From Shore to Structure: Engineering Sustainable Polymers from Seafood Waste

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Background

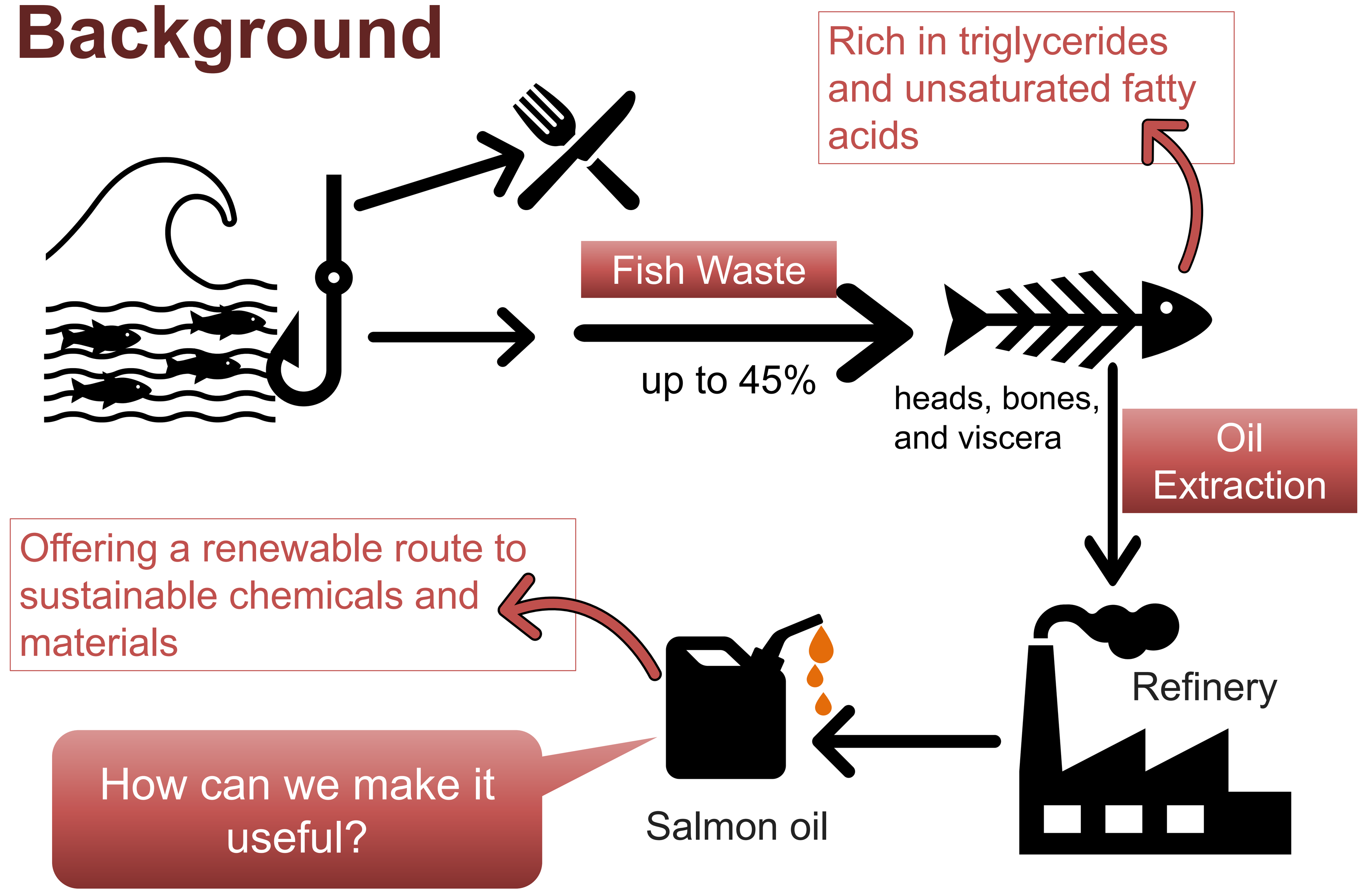


Figure 1. Flowchart of the oil extraction made from by-products of the fishing industry

Building on prior work from the Kerton and Kozak group[1-4], which demonstrated the conversion of fish oil into epoxides, cyclic carbonates, and ultimately **non-isocyanate polyurethanes (NIPUs)**, my research extends this platform by:

1. Broadening feedstocks to include **algae oil**, **salmon oil** and **omega-3 (ω-3) fish oil** and
2. Investigating how **composition and rheological properties** influence processing and polymer performance.

Aim: **To develop a deeper understanding of how marine oil characteristics control reactivity and how does pre-treatment of ocean-derived oils influence the mechanical performance of NIPUs?**

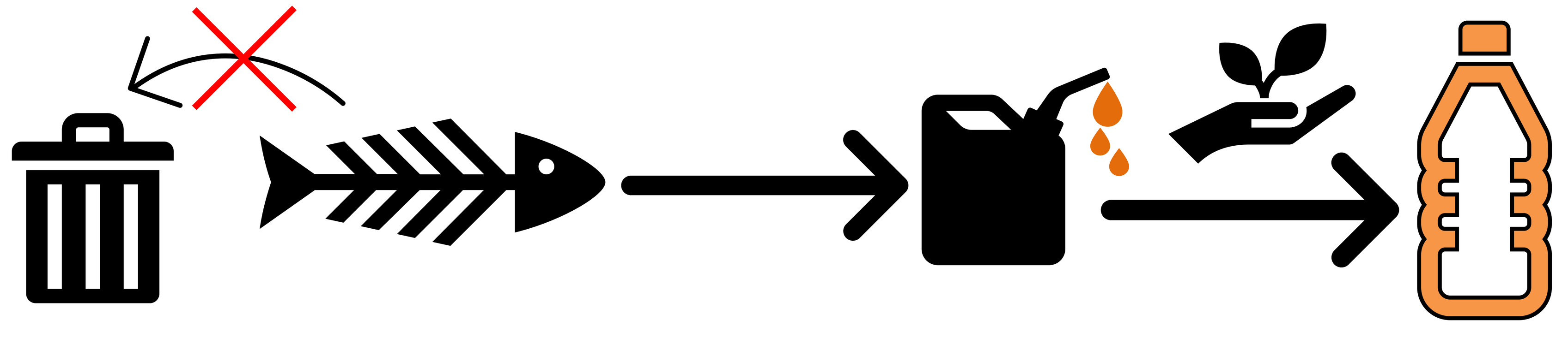
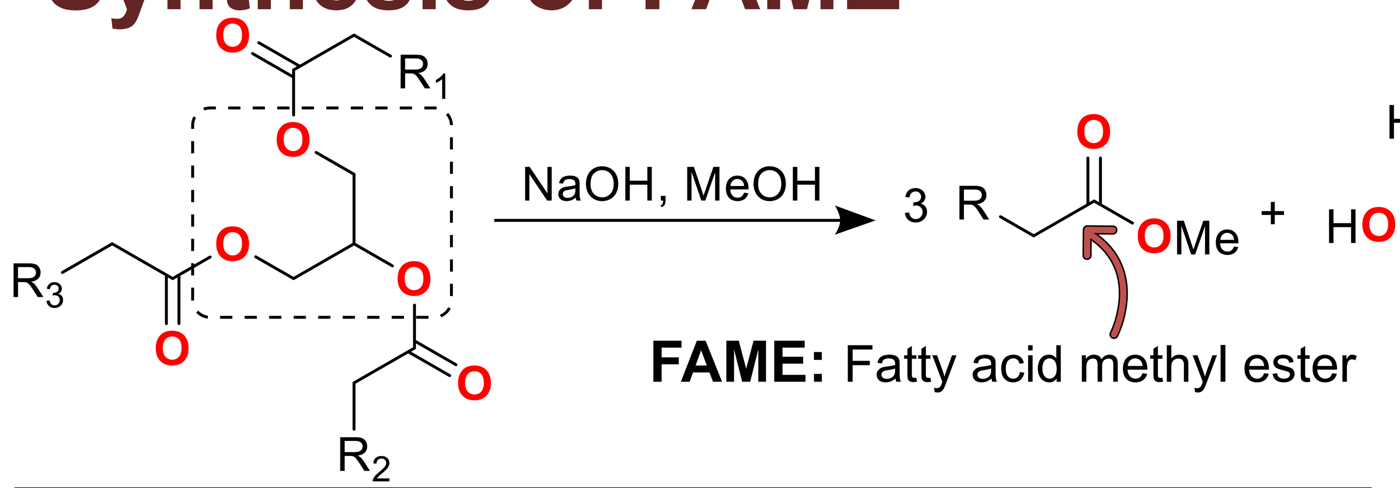


Figure 2. The goal of this project is to create biopolymers from oils sourced from the ocean, turning waste into wealth.

We thank Memorial University's CREAIT Network of core research infrastructure for their support with this work.

Synthesis of FAME



Scheme 1: Cleavage of fatty acid from triglyceride forming FAME[5]

Salmon oil has the lowest % of (C22:6)

Characterization of FAMEs

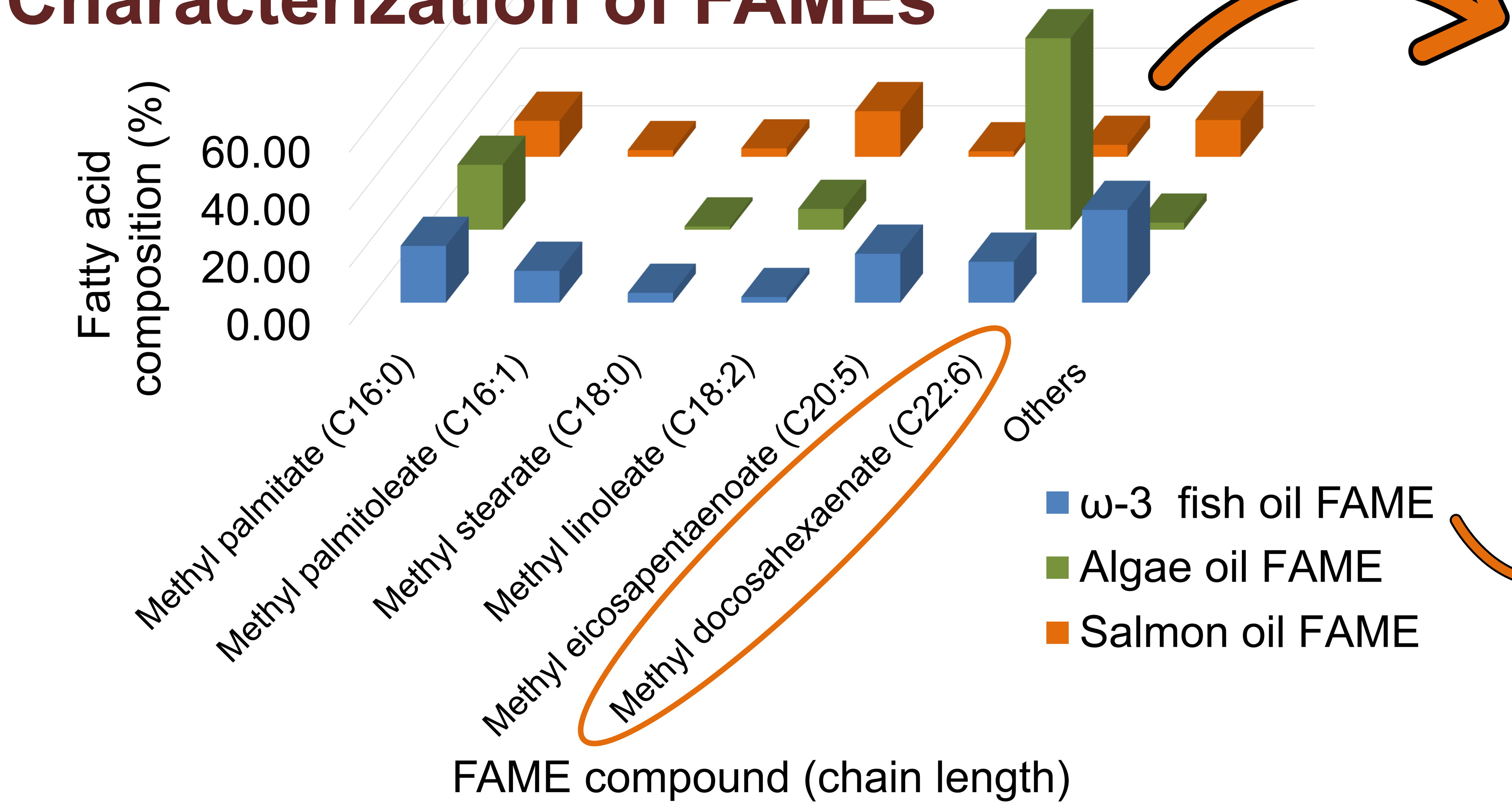
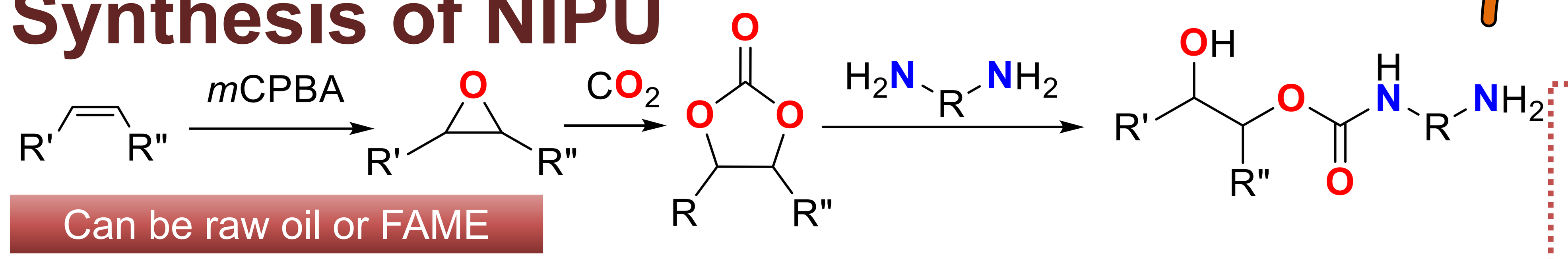
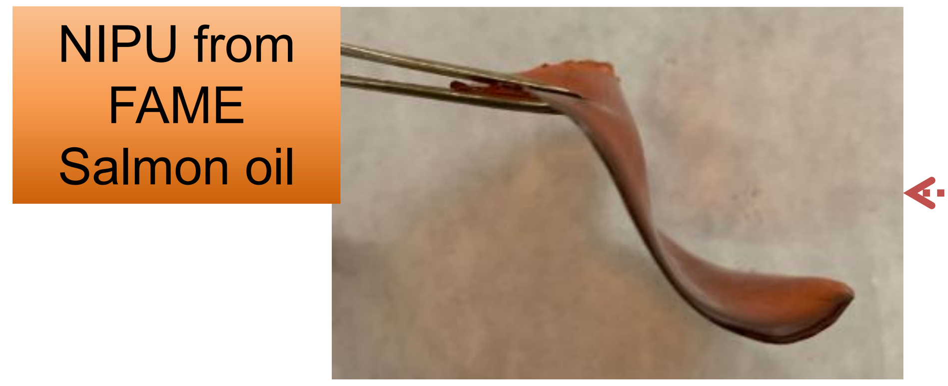


Figure 3. Gas Chromatography mass spectrometry (GCMS) qualitative data for algae, salmon and ω-3 fish oil for various percentage of fatty acid methyl .

Synthesis of NIPU



Scheme 2: Synthesis of epoxidation, followed by carbonation and NIPU.



Rheology (studying the flow of ocean-derived oils)

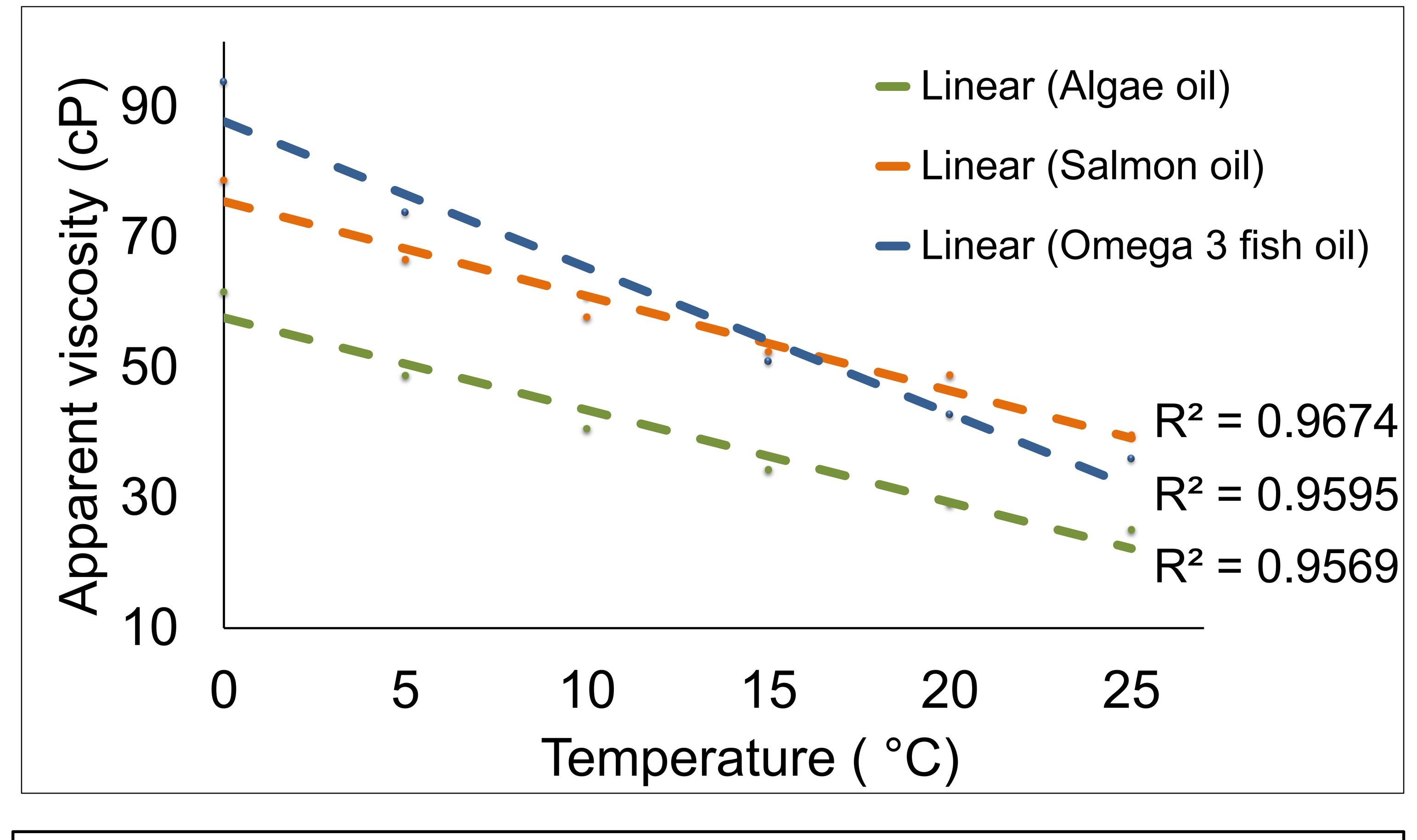


Figure 4. Rheology data at sheer rate 200 s^{-1} for algae, salmon and ω-3 fish oil.

Lower the % of methyl docosahexaenoate (C22:6) in FAME→ higher the viscosity of the oil at 25 °C

Oils	Conversion of oil to FAME (@ 25 °C)[a]
Salmon	56%
ω-3 fish	61%
Algae	95%

Conversion is inversely proportional to the viscosity of oil

[a] Determined by Nuclear Magnetic Resonance spectroscopy (NMR)

Dynamic Mechanical Analysis

So, does pre-treatment of ocean-derived oils affect the mechanical performance of NIPUs?

Comparing NIPU made from Salmon oil raw v/s NIPU made from FAME Salmon oil

Sample (@ 25 °C)	Salmon oil (raw) NIPU	Salmon oil (FAME) NIPU
Tensile Strength (MPa)	0.501	0.0337
Elongation at break	93.7%	179%
Young's Modulus (MPa)	0.00780	0.000507
	Rigid material	**Flexible material**

Yes, it does. Even small molecular differences in these oils cause significant changes in polymer mechanics.

Future directions

- ❑ Expanding to mixed-oil systems for tailored polymer properties.
- ❑ Exploring marine-degradable NIPU and other polymers for coatings, foams, and composites

References

(1)Adeoti, I. A.; Hawboldt, K. *Fuel* **2015**, *158*, 183–190. (2)Dong, T.; Dheressa, E.; Wiatrowski, M.; Pereira, A. P.; Zeller, A.; Laurens, L. M. L.; Pienkos, P. T. *ACS Sustain. Chem. Eng.* **2021**, *9* (38), 12858–12869. (3) Lage, S.; Gentili, F. G. *Bioresour. Technol.* **2018**, *257*, 121–128. (4) Laprise, C. M.; Hawboldt, K. A.; Kerton, F. M.; Kozak, C. M. *Macromol. Rapid Commun.* **2021**, *42* (3), 2000339. (5) Peddle, J. E.; Laprise, C. M.; Wheeler, M. D.; Fitzgerald, M. M.; Kerton, F. M.; Kozak, C. M. *Faraday Discuss.* **2025**.