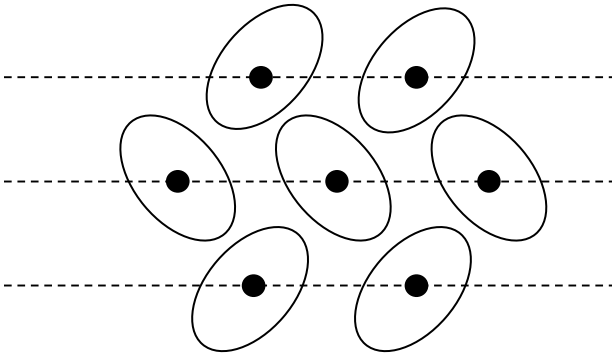


Cross-Sectional Structures of Triglycerides

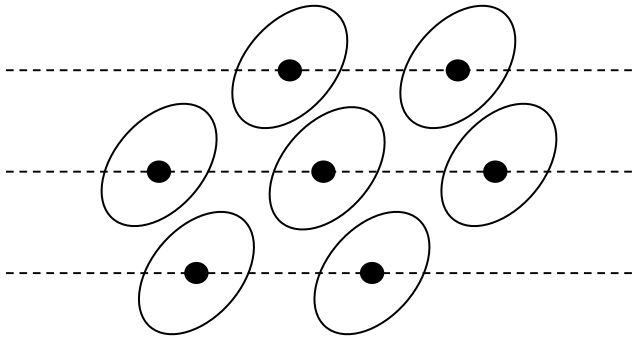


Freedom of molecular motion

Alpha

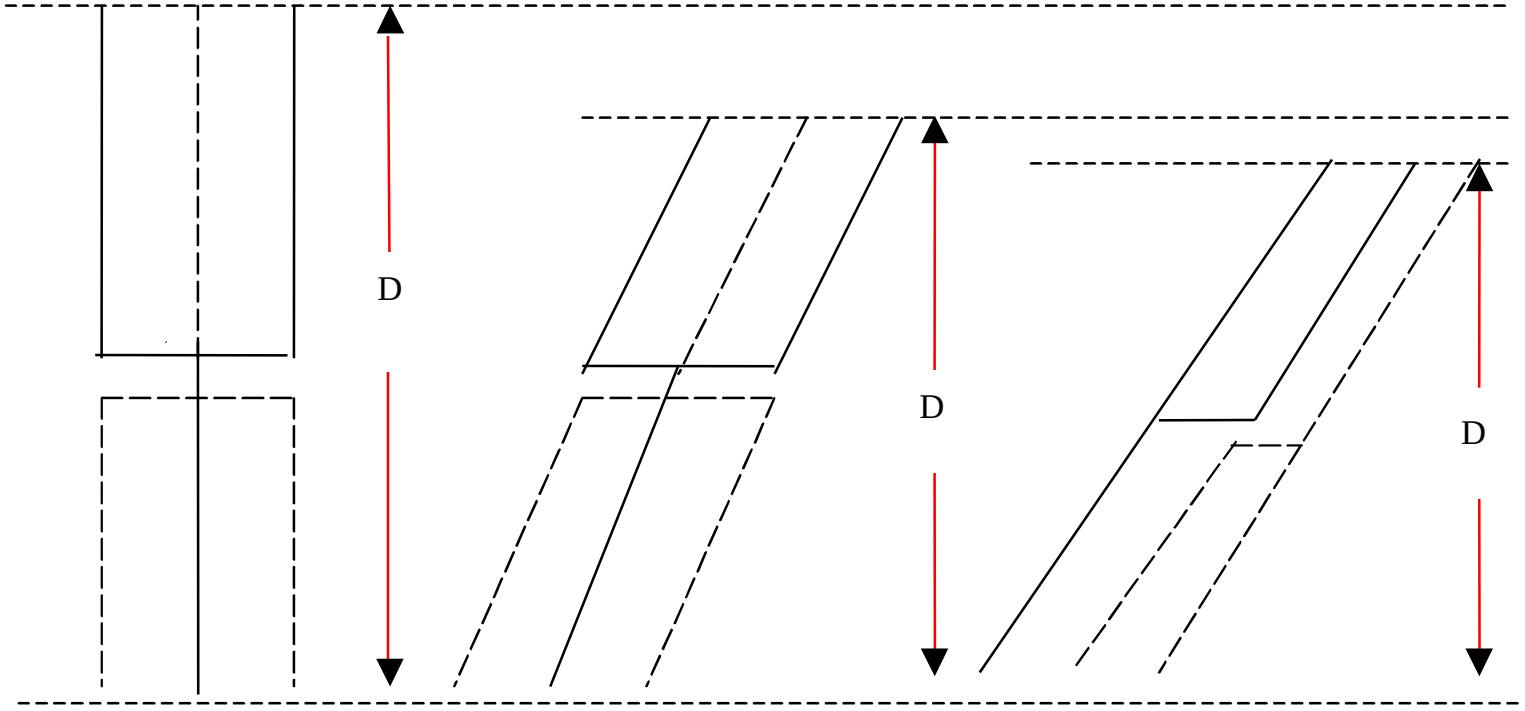


Beta Prime



Beta

Double Chain Length Structures of Triglycerides



Alpha
(Vertical tuning fork)

Beta-Prime
(Tilted tuning fork)

Beta
(Stacked chair)

Characteristics of Triglygeride Polymorphs

Alpha	Beta-Prime	Beta
Platelet	Fine needle	Long needle
5 μ	1 μ	25-50 μ
Most loosely packed	More closely packed	Most closely packed

PERKEMBANGAN INDUSTRI *SPECIALTY FATS* :

MASALAH, TANTANGAN, DAN SOLUSI

Jenny Elisabeth
Wilmar Group Indonesia

Bogor, 29 Januari 2009

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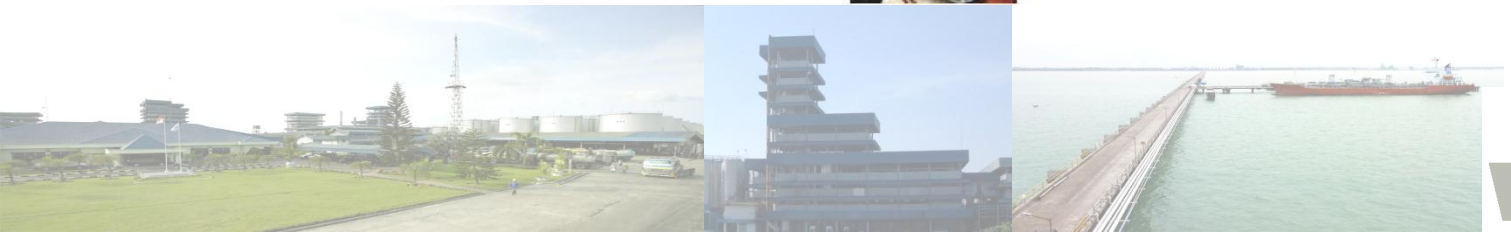
APLIKASI *SPECIALTY FATS*

DIPANDANG DARI 2 ASPEK :

1. Aspek sifat fungsional
   - Baking (*creaming, whipping*, emulsi, dll)
   - *Confectionery (moulding, coating, filling)*
   - *Frying and spray/release* (stabilitas tinggi terhadap panas dan oksidasi)



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APLIKASI *SPECIALTY FATS*

DIPANDANG DARI 2 ASPEK :

2. Aspek nutrisional (lebih sehat dan alami)
   - Kandungan dan distribusi asam lemak
   - Kandungan mono- dan digliserida
   - Omega-3, omega-6, lauric acid, MCT
   - OPO pada HMFS (*Human Milk Fat Substitute*)
   - CLA (*conjugated linoleic acid*)

KATEGORI PRODUK *SPECIALTY FATS*

CONFECTIONERY FATS

- CBE (Cocoa Butter Equivalent)
- CBR (Cocoa Butter Replacer)
- CBS (Cocoa Butter Substitute)
- Coating & Creaming Fat
- Milk Fat Replacer
- Spread Fat

BAKERY OIL/FAT

- Margarine
- Shortening
- Butter Oil Substitute (BOS)
- Spray Oil
- Release Oil

CULINARY OIL/FAT

- Frying Oil / Shortening
- Salad Oil

FUNCTIONAL OIL/FAT

- Hardstock Fat
- Hardener
- HMFS (Human Milk Fat Substitute)
- SUS Fat (Synthetic Cocoa Butter)

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TANTANGAN PADA PRODUK *SPECIALTY FATS*

CONFECTIONERY FATS	BAKERY OIL/FAT	CULINARY OIL/FAT	FUNCTIONAL OIL/FAT
- Low trans fat -Low saturated fat - Non hydrogenated - Natural high SUS	- Low trans fat -Low sat fat - Low calorie - High stability - Balance FAC (ω6 : ω3)	- Low trans fat - Low sat fat - Low calorie - High stability (heat and cold) - High Oleic	- Trans fat free - Low sat fat - High Oleic - High SUS - High OPO - High MCT - Bioactive compounds



PENGEMBANGAN PRODUK SPECIALTY FATS

Produksi bahan sumber minyak/lemak	Bioteknologi tanaman, mikroba, dan ternak
Proses produksi minyak/lemak	- Non-pelarut - Perlakuan enzim
Proses pemurnian minyak/lemak	- Proses fisik - Perlakuan enzim
Proses modifikasi minyak/lemak	- Fraksinasi khusus - IE Kimiawi - IE Enzimatik

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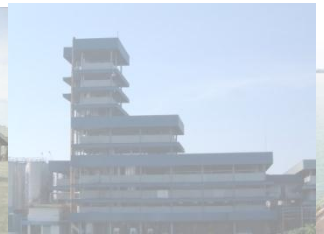
PROSES MODIFIKASI MINYAK/LEMAK

Polusi Lingkungan	Tinggi	Medium	Rendah
Kompleksitas	Tinggi	Medium	Tinggi
Lemak Trans	Tinggi	Rendah/Medium	Rendah
Biaya	Tinggi	Medium	Tinggi
	Hidrogenasi	Interesterifikasi	Fraksinasi

Blending

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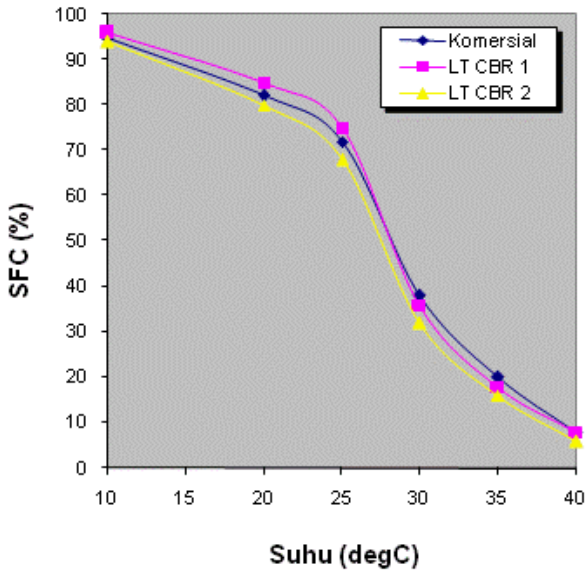
MASALAH LEMAK TRANS DAN SOLUSINYA

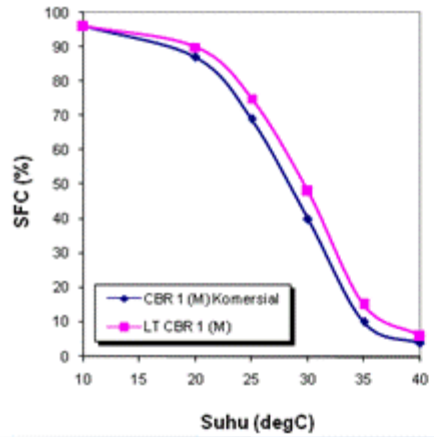
CBR – COATING FAT

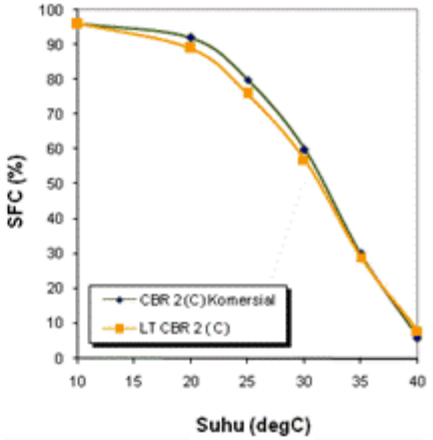
	Komersial	LT CBR 1	LT CBR 2
Bahan Baku	Palm Oil	Palm Oil	Palm Oil
Proses	Fraksinasi Hidrogenasi	Fraksinasi spesifik dan Hidrogenasi	Fraksinasi spesifik, Hidrogenasi, dan Blending
IV (Wijs)	52	34	47
SMP (^{o}C)	35 - 40	36 - 39	39 - 40
Trans Fat (%)	40	6	15



MASALAH LEMAK TRANS DAN SOLUSINYA

	CBR Moulding Fat		CBR Coating Fat	
	Komersial	LT	Komersial	LT
Bahan Baku	Palm Oil	Palm Oil dan Palm Kernel Oil	Palm Oil	Palm Oil dan Palm Kernel Oil
Proses	Fraksinasi dan Hidrogenasi Parsial	Fraksinasi, Hidrogenasi, Blending, IE Kimiawi	Fraksinasi dan Hidrogenasi Parsial	Fraksinasi, Hidrogenasi, Blending, IE Kimiawi
IV (Wijs)	53	8	52	10
SMP (^{o}C)	35	36	40	40
Trans Fat (%)	40	0.2	39	0.2





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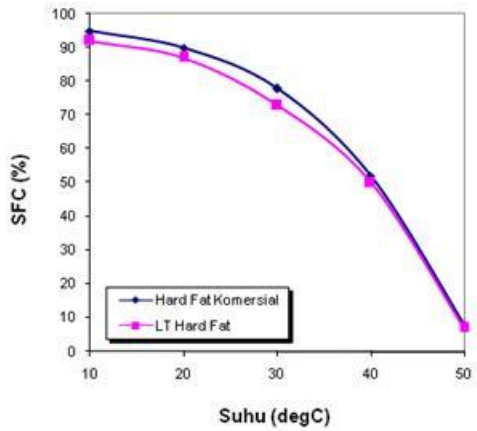
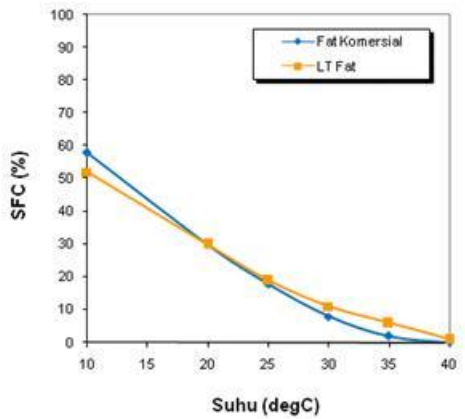
MASALAH LEMAK TRANS DAN SOLUSINYA

MARGARINE/SHORTENING FAT

	Hardstock Fat		Margarine/Shortening Fat	
	Komersial	LT	Komersial	LT
Bahan Baku	Palm Oil	Palm Oil	SBO	Palm Oil
Proses	Hidrogenasi Parsial	Fraksinasi, Blending, Hidrogenasi	Hidrogenasi	Fraksinasi, IE Kimiawi
IV (Wijs)	28	22	77	56
SMP (^{o}C)	51	52	33	39
Trans Fat (%)	20	0.2	35	0.2





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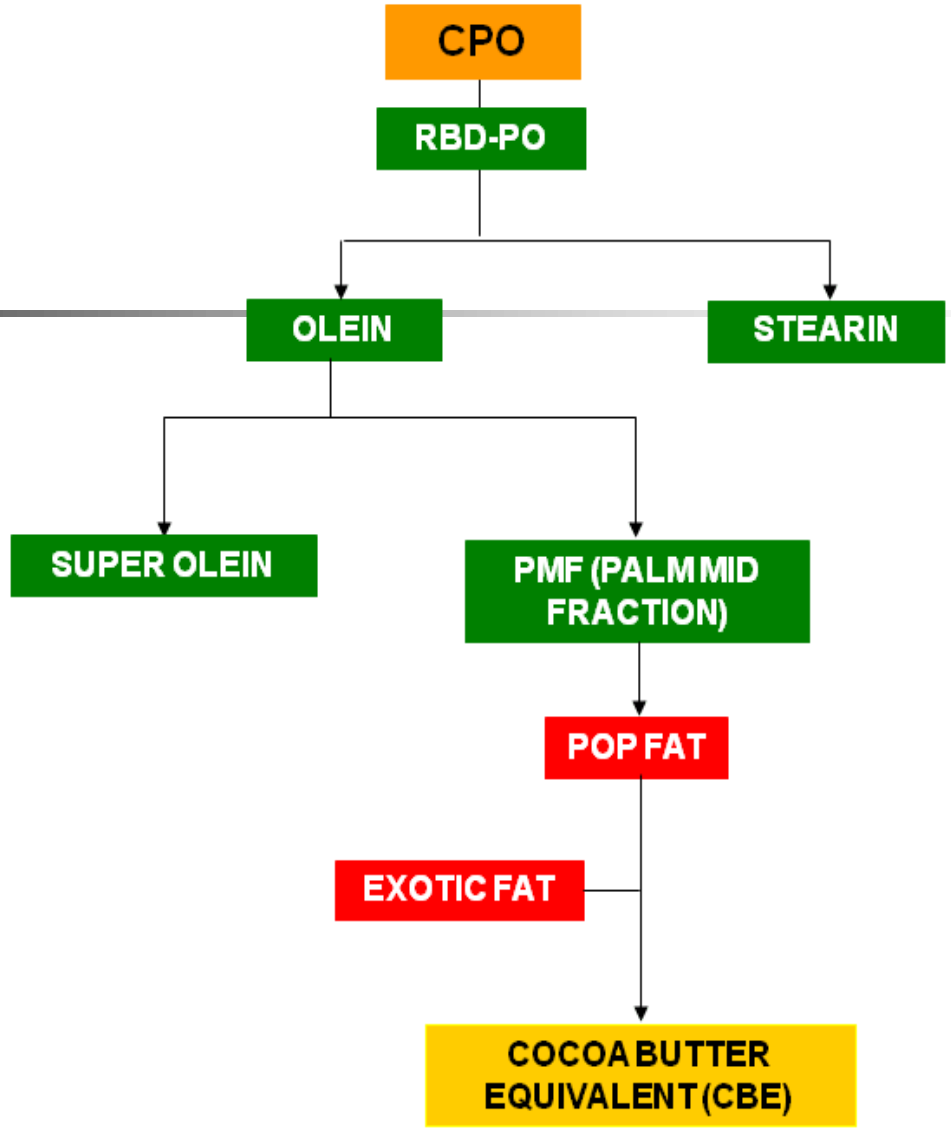
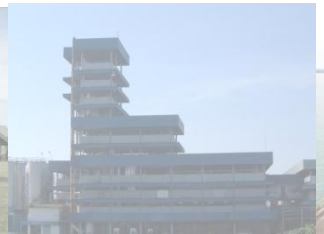
PROSES PEMBUATAN CBE





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PENGGANTI LEMAK COKLAT - CBE

KANDUNGAN SUS PADA BEBERAPA LEMAK EKSOTIK

- Cocoa Butter 75%
- Palm Mid Fraction 79%
- Shea Oil 38.5%
- Shea Stearin 80%
- Sal Oil 54.5%
- Sal Stearin 64.5%
- Mango Kernel Oil 47.5%
- Mango Kernel Stearin 69%
- Illipe Butter 83%
- Kokum Fat 80%
- Mowrah Stearin 79%

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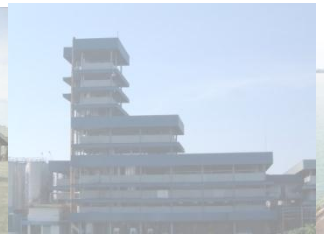
PENGGANTI LEMAK COKLAT - CBE

	Lemak Coklat	
	Alami	Novel
Bahan Baku	Lemak Coklat	Palm Oil dan SBO
Proses	Ekstraksi dan Refining	Fraksinasi, Hidrogenasi, IE Enzimatik, Fraksinasi Spesifik
IV (Wijs)	34	31
SMP (^{o}C)	34	36
Total SUS (%)	83	85
POP (%)	15	9
POS (%)	40	38
SOS (%)	28	38



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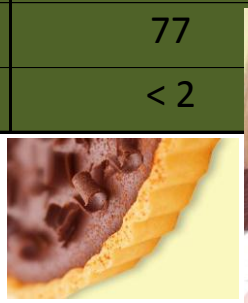
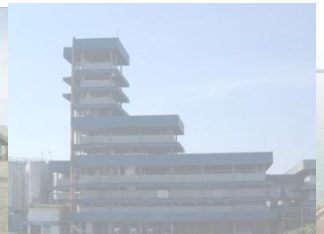
PENGGANTI LEMAK COKLAT - CBE

	Lemak Eksotik			
	Shea Stearin	Sal Stearin	Illipe Butter	Novel
Bahan Baku	Shea Oil	Sal Fat	Illipe Fat	SFO dan SBO
Proses	Ekstraksi/Fraksi-nasi, dan Refining	Ekstraksi/Fraksi-nasi, dan Refining	Ekstraksi dan Refining	Hidrogenasi, IE Enzimatik, Fraksinasi
IV (Wijs)	35	34	32	30
SMP (^{o}C)	40	38	35	34
Total SUS (%)	81	82	90	91
POP (%)	< 1	1	8	< 1
POS (%)	7	11	36	13
SOS (%)	70	56	43	77
SOA (%)	35	14	3	< 2





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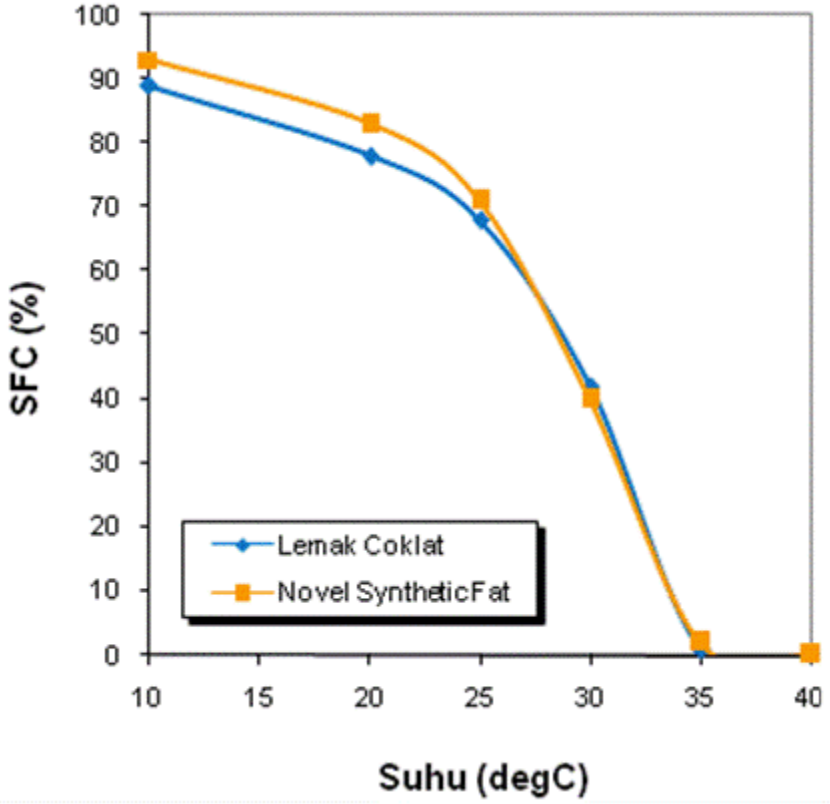
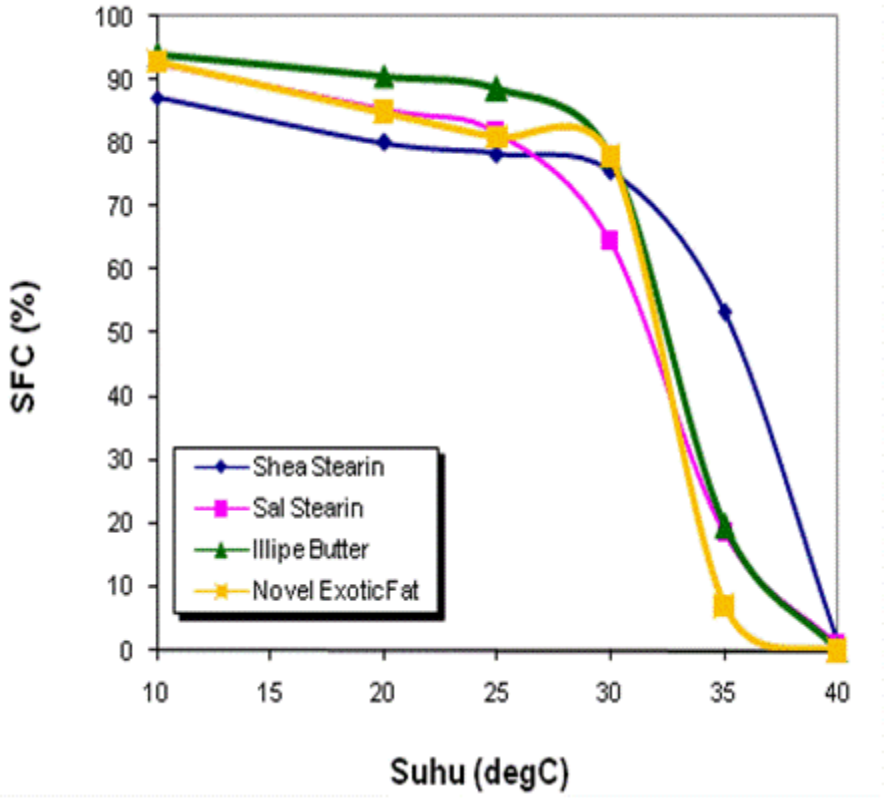
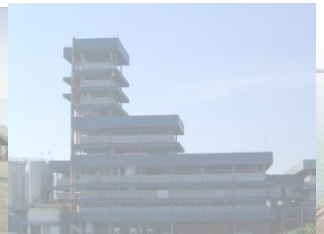
PENGGANTI LEMAK COKLAT - CBE







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MASALAH ASAM LEMAK JENUH

- Kebutuhan untuk kandungan asam lemak jenuh 30% max
- Saat ini belum dapat dipenuhi oleh minyak sawit
- Telah dikembangkan *high-oleic oil* dengan rekayasa genetika tanaman di Eropa

Asam Lemak (%)	Rapeseed Oil	High-Oleic Rapeseed Oil	Sunflower Oil	High-Oleic Sunflower Oil	Palm Olein
C16:0	4	4	4	4	39
C18:0	2	2	4	4	4
C18:1	61	75	25	80	43
C18:2	20	15	65	10	11
C18:3	10	2	tr	tr	tr

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