



Production and Application of Lipopeptide Biosurfactant for Dispersing Oil Spill in Seawater

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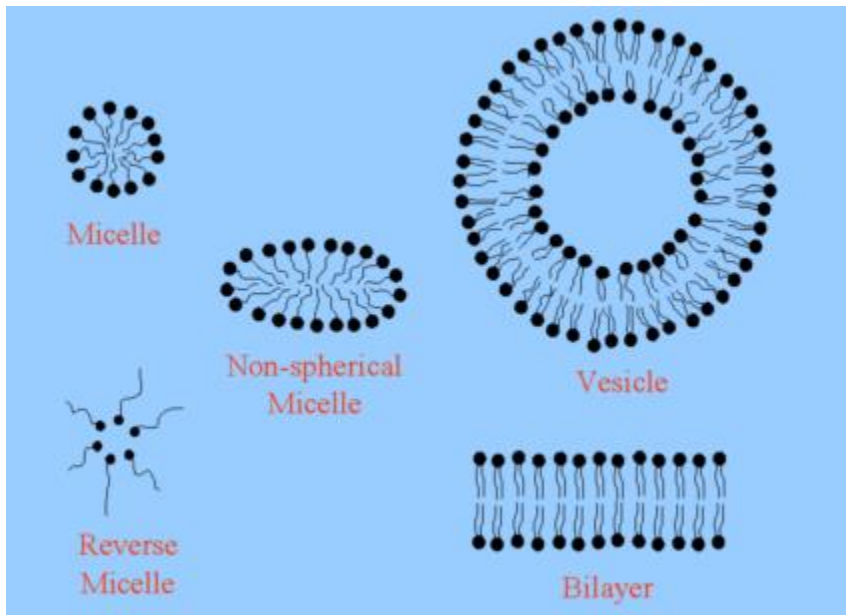
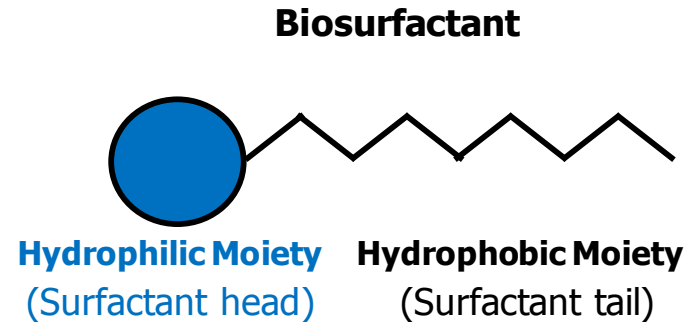
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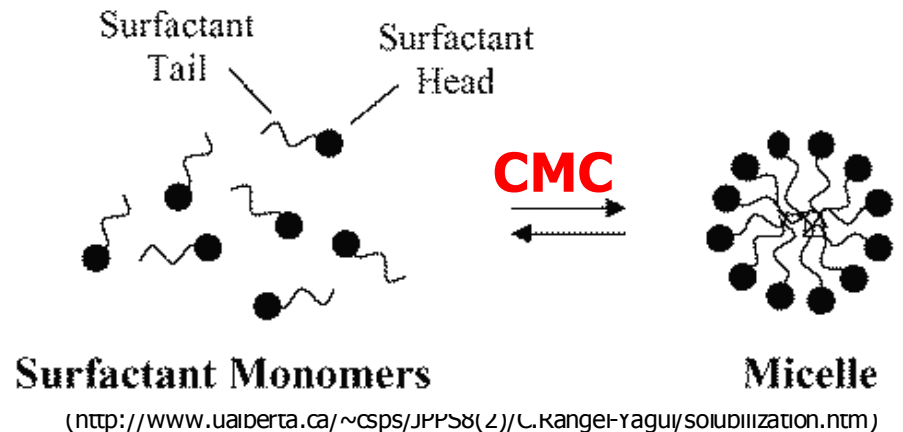
Biosurfactants are surface-active biomolecules produced by microorganisms.

Hydrophilic Moiety
<ul style="list-style-type: none"> • Acid • Peptide cations or anions • Mono-, di- or polysaccharides

Hydrophobic Moiety
<ul style="list-style-type: none"> • Unsaturated or saturated hydrocarbon chains • Fatty acids



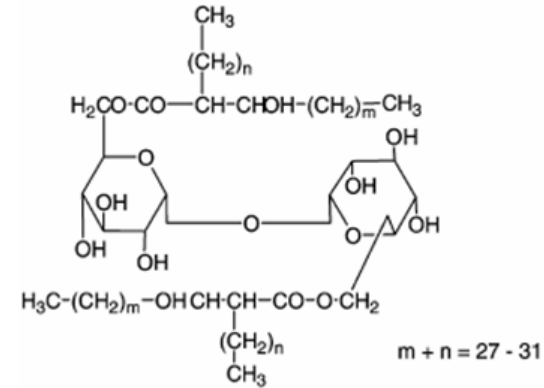
(<http://people.umass.edu/mcclemen/Group.html>)



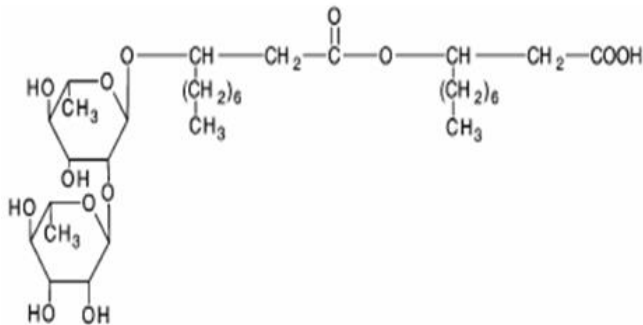
CMC = Critical Micelle Concentration

Classification of Biosurfactants

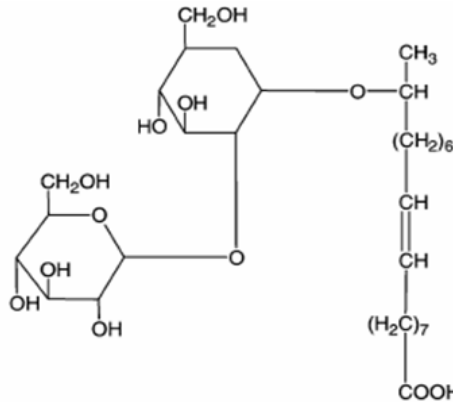
- Glycolipids – Sophorolipids, Trehalolipids, and Rhamnolipids
- Lipopeptides and Lipoproteins
- Fatty acids
- Phospholipids
- Neutral lipids
- Polymeric biosurfactants
- Particulate biosurfactants



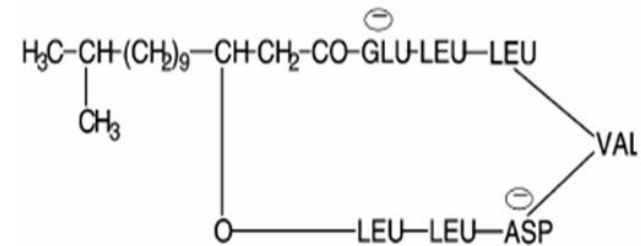
Trehalolipid



Rhamnolipid



Sophorolipid



Surfactin (Lipopeptide)

Advantages

- ✓ **Non-toxic or low in toxicity**
- ✓ **Biodegradable**
- ✓ **Wastes can be used as raw materials**
- ✓ **Able to work at critical condition**
- ✓ **Wide applications**

Limitations

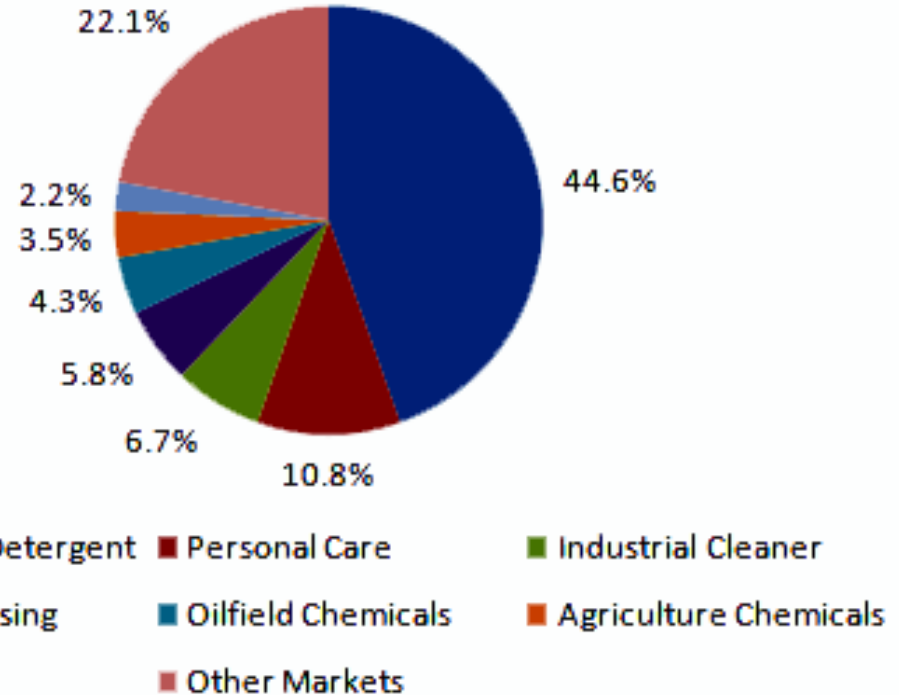
- ✓ **Low production yield**
- ✓ **High production cost**

Biosurfactant applications

1. Household detergent
2. Personal care
3. Industrial cleaner
4. Food processing
5. Oilfield chemicals
6. Agriculture chemicals
7. Textiles
8. Others

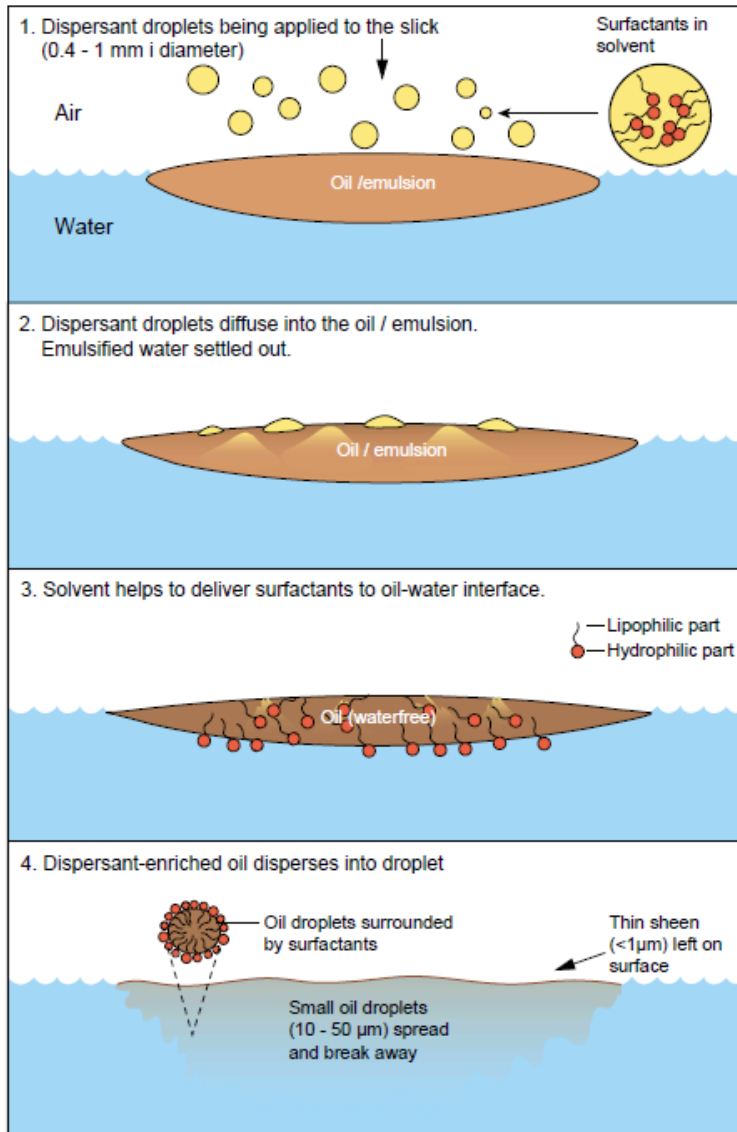
Environmental applications

- Soil bioremediation
- Oil dispersant



Biosurfactant market volume share (by application, 2013)

(<http://www.grandviewresearch.com/industry-analysis/biosurfactants-industry>)



- Blend of two or three surfactants
- Ex. nonionic /anionic/solvent

↓ Oil droplets

Increase **natural attenuation** and **biodegradation** by microorganism.

However, synthetic dispersants are usually toxic and may decrease biological activity of microorganisms.



Mechanism when applying dispersant (modified after Fiocco, 1995).

Low cost substrates???



Substrates



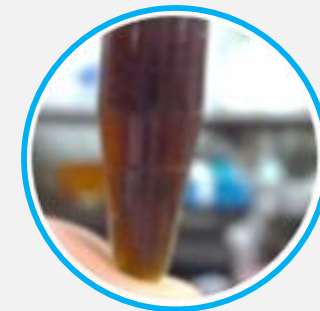
Microorganisms

Biosurfactant producing
Microorganisms???



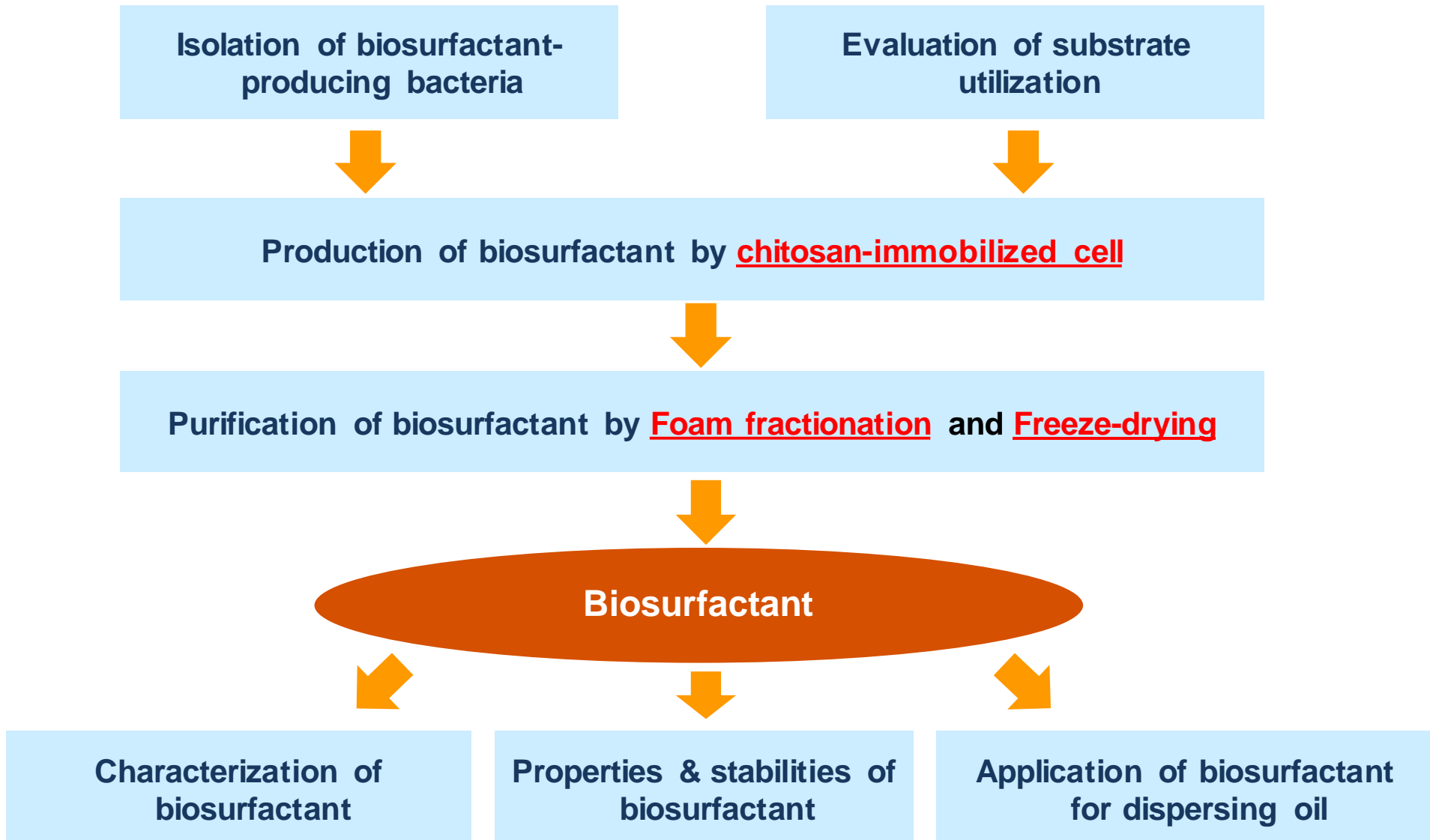
**Production & downstream
processes**

Production & downstream
Processes???



Biosurfactants

Dispersing oil
application???



Biosurfactant producing microorganisms & Substrate selection

Isolation of microorganisms



Microbial screening

107 species

Surface tension < 40 mN/m

58 species

Bacillus sp.
GY19

Highest yield

Substrate Selection

Pure substrate

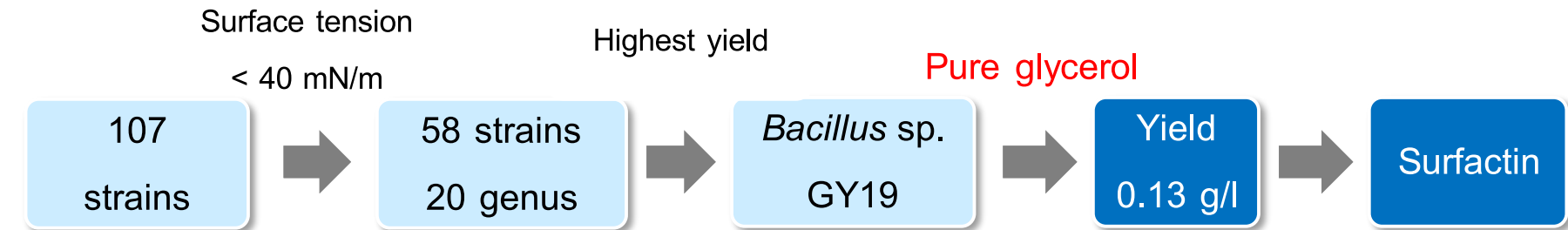
- Glycerol
- Soybean oil
- Palm oil
- Crude oil
- Diesel
- Lube

Organic waste

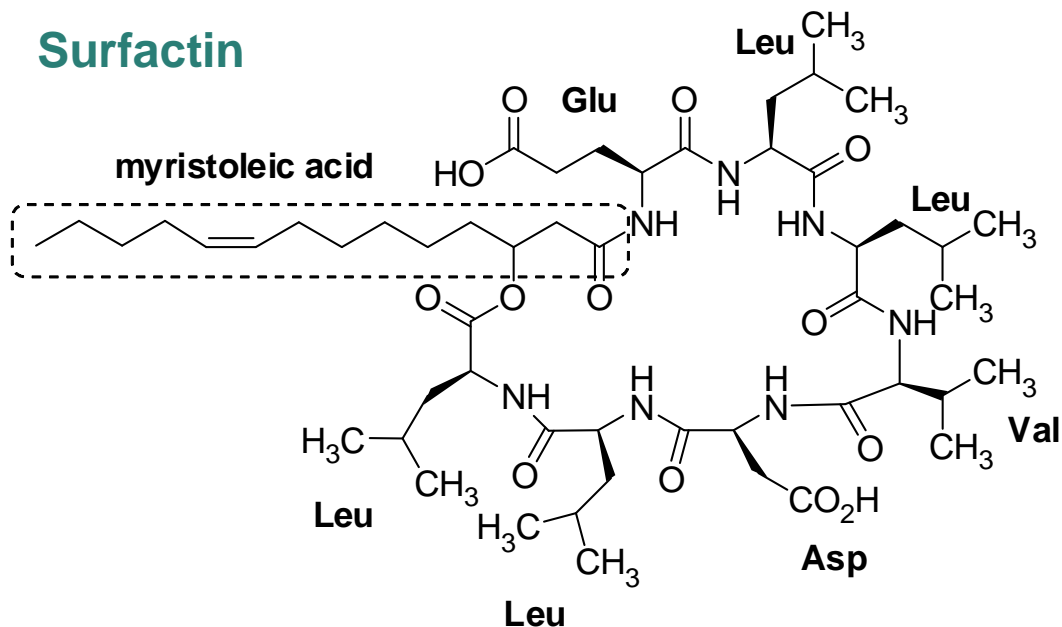
- Slop oil
- Bottom glycerol

- High yield
- Low cost
- Waste reduction

Screening of biosurfactant-producing bacteria



Surfactin



Bottom glycerol

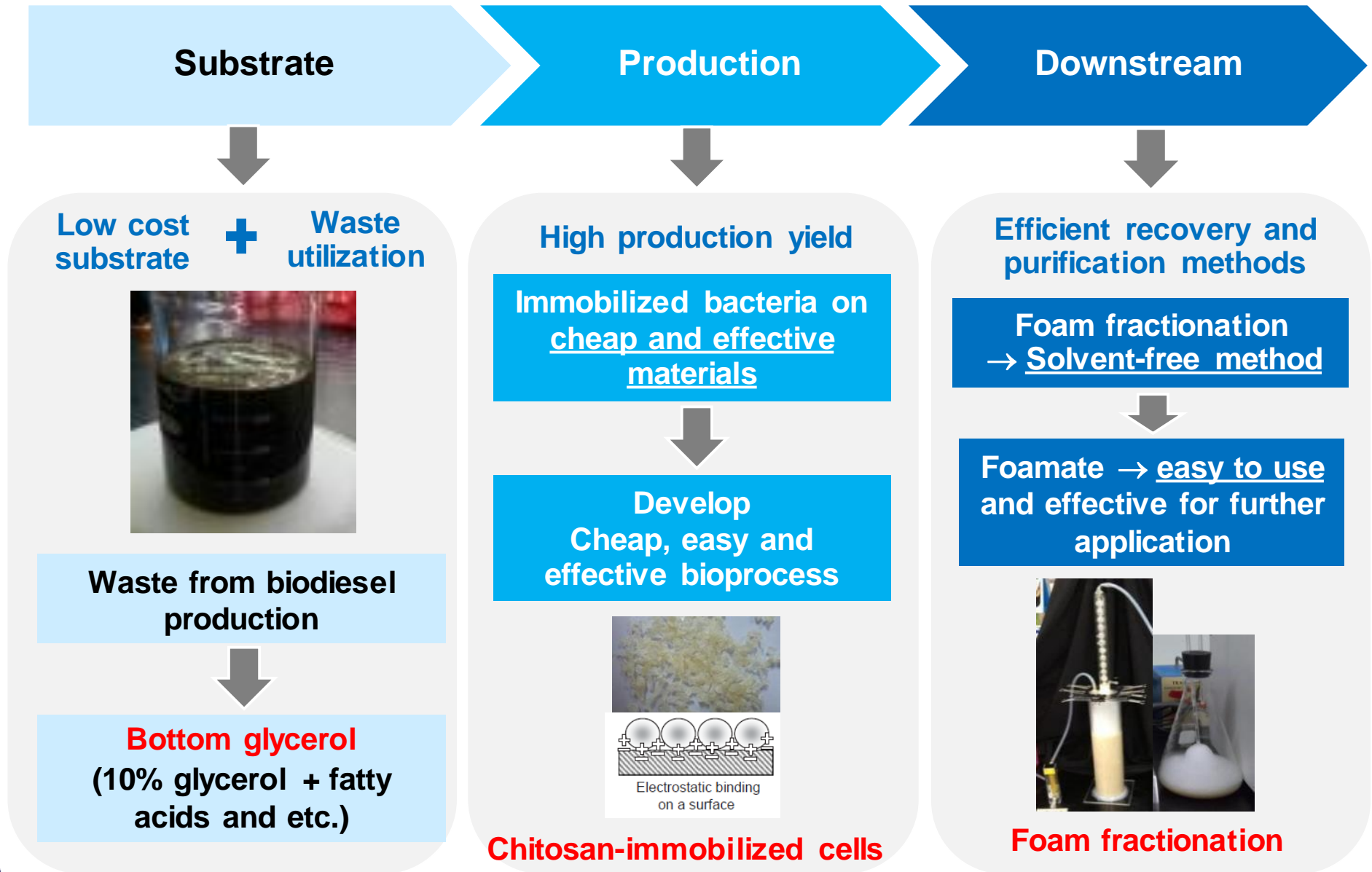
+ palm oil

Yield 2.8 g/l

Lipopeptide biosurfactant

Biosurfactant from pure glycerol

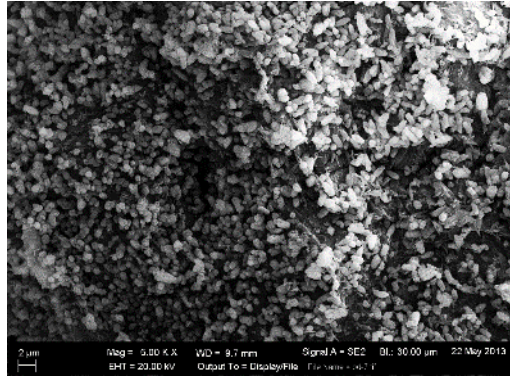
Lipopeptide production and recovery processes



Lipopeptide production by chitosan immobilized cells in stirred tank bioreactor

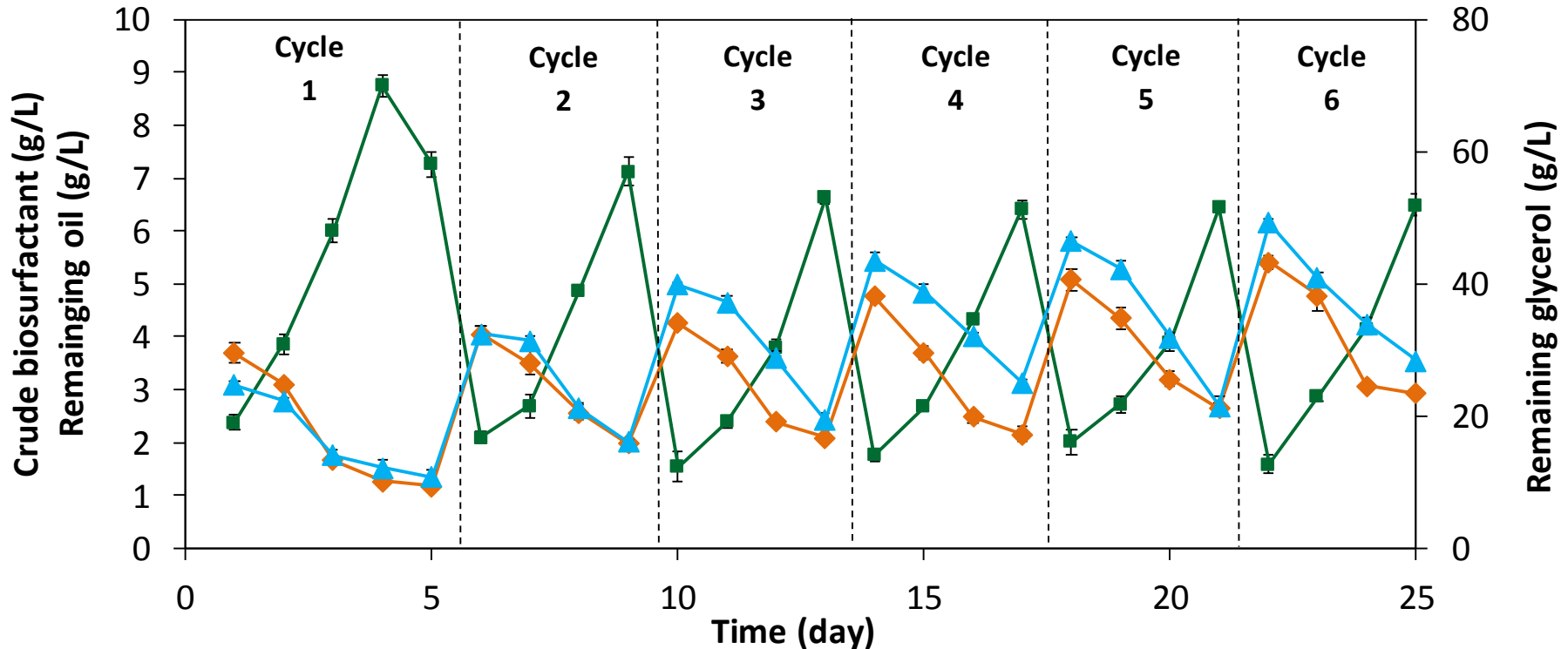


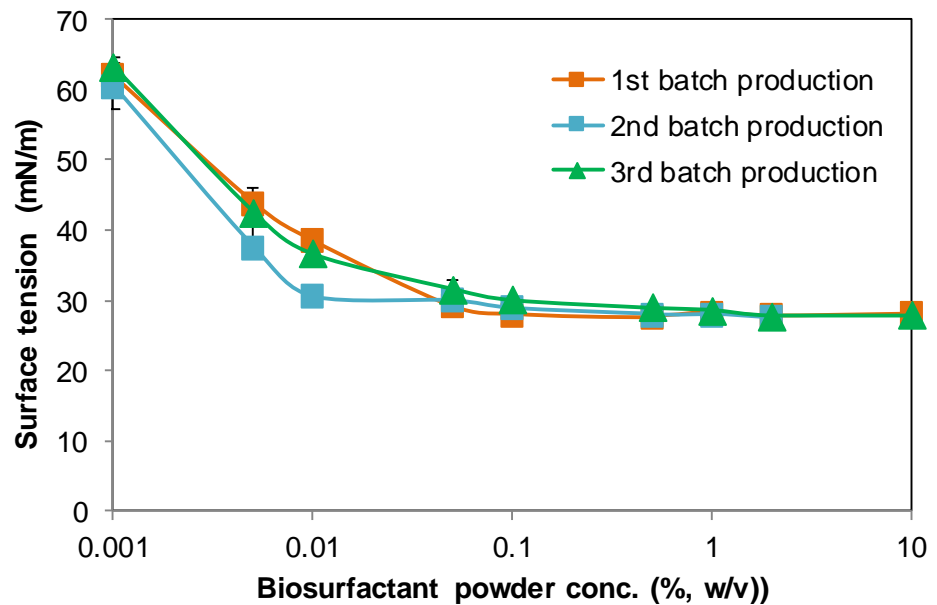
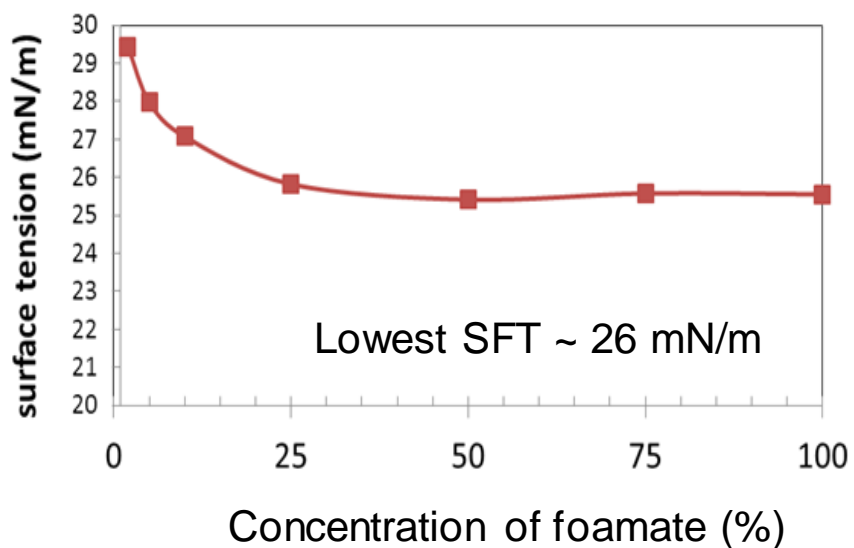
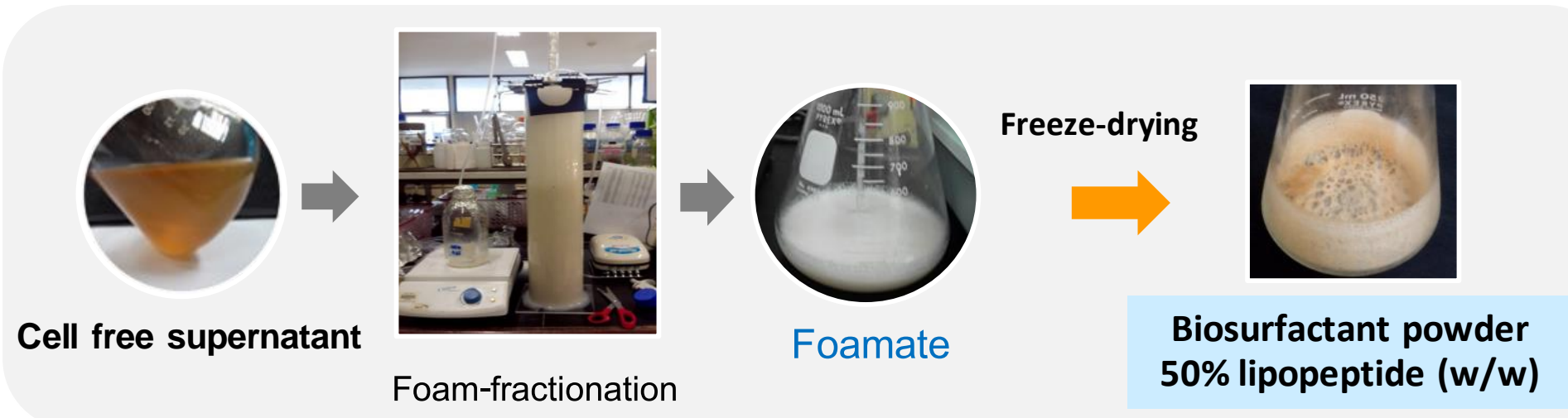
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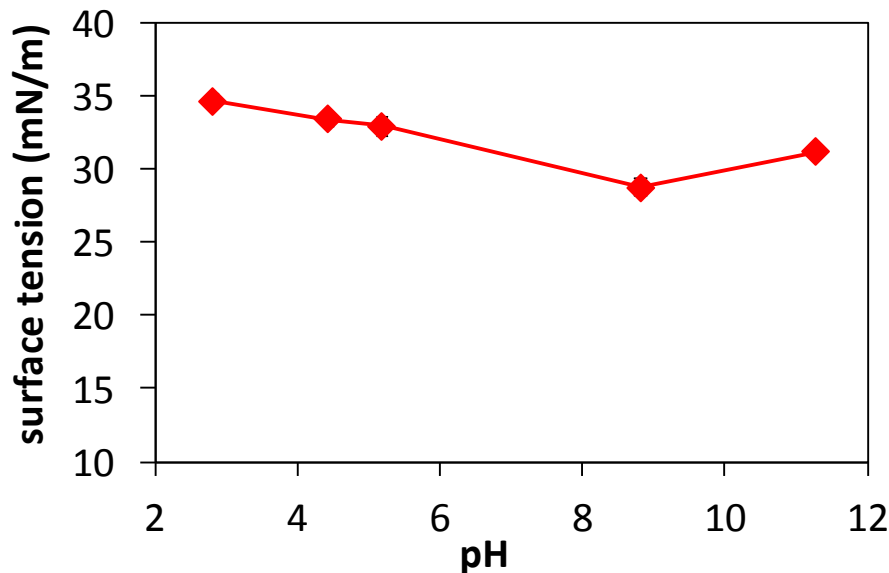
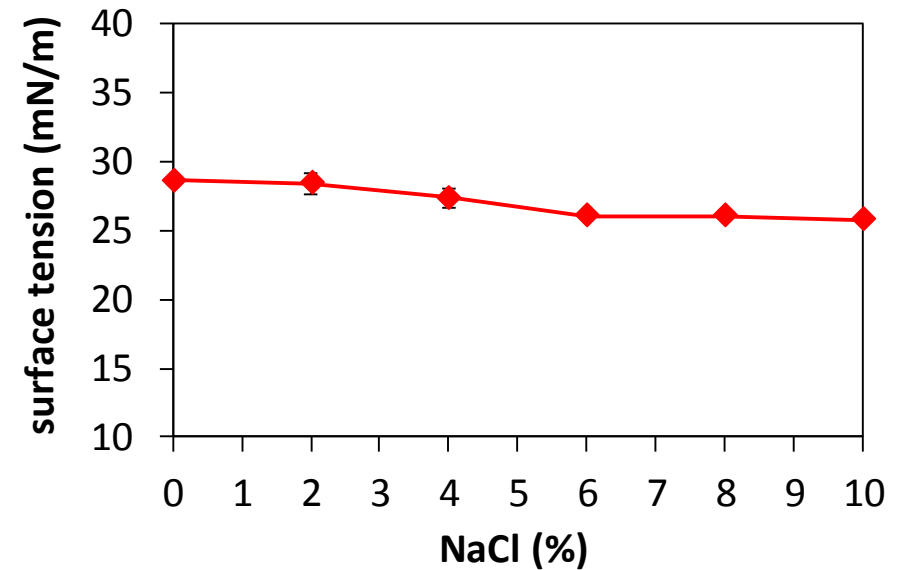
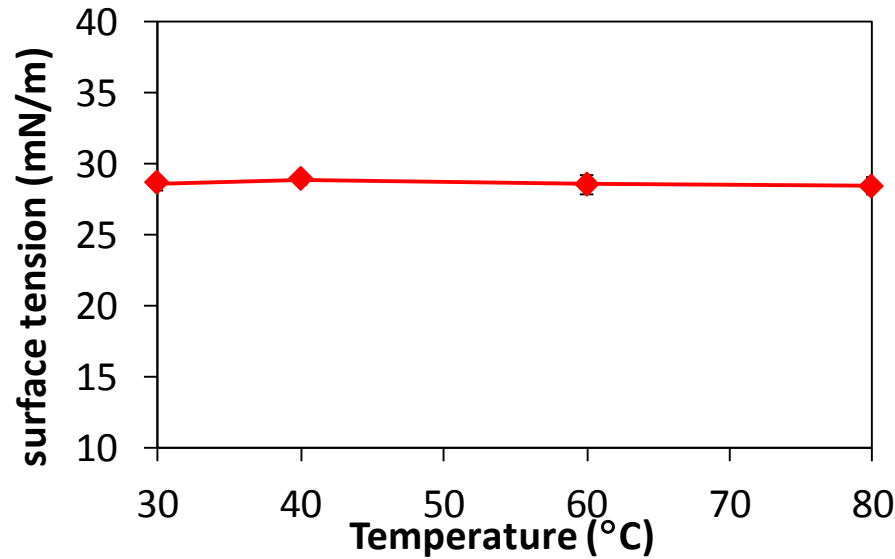


- Palm oil was added as precursor
- Maximum lipopeptide yield 6.65 g/L

■ Crude biosurfactant
 ◆ Oil
 ▲ Glycerol



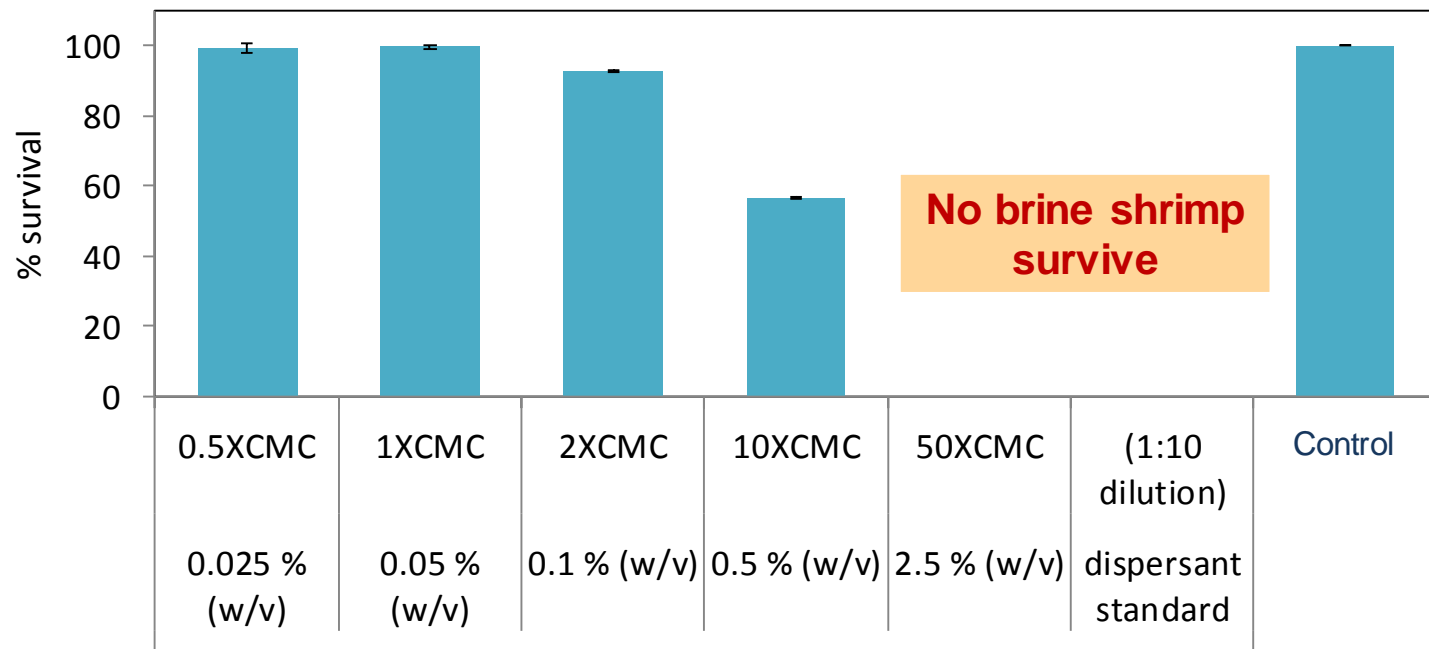




Surface activity was stable at

- **Temperature (40-100°C)**
- **Electrolytes (> 6% NaCl)**
- **pH 7-11.**

Toxic to brine shrimp at very high concentrations

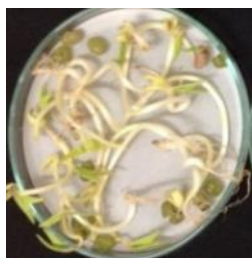


Brine shrimp

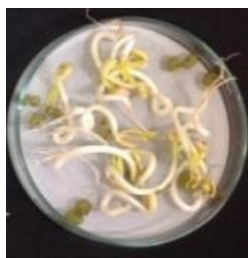


Artimia assay (Luna et al., 2013)

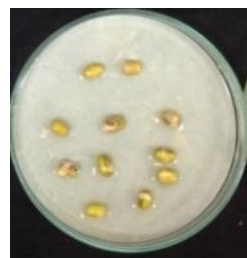
No toxicity to plant seedlings



Water



Biosurfactant

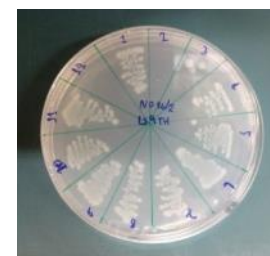


SDS

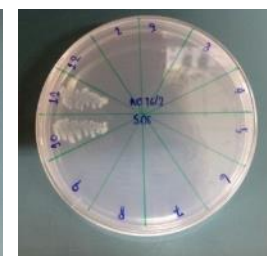
No toxicity to PAH-degrading bacteria



Biosurfactant



LS9TH



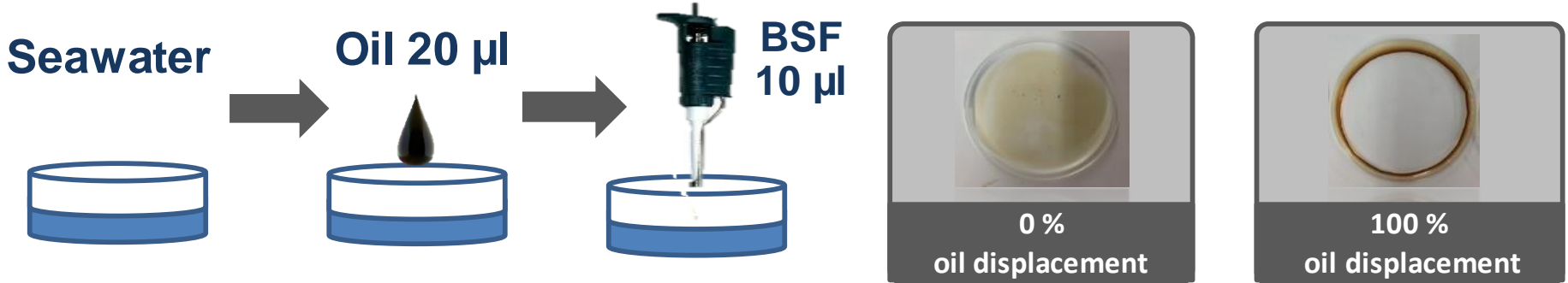
SDS

lipopeptide conc.

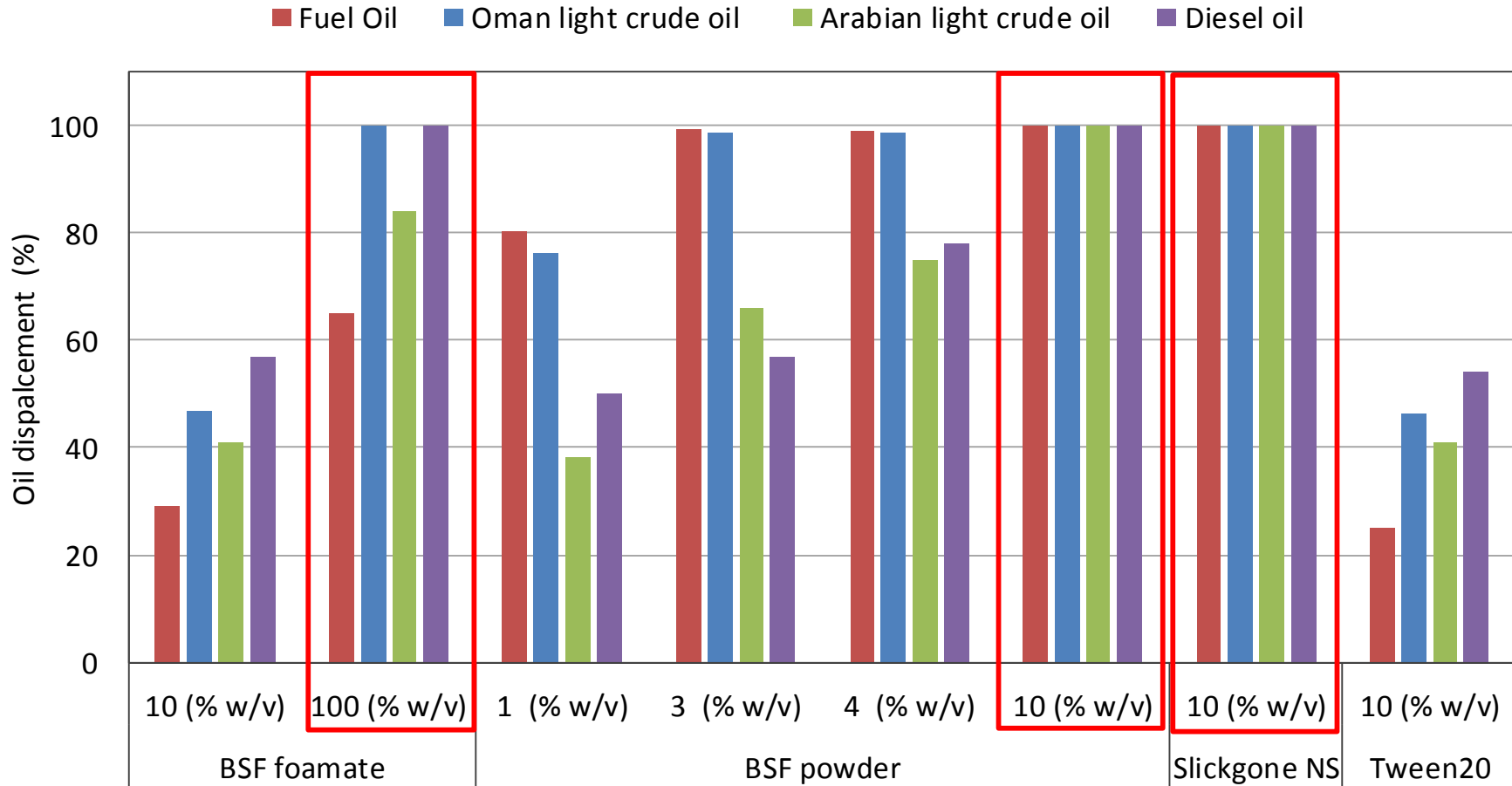
- Varying from 0.25-10 % (w/v)

Petroleum type

- Oman light crude oil
- Arabian light crude oil
- Diesel oil
- Fuel oil



$$\text{Oil displacement (\%)} = \frac{\text{Diameter of clear zone}}{\text{Diameter of oil layer}} \times 100$$



Oil displacement activities of foamate and powder were comparable to a commercial dispersant (Slickgone NS) and much higher than a synthetic surfactant (Tween 20).

- 1 Lipopeptide biosurfactant could be produced from **chitosan-immobilized *Bacillus sp. GY19*** in stirred tank fermenter.
- 2 Lipopeptides could be recovered from cell-free culture medium by **foam fractionation process**.
- 3 Lipopeptides have **good surface activity, low toxicity, and stable under various conditions**.
- 4 Both foamate and powder containing **lipopeptides could be used directly as dispersants for oil spill remediation**



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