OPEN HOUSE

Department of Chemical Engineering

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Production, Characterization & Process Optimization of Biodiesel From Waste Cooking Oil

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Process Flow Chart



Waste Cooking Oil (WCO) is procured from IIT Delhi Hostel Mess



KOH and Methanol (6×moles of WCO) in required quantities are mixed



Waste Cooking Oil (WCO) being filtered for coarse impurities



Waste Cooking Oil (WCO) post pre-filtration



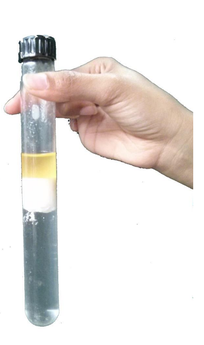
WCO and KOH+Methanol solution is heated and stirred at 60°C for 1 hour



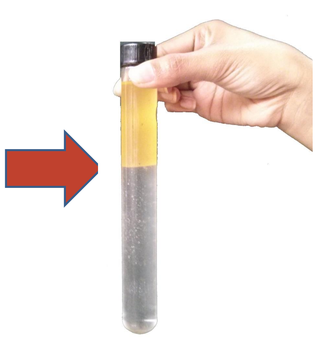
Product mixture is allowed to settle in a separating funnel where glycerol is separated



Separated Biodiesel+Soap



Washed supernatant with biodiesel on the top and soap forming a layer



Biodiesel after third wash



Separated Glycerol



Product Biodiesel



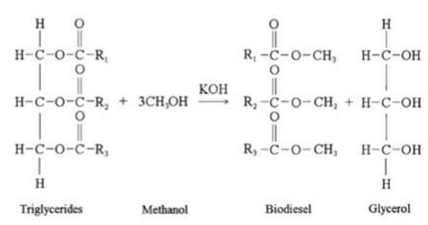
The washed biodiesel is desiccated in a desiccator to remove water.

Biodiesel is a hydrocarbon fuel manufactured from vegetable oils, animals fats or recycled restaurant greases. It is biodegradable and produces lesser carbon footprint than conventional petroleum based diesel due to carbon fixation. With an increasing energy crisis, need for alternative energy resources is increasing. Owing to its adaptability to the current CI engines, Biodiesel is increasingly being used as a blend with petroleum based diesel.

In this research based project, we have prepared biodiesel from **waste cooking oil** (WCO) (procured from **IIT Delhi Hostel Mess**) using a base catalyzed trans-esterification reaction. The raw material - WCO and product - biodiesel have been extensively characterized. These characteristics were compared and found to comply with pre-existing **European and American Standards (EN 14214 and ASTM D6751)**. The process parameters, amount of catalyst and temperature have been optimized to give the best yield.

Trans esterification is an equilibrium reaction where WCO (**Triglycerides**) are converted to **Fatty Acid Methyl Esters (FAME)** in the presence of basic catalyst **KOH and Methanol**. Glycerol is produced as a by product. In order to shift the equilibrium to the product side, excess of methanol is used.

Often soap is formed during the reaction due to Free Fatty Acids (FFAs) present in the reactant WCO. **Glycerol** formed in the reaction, being significantly heavier than biodiesel is separated using a separating funnel. The biodiesel is then washed with water to remove soap which may have formed as a result of FFA content in WCO. The biodiesel is then desiccated and is ready for testing.



Characterization

Waste Cooking Oil

Property	Experimental Value
Kinematic Viscosity $\left(\frac{mm^2}{s}\right)$ at 40^0C	35.137
Calorific Value $\left(\frac{MJ}{kg}\right)$	40.054
Acid Value $\left(\frac{mg\ KOH}{g\ Oil}\right)$	0.448
Density $\left(\frac{kg}{m^3}\right)$ at 15^0C	960

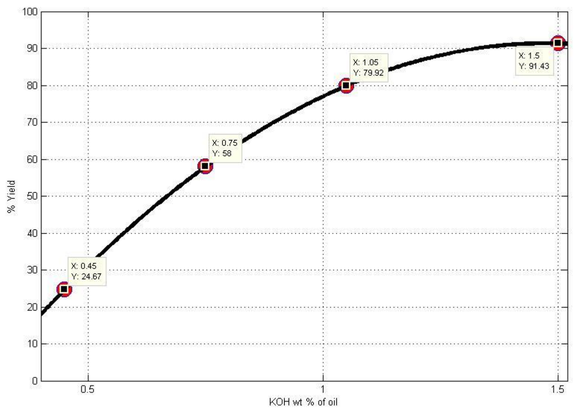
Biodiesel

Property	Experimental Value	EN 14214 Standards	ASTM D6751 Standards
Kinematic Viscosity $\left(\frac{mm^2}{s}\right)$ at 40^0C	4.539	3.5 - 5	1.9 – 6
Calorific Value $\left(\frac{MJ}{kg}\right)$	40.629	37.27 - 40.72*	-
Ignition Point (°C)	190	-	-
Acid Value $\left(\frac{mg\ KOH}{g\ Oil}\right)$	0.308	<0.5	<0.5
Density $\left(\frac{kg}{m^3}\right)$ at 15^0C	850	860 – 900	-

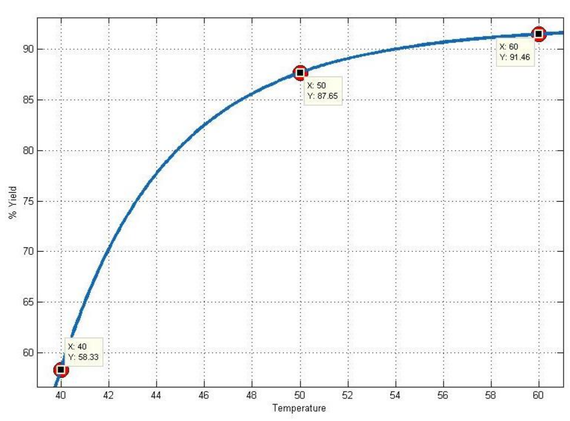
*Value as reported in literature: Enweremadu and Mbarawa (2009)

Process Optimization

Optimization With Respect To Catalyst



Optimization With Respect To Temperature



- As amount of catalyst increases, yield increases, but the amount of soap formed also increases. Therefore, from the plot, it is best to operate the reaction at 1.47 wt% KOH. The expected yield in this case is 91.43%.
- As temperature increases, yield increases. However, boiling point of methanol being 64°C, the reaction needs to be operated below this temperature. From the plot, it is best to operate the reaction at 60°C with sufficient temperature control.

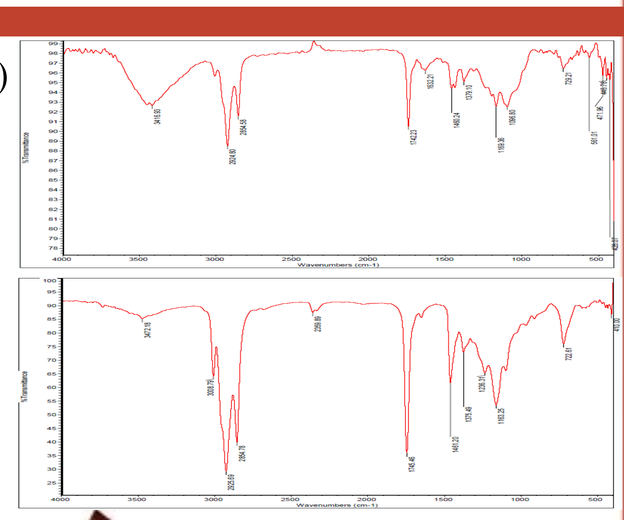
Fourier Transform Infrared Spectroscopy (FTIR)

Detector: DTGS KBr | Beam splitter: KBr | Source: IR

Analysis Of Troughs In The Spectra

Oil (cm^{-1})	Biodiesel (cm^{-1})	Remarks	Comments
722.61	729.21	-CH_2 rocking	
1163.25	1169.36	C-O-C sum stretch, C-C stretch	
1375.49	1379.10	O-CH_2	
	1436.24	(CO)-O-CH_3	
1745.46	1742.40	C=O Ester	
2854.78	2854.58	-CH_2	R1 group
2925.69	2925.65	-CH_2	R2 group
3008.79	3008.78	-CH_2	R3 group
3472.18	3416.93	-OH bond	Presence of free fatty acids, Methanol

Long carbon chains are identified by CH_2 as R1 , R2 and R3. The most significant result from trans esterification is the new signal at 1436.24 cm^{-1} which is definitely the methyl ester group with its deformation vibration. The peak at 3416.93 cm^{-1}represents presence of free fatty acids in biodiesel and oil. Also a characteristic peak of ester C=O at 1742.40 cm^{-1} is significant both in WCO and biodiesel which distinguish the above sample from petroleum derived diesel.



FTIR Spectra for Biodiesel (Top); Waste Cooking Oil (Bottom)