OIL FROM FISH PROCESSING BYPRODUCTS AND UNDERUTILIZED FISH AS A VIABLE RENEWABLE RESOURCE FOR BIODIESEL PRODUCTION

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Biodiesel

$$TG + 3ROH \xrightarrow{\text{Catalyst}} 3R'CO_2\text{-}R + GL$$

A complete list of potential domestic oil sources for biodiesel

- Food grade cooking oils - soy, canola, peanut and sunflower oils
- Off-quality and rancid vegetable oils
- Used cooking oils from restaurants
- Animal fats - beef, pork, chicken fats and fish oils

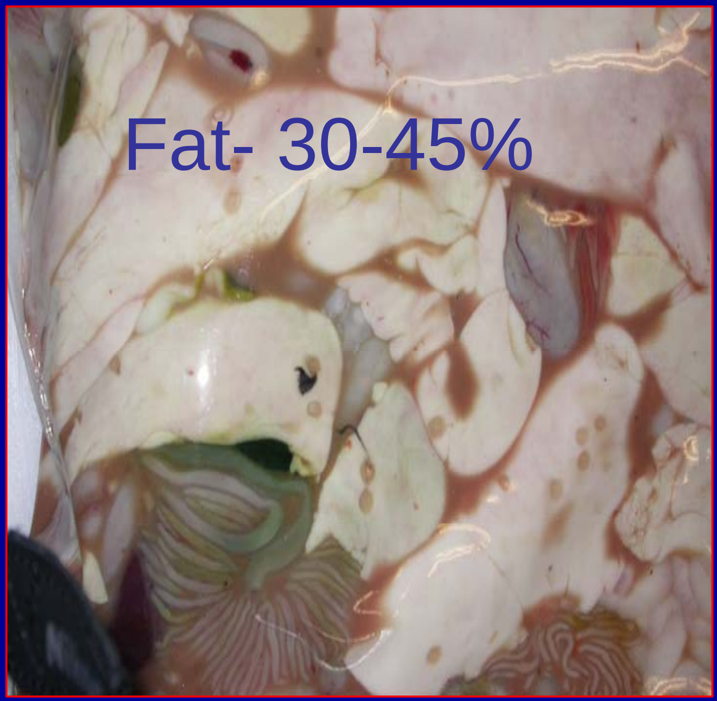
- **In the United States most of the vegetable oil-based biodiesel is generated using soybean oil in a base-catalyzed transesterification process.**

- **Over 70% of the production cost is due to the feedstock.**

Fish Oil as an Alternative Feedstock

Fish oil can be an alternative feedstock to produce biodiesel.

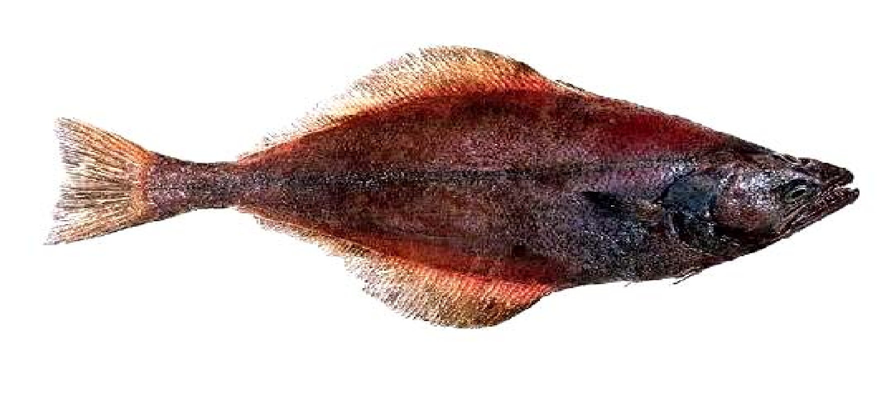
Fish oil from byproducts and underutilized fish can be easily converted into usable biodiesel, which is a clean-burning bio-oil and can be used to reduce dependence on imported fuel and improve air quality.



Good source for fish oil pollock livers

Good source for fish oil salmon heads

Arrowtooth Flounder



In the Bering Sea and Aleutian Islands, the National Marine Fisheries Service has estimated an annual exploitable biomass of the arrowtooth flounder at 576,000 mt (ADFG, 2005), which contains approximately 5% fat (Sathivel et al., 2005).

It is clearly indicated that larger quantities of fish oil can be produced from fish byproducts and underutilized fish.

Melting points and enthalpies of fatty acids and melting points of methyl esters

Samples	Melting point of fatty acids (^{o}C)[a]	Enthalpy (j/g)[c]	Melting point of methyl esters (^{o}C)[b]
C14:0	53.5	198.3	18.5
C16:0	59.8	212.8	30.5
C18:0	67.6	226.3	39.1
C20:0	70.6	236.9	
C16:1	-0.9	125.8	-20
C18:1	-5.7	152.2	-35
C18:2	-13	119.1	-57
C18:3	-21	115	
C20:2	-8.3	103.1	
C20:4	-43.4	113.3	
C22:6	-47.4	89.1	

[a]Sathivel, 2001; [b]Briggs, 2005

Melting ranges and enthalpies of unrefined fish oils

Unrefined Fish Oil	Melting ranges (°C)	Enthalpy (j/g)	Viscosity (Pa.s)
Crude pink salmon oil	-64.7 to 20.8[a]	39[a]	0.036[a]
Crude red salmon oil	-69.6 to -0.36[a]	40[a]	0.032[a]
Crude pollock oil	-48.0 to 10[b]	79.6[b]	0.039[b]
Crude arrowtooth flounder oil	-51.4 to 7.3[c]	84.7[c]	0.041[c]
Crude catfish oil	-46 to 20.4[d]	73.9 [d]	0.049[e]

[a]Sathivel 2005a; [b]Sathivel 2005b; [c]Unpublished data; [d]Sathivel 2001; [e]Sathivel et al. 2003b.

- **One use of biodiesel is to fuel diesel engines. Fish oil can be used directly in diesel engines, but there will be several complications.**

- **First, fish oil does not flow well because its viscosity is much higher than petrol diesel.**

- **A second complication is that straight unrefined fish oils do not burn as cleanly as biodiesel due to impurities such as soluble protein and water and will result in more particulate-laden emissions and carbon buildup on fuel injectors and inside the engine.**

- **Third, use of unrefined fish oil as an energy source for operating the processing plant such as boiler fuel and other industry purposes do not qualify for tax incentives designed to foster the use of biodiesel as a fuel source for vehicles.**

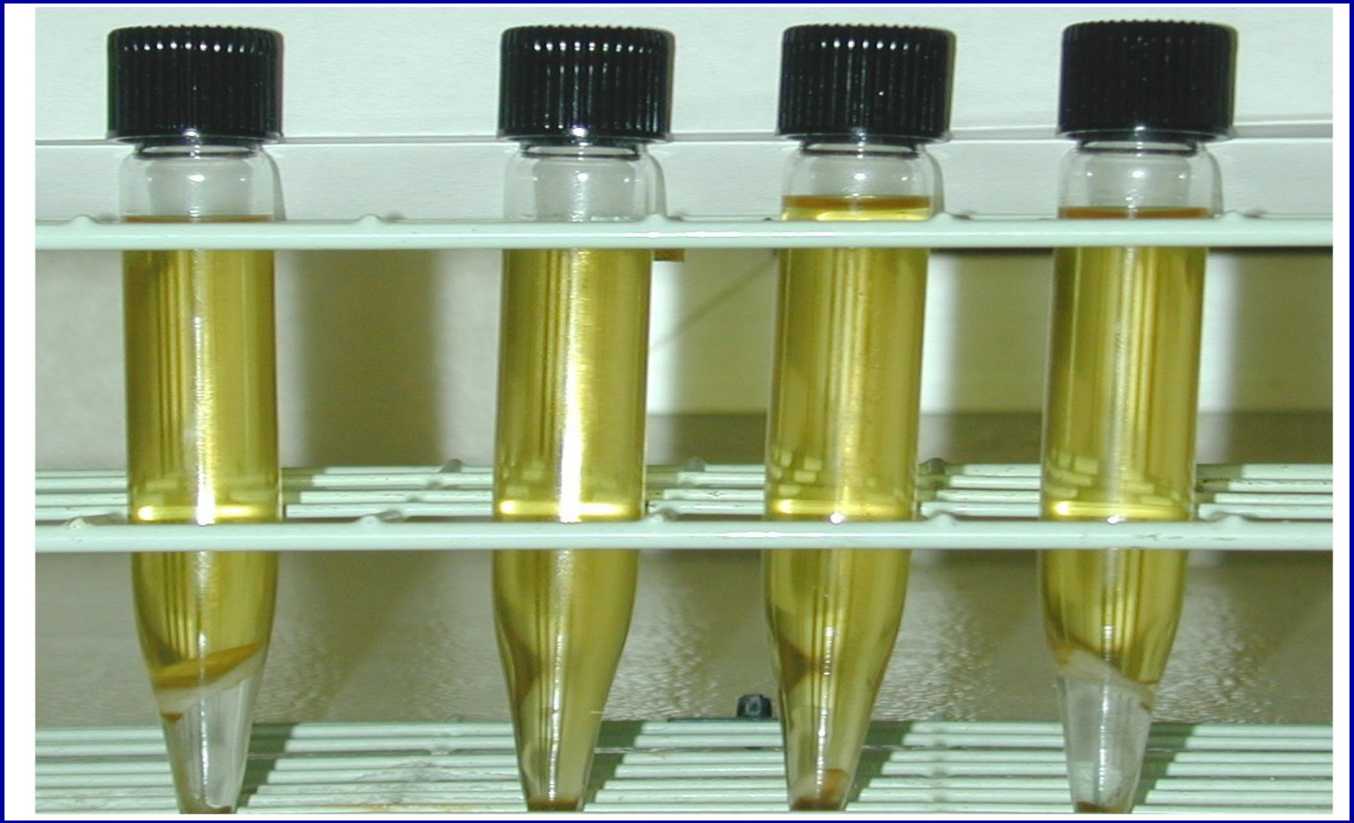
Crude Oil

The oils obtained directly from rendering contain varying but relatively small amounts of naturally occurring non-glyceride materials that are removed through series of processing steps.

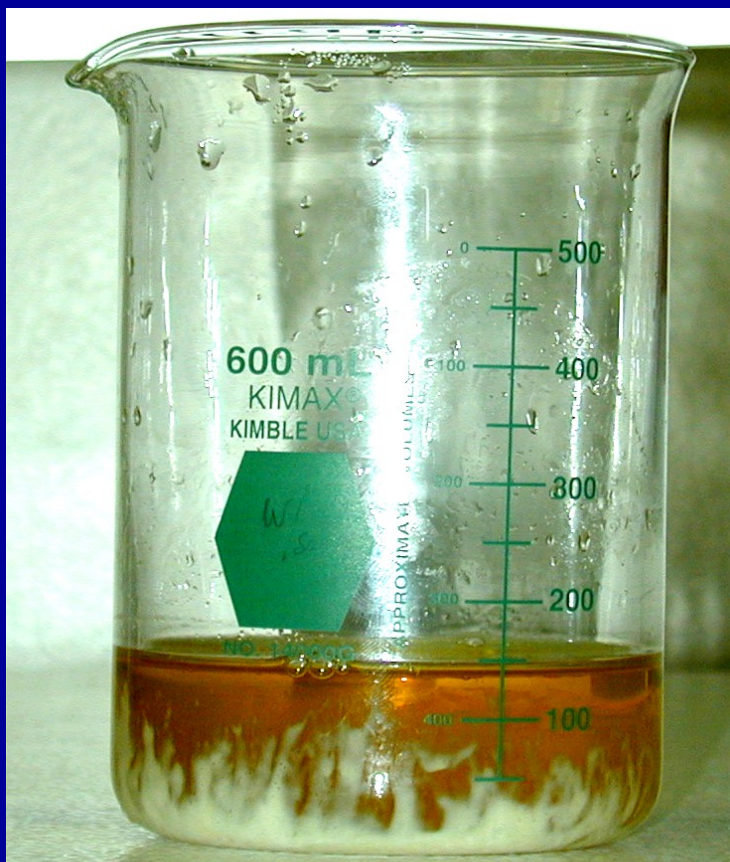
For example, crude oils contain some free fatty acids, water, and protein that must be removed.

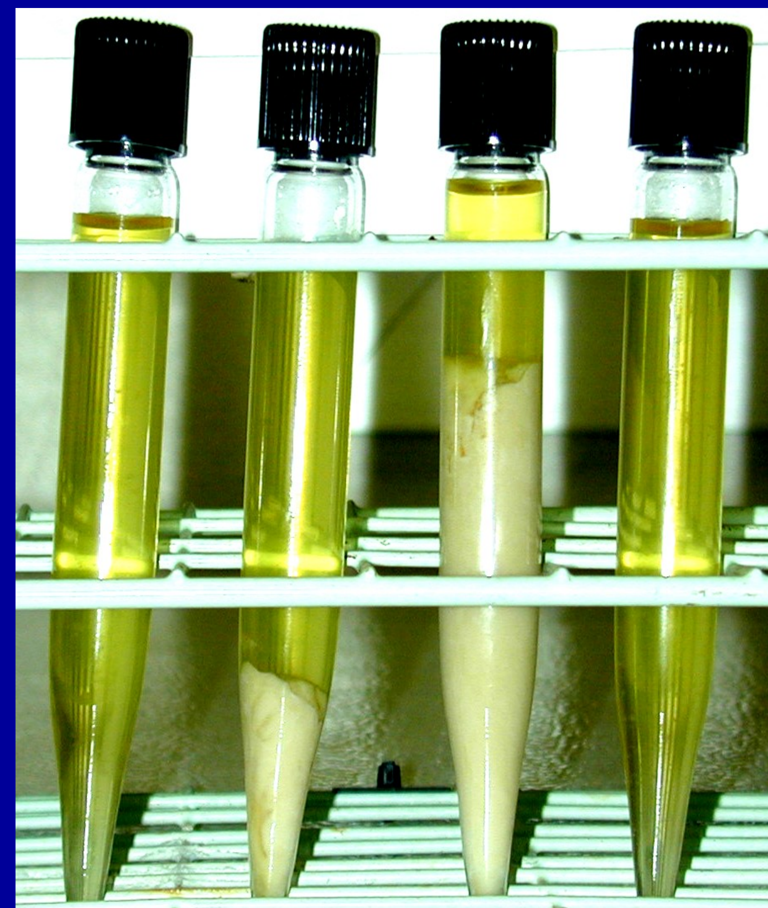
Degumming

The gum can be removed from oil with water or acids such as phosphoric acid or citric acid.



Neutralized Fish Oil





Bleaching

Bleaching is designed to improve color, flavor and oxidation stability of the oil by removal of compounds responsible for color and off-flavor.

Deodorizing

Deodorization is the last major processing step in the refining of edible oils. Due to current harvesting, processing practices, high concentration of polyunsaturated fatty acids and other contaminants, crude fish oil are easily subjected to deterioration.

Deodorization has been considered as a unit process that finally establishes the oil flavor and odor characteristics that are most readily recognized by the consumer.

Limitations of Commercial Fish Oil Purification

Multistep procedure – time consuming/labor intensive

High processing cost

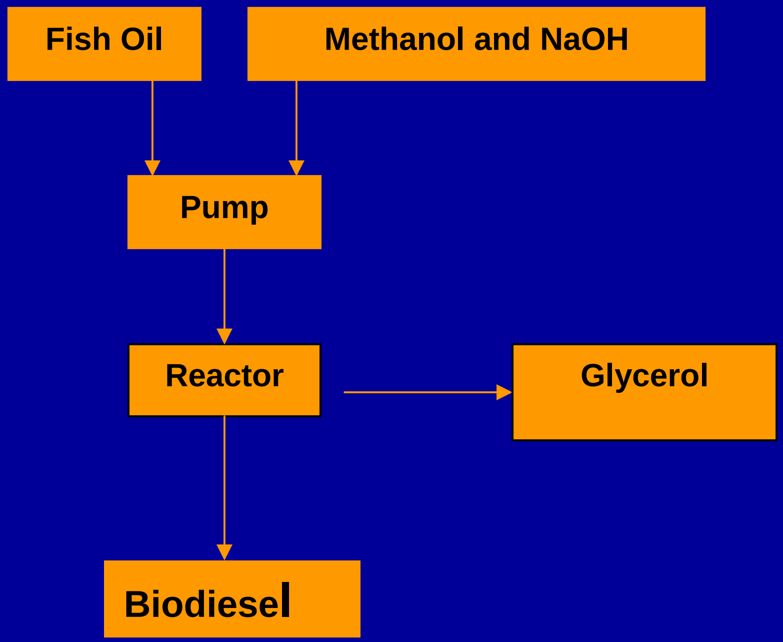
High refining loss

More oxidation

Chitosan

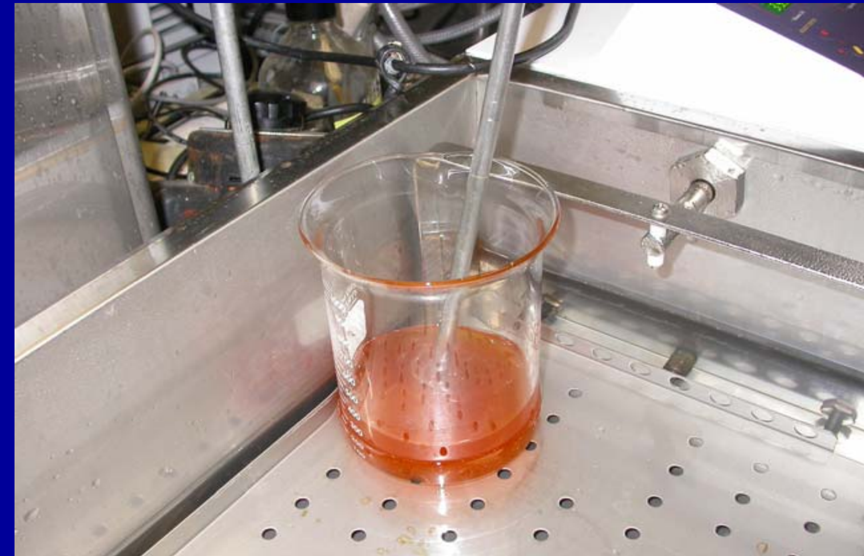
Shrimp, crab, and other crustacean shells are mainly composed of chitin that can be converted to chitosan by deacetylation.

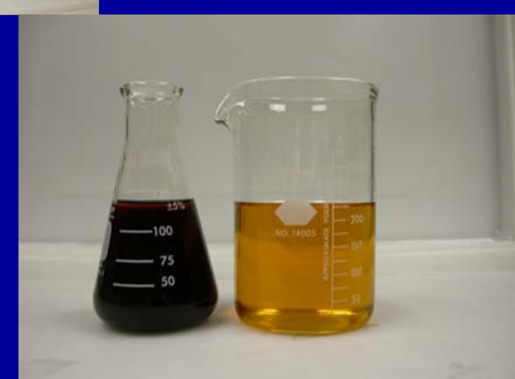
	Before	After
Water activity	0.9	0.43
PV (milliequivalent peroxide/kg sample)	1.8	1.6
L*	21.9	21.5
a*	0.9	2.6
b*	1.7	2.7



Biodiesel Production


1000 mL
PYREX




100
75
50

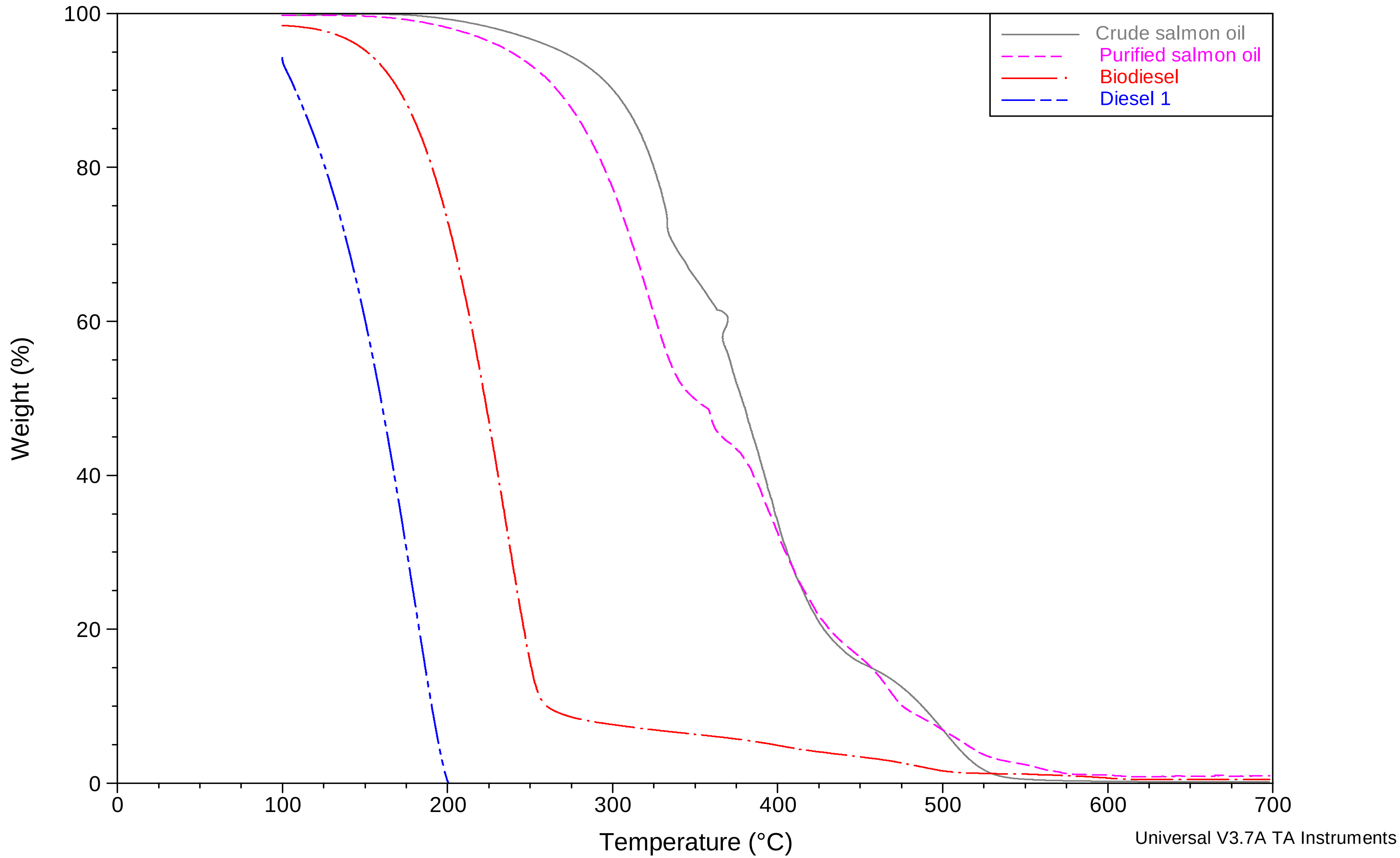
Viscosity of salmon oil, biodiesel, and diesel (Pa.s)

Samples	Viscosity at 25 ^oC	Viscosity at 0 ^oC
Crude salmon oil	0.014	0.04
Purified salmon oil	0.013	0.03
Salmon biodiesel	0.004	0.005
Diesel (D1)	0.004	0.004


MSR


MSR

Thermal Analysis



Further Study

- **Perform chemical kinetic studies in order to obtain rate constants and activation energy values.**

- **Characterizing low temperature phase stability studies of fish oil based diesel and regular diesel blends.**

- **Fuel property testing**

  Cetane number ASTM D613
  Lubricity (4-ball wear test) ASTM D6078 and D6079
  Flash point ASTM D93; energy value ASTM D240
  Oxidative stability
  Cloud point and low temperature filter plugging point ASTM D2500
  Energy

  These tests will determine whether the new formulation meets ASTM D 6751 biodiesel standards.

- **Emissions testing**

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Thank You