POPSIG

Evening talk cum webinar

Four Decades in ASEAN : Process Engineering and Innovation in the Oleochemical Industry

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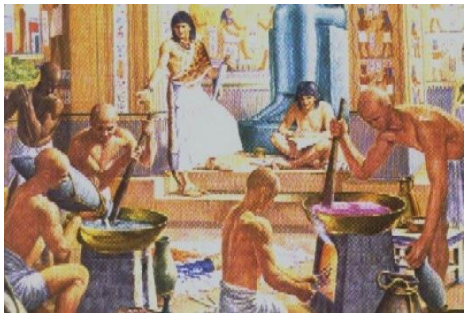
AOMG

History of oleochemicals

History of oleochemicals (1)



- 600 BC Phoenicians soap from goat fat and ash
- 1779 Scheele discovered glycerol
- 1813 Chevreul described fatty acids
- **1825** Chevreul & Gay-Lussac patent for stearic acid candle. Gay-Lussac patented distillation of fatty acids. *Beginning of oleochemicals.*

Chevreul

Gay-Lussac

Key national process milestones (3)

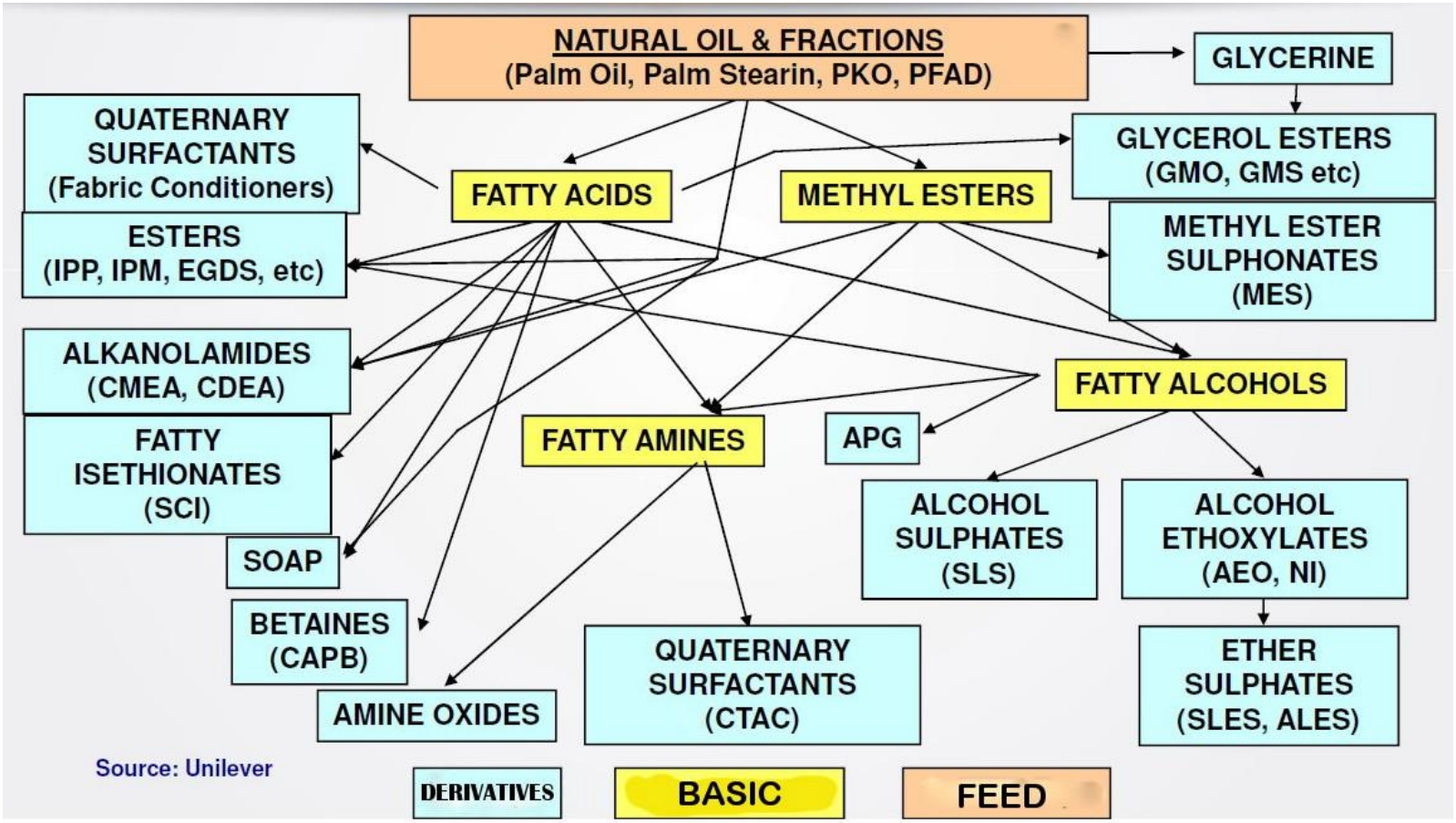
- Tax holidays eg pioneer status
- Oleochemical manufacturers drive technology providers due to low margins and therefore need for larger and efficient plants
- Due to demand for plants, technology suppliers were able to invest in R&D

Oleochemicals in ASEAN

- 1980 First oleochemical plant **Acidchem** in Penang
- 1981 European, US & Japanese producers
- 1984 **MOMG**
  (Malaysian Oleochemical Manufacturers Group)
- 1986 **POMA**
  (Philippines Oleochemical Manufacturers Group)
- 1986 **AOMG**
  (ASEAN Oleochemicals Manufacturers Group)
- 1996 **APOLIN**
  (Asosiasi Produsen Oleochemical Indonesia)
- Late 1990s Europeans left
- 2000 Mad cow disease, tallow to palm

Process Engineering & Innovation

Oleochemical Routes



The products

- Basic oleochemicals
  - Fatty acids (DFA, stearic acid, fractions etc)
  - Methy esters
  - Fatty alcohols
  - Fatty amines
- Derivatives
  - Esters
  - Glycerol esters
  - Alcohol sulphates and ethoxylates
  - Soap noodles

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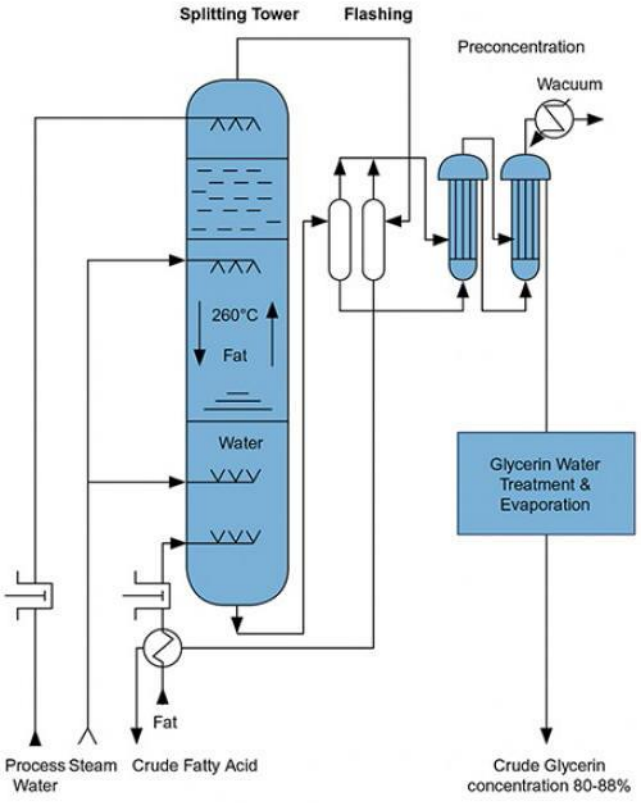
1. Capacity/Technology

Technology advantage

- 1980 Small plants 30,000t/a, smaller than Europe or USA
- 2010 Large plants 150,000 to 250,000 t/a, largest and most modern, superior technology

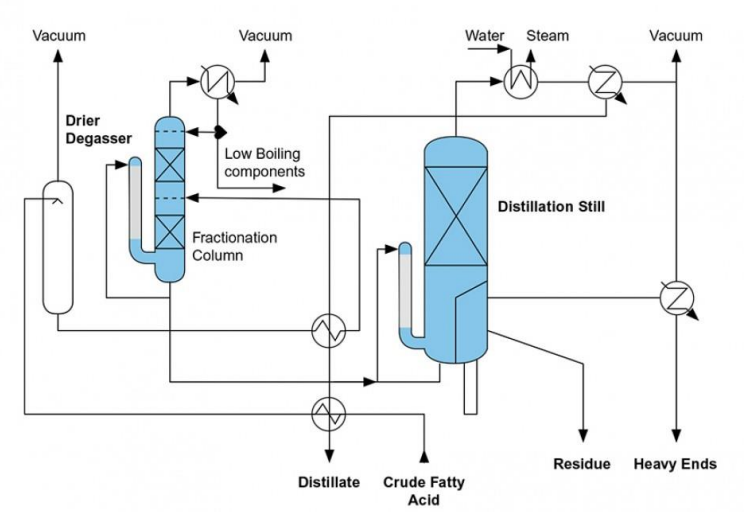
Splitting

- One splitter 600t/d
- Higher temperature /pressure 260°C/63 bar
- Splitting degree > 99%
- Less HP steam consumption
  - Lower exit temperature split fatty acid (90-95°C) & sweetwater (120-130°C)
- Less fouling internals



Distillation & fractionation

- High purities >99%
- Falling film reboilers
- Top products condensers generate steam
- Cater for different feeds
- High performance structured packing & smaller columns



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2. Fatty Alcohols

Development of fatty alcohol technology

Period	Raw Material	Catalyst	Conditions	Company
1960s	Fatty acids	Slurry	300 bar, liquid	Lurgi
1980s	Methyl ester	Fixed	300 bar, trickle	Lurgi
2000s	Fatty acids	Fixed	300 bar, trickle	Lurgi
✓	Wax ester	Fixed	70 bar, trickle	Lurgi
✓✓✓	Methyl ester	Fixed	40 bar, vapour	Davy

Own technology – Henkel methanolysis, P&G, Kao

Synthetic fatty alcohols technology

- Ziegler
- Hydroformylation

Synthetic vs natural

- >1974 Natural fatty alcohols gains market share (1973 oil crisis)
- 2003 Producers in Europe, USA and Japan close inefficient units
- 2015 Excess natural capacity
  Low oil prices see new synthetic plants

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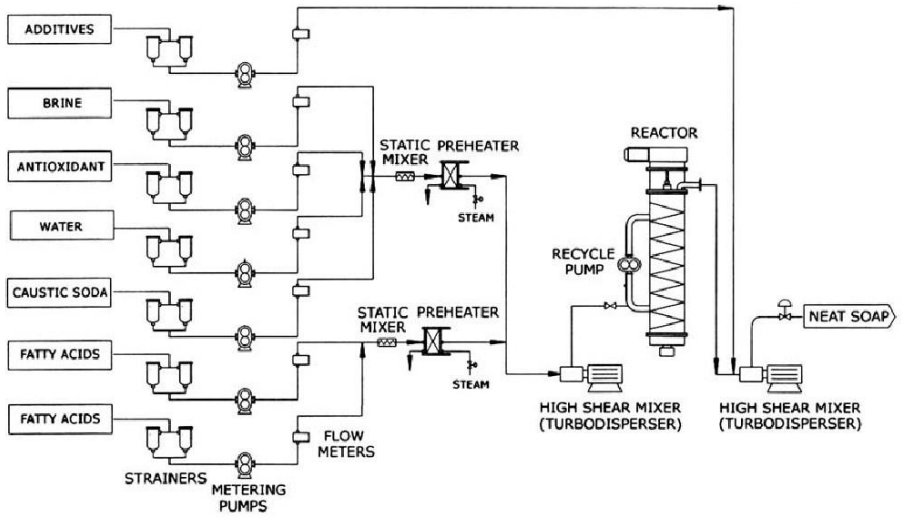
3. Soap Noodles

1982 Unichema makes soap from DFA



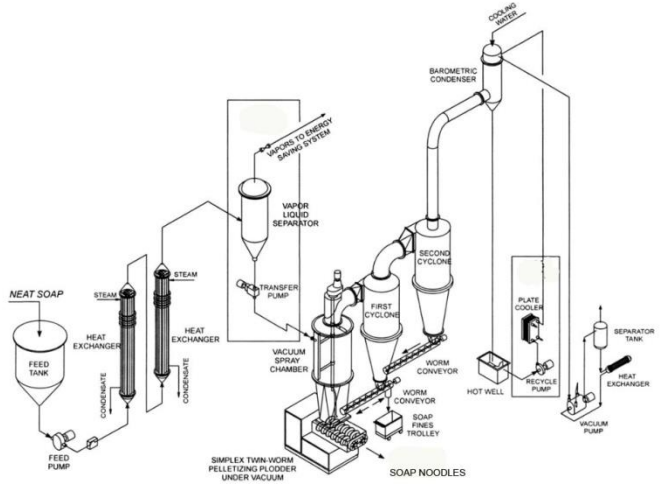
Previously

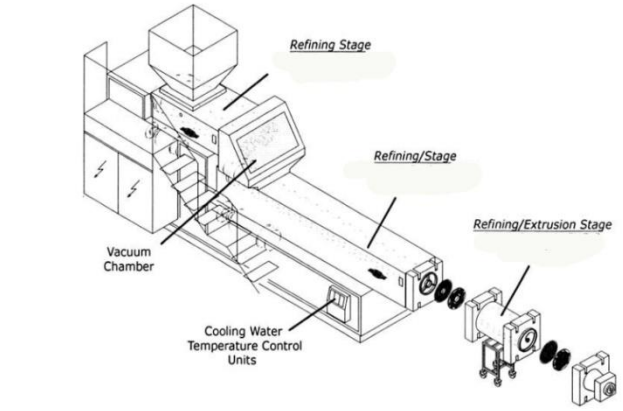
- DFA is unstable
- Resultant soap is beige with an odour

Unichema soap noodles were white with no odour

Lux toilet soap made from
Unichema soap noodles

DFA soap noodles creates a new market





- Soap bar finisher focuses on his market
- Specifies his requirements
- His own additives eg perfume, colour

<u>Market is evergreen</u>

Move to liquid soaps when annual usage > 1kg per year per person

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4. Biodiesel

Malaysian Palm Biodiesel Timelines

- 1982 Commenced R&D project
- 1986 -1994 Successful field trials
- 2000 – 2006 Pilot plant to commercial production
- 2008 Biofuel Industry Act 2007
- 2011 B5, 2014 B7, 2016 B10

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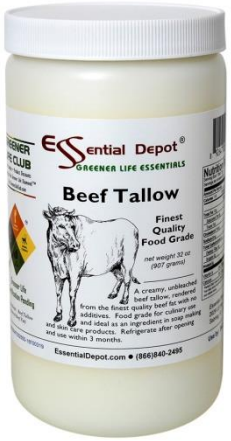
5. Raw Materials

Raw materials for oleochemicals

Before 1980

Tallow (C16-18)



Coconut (C12-14)

From 1980

Palm oil (C16-18)

Palm kernel oil (C12-14)

Tallow vs Palm

- BSE in 2000 proved palm can replace tallow in most instances
- Tallow type oleic acid is in demand
- Distillative fractionation of palm oil fatty acids – carry over of C18:0 increased cloud point - C18:2 too high
- PK bottoms ex distillative fractionation subjected to crystallisation fractionation yields C18:1 of 78%

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6. Process Safety

1990s major process safety incidents

- Industry reputation low
- High premiums /not insurable
- Improved after 1998

Stearic acid warehouse fire	**1992 Bellows rupture in Johor**
1993 Selangor 1994 Penang	**1997 Explosion H2 generation plant in Selangor**

"...there are no new accidents. Rather there are old accidents repeated by new people ....."
Judith Hackitt, chair of UK HSE
July 2013

A safer and reliable industry

- **MOMG** Technical Committee started in 1992
- **AOMG** Technical Committee in started in 2007
- Annual process safety **workshops** since 2011
- Members have implemented **PSM** (Process Safety Management)

7th AOMG Process Safety Workshop 27-28th July 2017, Yogyakarta, Indonesia

Process Engineering & Innovation

7. Sustainability

Sustainability

- AOMG members are RSPO Supply Chain Certificate holders for
  MB (Mass Balance) and/or
  SG (Segregated)

RSPO

- AOMG pushed for physical transition for oleochemicals which rules were approved in July 2013

- MOMG members have an ongoing LCA exercise with MPOB

Going Forward

Going Forward

1. Bioproducts

What is a Biorefinery

- A facility that integrates biomass conversion processes and equipment to produce fuels, power, heat and value-added chemicals from biomass
- It is analogous to a petroleum refinery which produces multiple fuels and products from petroleum
- Growth in end-use industries eg. personal care, surfactants, lubricants and polyols driving demand for bio-based oleochemicals.

Biolubricants

- Advantages : energy saving, high viscosity index, biodegradability and non-toxic nature
- Usually esters with high oleic acid content
- > 50% in industrial segments replacing petroleum based
- Examples : drilling, metal working fluids, process oils

Natural Polyols

- 1937 PU invented
- 1970s Natural Polyols based on Castor Oil and Soy Bean Oil
- 1990s Palm Oil based Polyols PORIM/MPOB and Intermed.
- 1999 First patent filed
- Only Intermed/Polygreen Chemicals remain active as the only palm-based NOP, capacity 30,000 MT annually

PolyGreen
natural polyols

Present scenario of Natural Polyols

- Worldwide 7.5 mil MT Polyols consumed annually with an estimated growth rate of 6% per year
- PolyGreen presently sells to the manufacturers of mattresses, furniture and footwear
- New markets are developed for High Resilient Foams for the furniture and automotive industry
- Future markets will be for CASE (Coatings, Adhesives, Sealants, Elastomers)




Going Forward

2. Bio-processes
Bioprocess engineering focuses on the role of living organisms in the manufacturing process

Enzymatic process

Biodiesel

- Enzymatic process can use feedstocks with low or high free fatty acids eg UCO and PFAD
- Eliminate hazardous catalyst eg sodium methoxide
- Lower energy

Fermentation

Adipic Acid

- Yeast fermentation to produce diacids
- Based on fatty acids (prev. petroleum)
- Low cost
- Less pollutants
- Key component of nylon 6,6

2nd Gen Biofuels

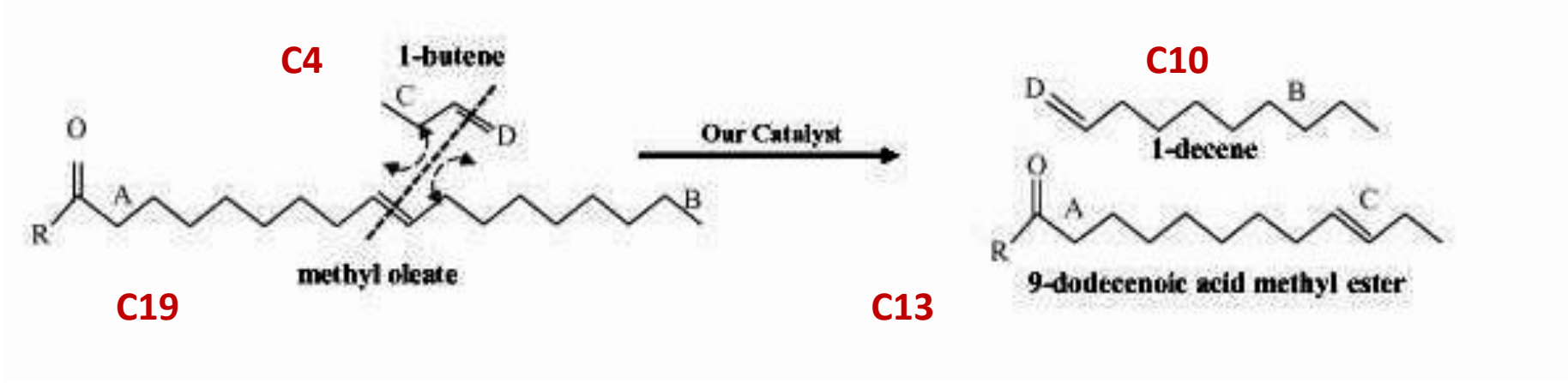
EPP 7 Bio oil from biomass-to-liquid technology

- Extraction technologies for syngas
  - Thermochemical conversion
  - Biochemical conversion (fermentation/bacteria)
- Fisher-Tropsch process (gas to liquid) requires high energy investment

Going Forward

3. Metathesis

Elevance Metathesis Technology

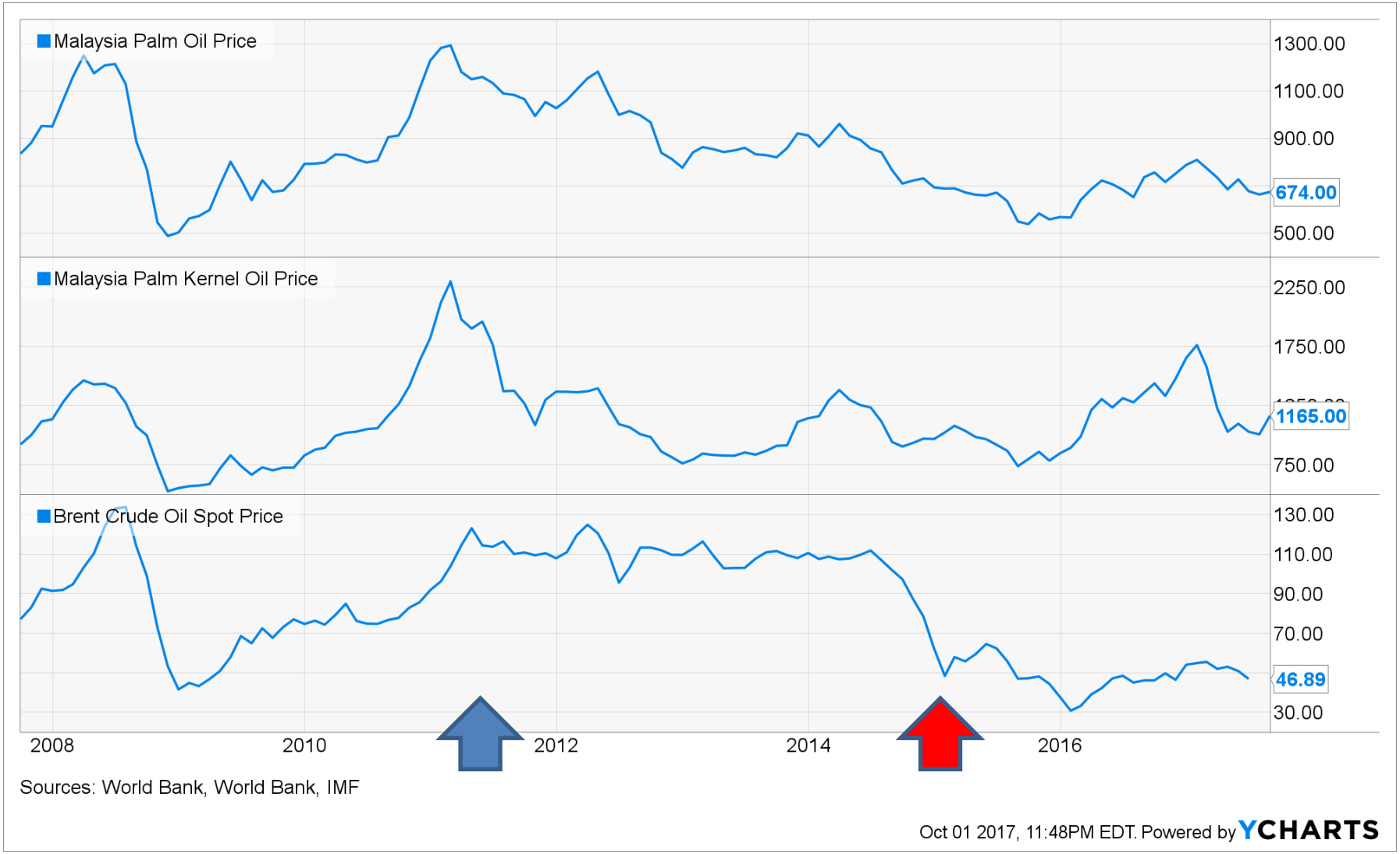


- Metathesis can break carbon-carbon double bonds
- A petrochemical is combined with an oleochemical
- Molecules recombine into new di-functional molecules

Three product streams

1. Olefins – 1-decene for co-polymers
2. Speciality chemicals – di-functional products from oleochemicals and petrochemicals in one molecule eg 9DDA (9-dodecenoic acid) are key products for nylon 6,12
3. Oleochemicals – C16 and C18 methyl esters eg for MES

10 Year Historical Prices



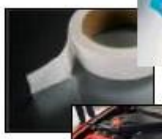
Cracking and Reforming into Building Blocks

Naphtha

- Olefins
  - Ethylene
  - Propylene
  - Butylene
  - Butadiene
- Aromatics
  - Benzene
  - Toluene
  - Xylene

PE
PVC
PP
PIB
PAN
PS
ABS
N6,6
N6
PU
PET










How can we turn this....

...into this

NatureWorks

genomatica

gevo

AMYRIS

verdezyne

reverdia

avantium

Rennovia

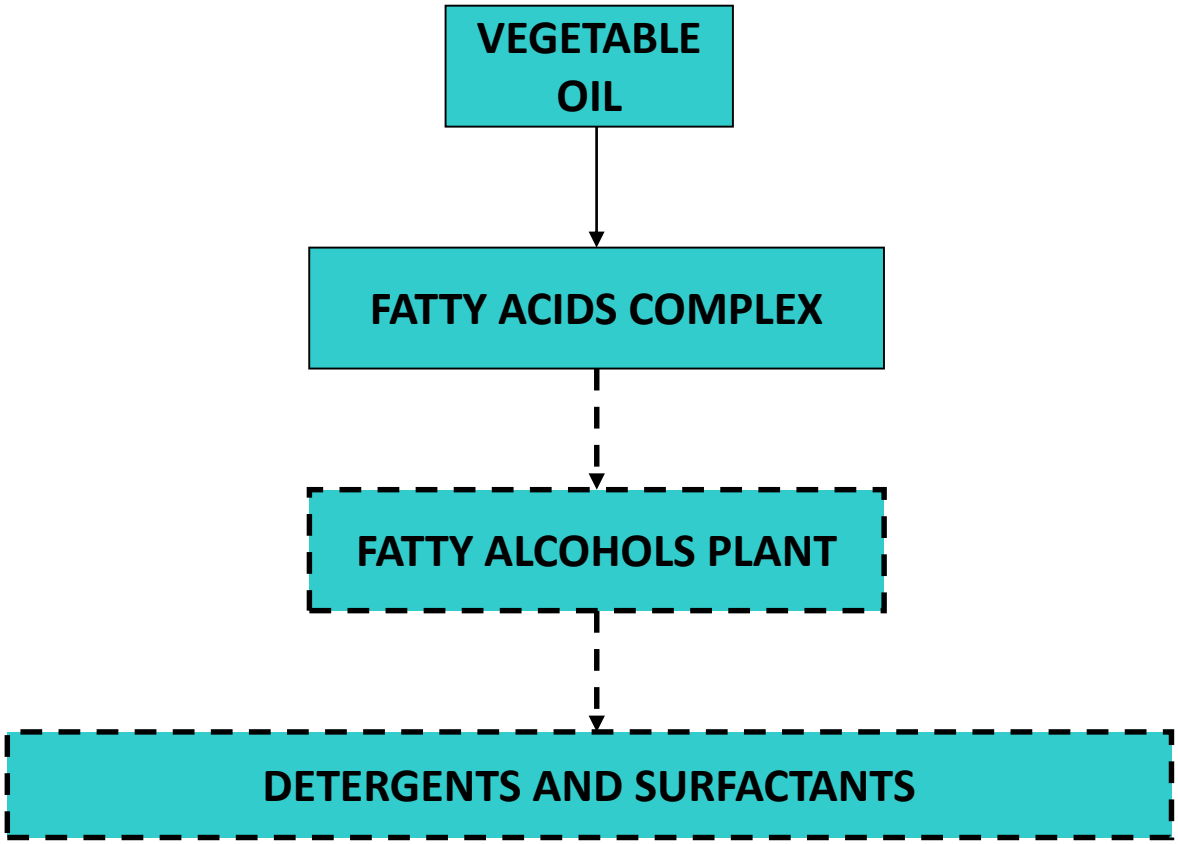
bioamber

verdezyne

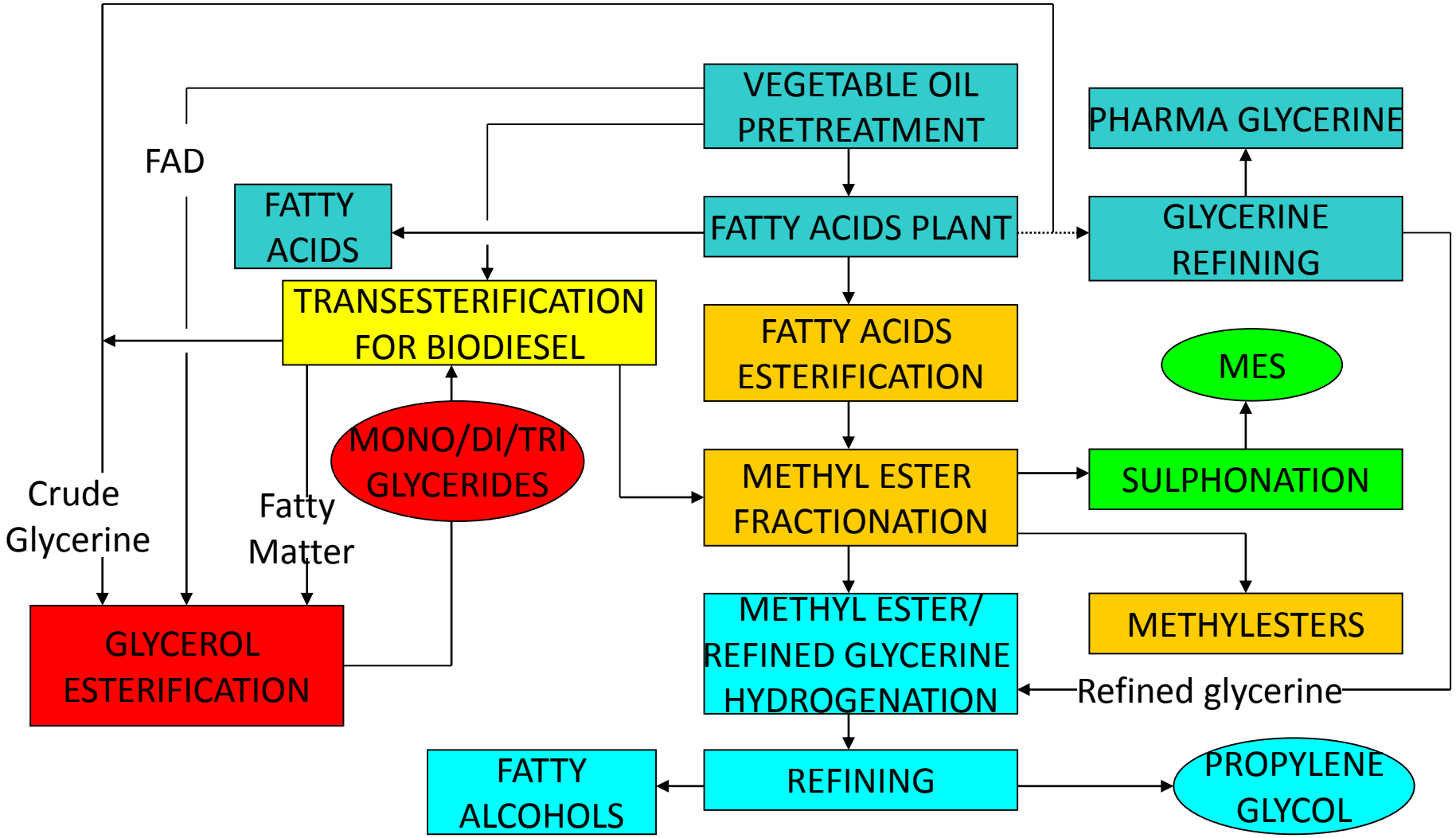
Going Forward

4. 2nd Generation Oleochemical Complex

Classic 1st Generation



Multi-purpose 2nd Generation



Desmet Ballestra

Going Forward

5. Further downstream

Challenges for specialities

- Know-how not with plant suppliers
- Lower tonnage in multipurpose batch reactors
- Production intervention needed by experienced staff
- Not sold by specifications alone
- Need specialized applied research and marketing

Going Forward

6. Position of oleochemicals processing

IChemE seminar 8th August 2017, KL

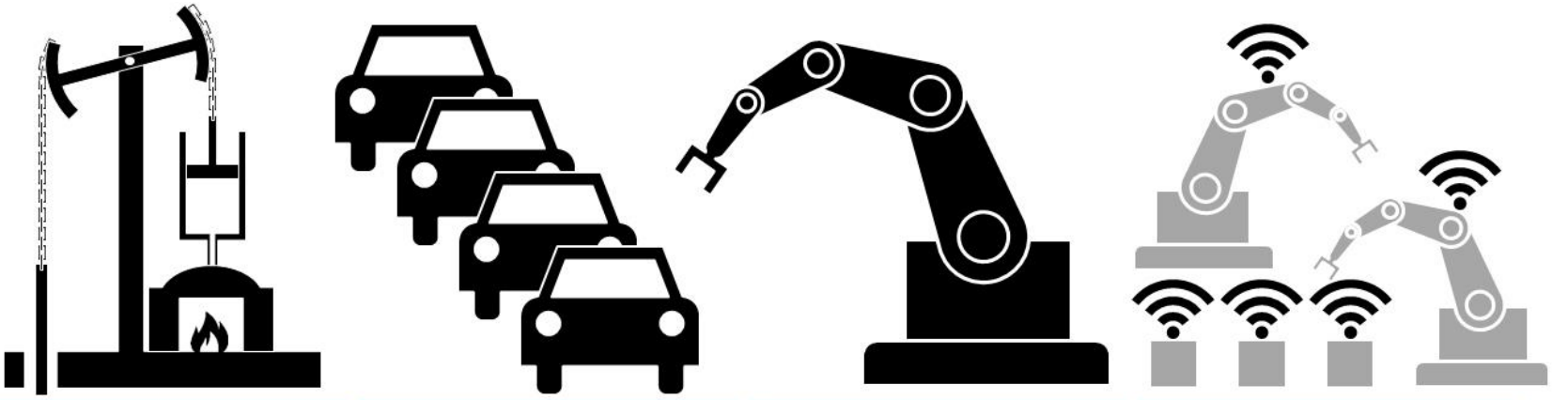
Can Malaysia continue to the global technology leader in processing its Golden Crop?

Panel members observed that the refining and oleochemical sector were the most advanced in palm oil processing

IChemE

Palm Oil Processing
Special Interest Group

The Future



Mechanization	Mass production	Automation	Cyber systems
Plantation			
	Mill/Crusher		
		Refinery	
		Oleochemical	?

Conclusions

- 193 years since beginning
  38 years in ASEAN
  unprecedented progress
- Palm and palm kernel is the raw material of choice
- The industry is safer and sustainable
- Future is multi-purpose plants & bio-process
- Line between oleo and petrochemicals blurring. Current low petroleum prices favour petrochemicals.

Thank You

Q & A

Investment Costs

Year	Capacity	US$	Type
	000t/a	millions	
1980s	50	15	Fatty acids
1990s	110	50	+ soap noodles
2000s	200	75	++ esters
2010s	250	500	+++ fatty alcohol
Recent investments			
2014	350	200	Evyap Sabun
2016	160	150	Unilever Indonesia
2017	160	350	Sinarmas Cepsa
2017	10	10	KLK Oleo addition