History of Biodiesel:

Rudolph Diesel himself developed biodiesel in 1890, wherein pure vegetable oils were used in diesel engines for agriculture, where petroleum diesel was not available. Modern biodiesel fuel is an outcome of research conducted in 1930s in Belgium, which is made by converting vegetable oils into compounds called fatty acid methyl esters. Process of trans-esterification was used to convert vegetable oils into fatty acid alkyl esters and use as diesel fuel replacement with lower viscosity of vegetable oil. Biodiesel is the trade name of fatty acid methyl esters. Concerns over environment, energy security and use of agro products brought the use of vegetable oils to the forefront.

Biodiesel industry became house hold name in U.S. after terrorist attack of 9/11/2001, resulting in high oil prices. Biodiesel is being used Worldwide now, due to concerns over Global warming. The future of biodiesel lies in the world's ability to produce renewable feedstock's such as vegetable oils and fats to keep the cost of biodiesel competitive with petroleum.

Biodiesel- Need of the hour:

Biodiesel is a fuel manufactured from non-edible vegetable oils, used cooking oil and animal fat. The fuel typically contains different types of Fatty Acid Alkyl (Methyl / Ethyl) Esters, conforming to BIS specification IS 15607 :2016.

Biodiesel is manufactured from plant oils, animal fats, recycled cooking oils and has following ***Salient advantages***:

- It is renewable & energy efficient.
- It displaces petroleum-derived diesel fuel
- It can be used in most diesel equipment with nil or only minor modifications.
- It reduces global warming gas emissions.
- It can reduce tailpipe emissions from older vehicles, including air toxics
- It is nontoxic, biodegradable and suitable for sensitive environments.
- It is majorly produced domestically from agricultural or recycled resources.
- Sulphur content is very less.
- The main benefit of biodiesel is that it can be described as 'carbon neutral'. This means that the fuel produces no net output of carbon in the form of carbon dioxide (CO_2). This effect occurs because when the oil crop grows it absorbs the same amount of CO_2 as is released when the fuel is combusted.

Introduction:

- Biodiesel blend is a mixer of methyl or ethyl esters derived from a broad variety of renewable sources such as vegetable oil, animal fat and recycled cooking oil. These esters are oxygenated organic compounds that can be used in compression ignition engines owing to their key properties which are comparable with existing diesel fuel. Furthermore, it is eco-friendly, renewable and sustainable fuel which offer carbon neutral cycle. "Soy Methyl Ester" diesel ("SME" or "SOME"), derived from soybean oil, is the most common biodiesel available in the United States. "Rapeseed Methyl Ester" diesel ("RME"), derived from rapeseed oil, is the most common biodiesel blend stock available in Europe. On the other hand, Palm Methyl Ester ("PME"), derived from palm oil, is the most common biodiesel blend stock available in Asia as of today. Collectively, these fuels are sometimes referred to as "Fatty Acid Methyl Esters" ("FAME") or "Fatty Acid Ethyl Esters" ("FAEE").

Biodiesel production:

Biodiesel is produced by a process called trans-esterification, in which various oils (triglycerides) are converted into methyl esters through a chemical reaction with methanol (FAME) or ethanol (FAEE) in the presence of a catalyst, such as sodium or potassium hydroxide (Fig.1). By-product of the trans-esterification process includes glycerol which needs to be removed from the finished product along with traces of the methanol or ethanol, un-reacted triglycerides, and the catalyst.

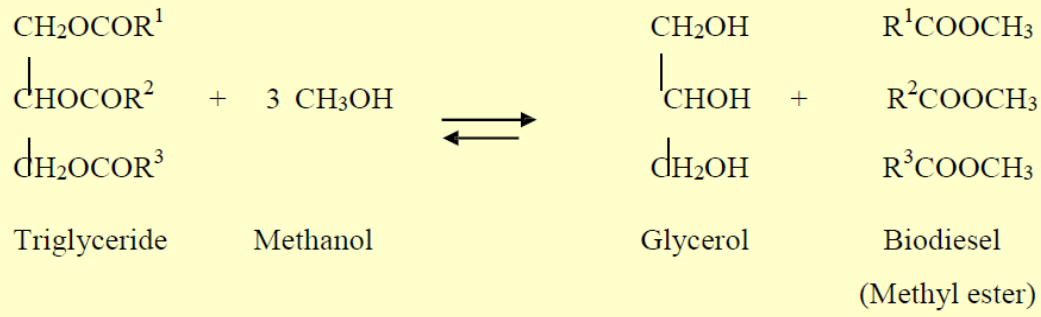

Figure 1: Transesterification reactions for biodiesel synthesis

R^1, R^2 & R^3 Fatty acid chain of triglyceride.

The simplified process schematic of the biodiesel production process is depicted in Figure 2 below –

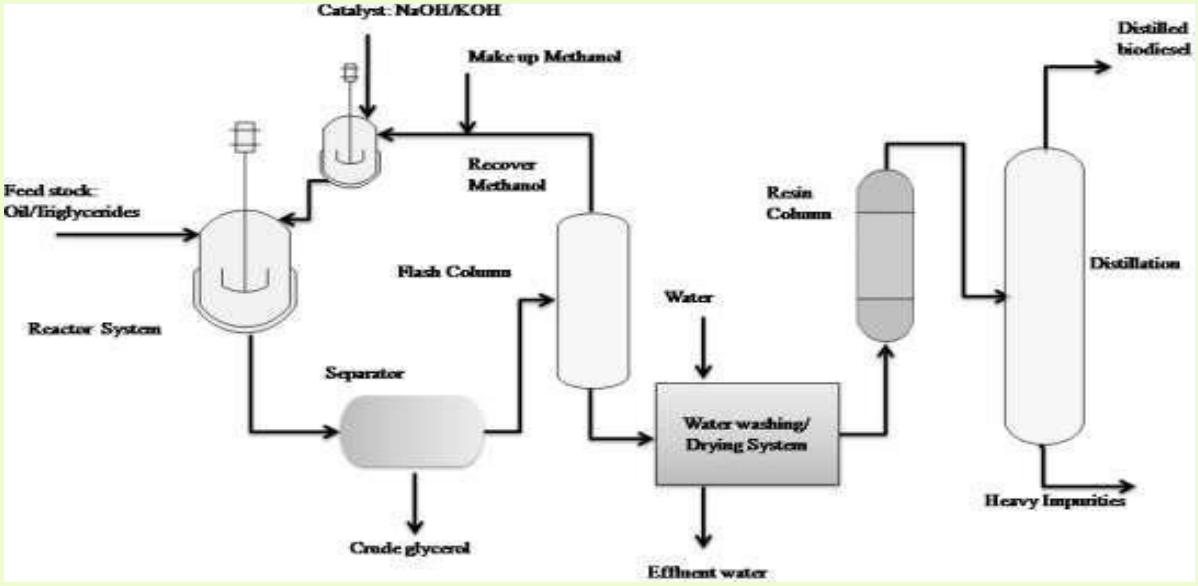

Figure 2: Simplified process flow diagram for conventional homogeneous catalytic biodiesel process

Specifications:

Biodiesel is produced in a pure form (referred to as “B100”or “neat biodiesel”) and is typically blended with petroleum-based diesel fuel. Such biodiesel blends are designated as BXX, where XX represents the percentage by volume of pure biodiesel contained in the blend (e.g., “B5,” “B20”).

Automotive diesel fuel specification (IS 1460: 2017) permits FAME Content, 7 % max, v/v both for Bharat Stage IV & VI grade fuels. Earlier Biodiesel blending in HSD was permitted upto 5 % v/v. Subsequently, the specification for blending of Biodiesel in the range of 6 % to 20 % v/v (IS 16531:2016) have been formulated.

IS 15607:2016 specification of biodiesel (B100) as blending stock –

Sr. No.	**Characteristics**	**Requirement IS 15607:2016**
i)	Density at 15°C, Kg/m^3.	860 – 900
ii)	Kinematic Viscosity at 40°C, cSt	3.5 – 5.0
iii)	Flash Point (PMCC) °C, min	101
iv)	Sulphur[3], mg/kg, max.	10.0
v)	Carbon Residue (Ramsbottom), % by mass, max.	0.05
vi)	Sulphated Ash, % by mass, max.	0.02
vii)	Water content, mg/kg, max.	500
viii)	Total contamination, mg/kg, max.	24
ix)	Copper corrosion, 3 hrs at 50°C, max	1
x)	Cetane No., min	51
xi)	Acid Value, mg KOH/g, max	0.50
xii)	Methanol, % by mass, max	0.20
xiii)	Ester Content, % by mass, min	96.5
xiv)	Monoglycerides content, % by mass, max.	0.7
xv)	Diglycerides content, % by mass, max.	0.2
xvi)	Triglycerides content, % by mass, max.	0.2
xvii)	Free Glycerol , % by mass, max	0.02
xviii)	Total Glycerol, % by mass, max	0.25
xix)	Phosphorous, mg/kg, max	4.0
xx)	Sodium + Potassium, mg/kg, max	5
xxi)	Calcium + Magnesium, mg/kg, max.	5
xxii)	Iodine value, gm Iodine/100 gm, max.	120
xxiii)	Oxidation stability, at 110°C hrs, min.	8
xxiv)	CFPP, °C, max. a) Winter (Nov. to Feb.) b) Summer (Other months)	 +6 +18
xxv)	Linolenic acid methyl ester,% m/m, max.	12
xxvi)	Polyunsaturated (>/=4 double bonds) methyl ester, % m/m, max.	1

Storage and Handling of B100 and Bio-Diesel blends:
a) B100

- The selection of material for the construction of the storage and handling facilities shall be such that it is compatible to both fuel and the material used for storage and handling facilities. It is recommended that integrity of all materials coming in to contact with the fuel will be verified with 'Soak testing' or any other suitable method as per standard engineering practice.
- B100 may degrade, soften or seep through some hoses, gaskets, seals, elastomers, glues and plastics with prolonged exposure.
- Nozzles, fittings, connectors, piping, pump and impellers may be of best suitable material compatible with B100 as recommended for the storage tanks.
- Zinc, Brass, Bronze, Tin, Lead and Copper are some of the sensitive materials known to be degraded while in contact with B100. Lead solders, zinc linings, copper pipes, brass regulators and copper fittings shall be avoided.
- Stainless Steel, mild steel or Aluminium have shown acceptable resistance to corrosion by B100.
- Non-metallic materials that degrade when in contact with B100 include Nitrile Rubber, Natural Rubber, Polypropylene, Tygon, Polyurethane, Polyvinyl Chlorides and hence their contact with B-100 shall be avoided.
- Non-metallic materials that have been successfully used with B100 include Viton, Teflon, Fluor silicon / Fluorinated plastics & Nylon.
- Epicoating is not recommended for the tanks proposed for storage of B100.
- Epicoating recommended in storage tank for general hydrocarbons may not be compatible for system handling B100, B5 and B6-B20. Compatibility may be ensured before any application or use.
- The storage tanks and allied facilities for B100 shall be positively segregated. The tank shall be absolutely free from water at all times.

Untreated biodiesel blend stocks generally exhibit poor oxidation stability, which can result in long-term storage problems. Thus, anti-oxidation additives are added to improve its storage stability. Biodiesel blend stock and higher biodiesel blends act as solvents, removing historical deposits accumulated from the use of petroleum diesel fuel. *The materials removed accumulate in fuel filters, resulting in more frequent than typical service intervals until the deposits have stabilized. Therefore, when converting from petroleum diesel fuel to a biodiesel blend, fuel storage and vehicle/equipment tanks should be cleaned and rid of any residual water.*

b) Bio-diesel blends:
Various Bio-Diesel blends can also be stored in AG/UG tanks. However, care shall be taken for ensuring homogeneity of the product. This is important as the density of Bio-Diesel is higher than HSD. Suitable vertical churning facility/ blending facility may be provided. Free Water presence and moisture ingress shall be avoided.

Health & Safety aspects:
Biodiesel and their blend stocks are biodegradable, which may render them useful in applications where biodegradability is desired.

- Biodiesel has a higher flash point than petroleum-based diesel fuel, which allows for transportation and storage without the restrictions associated with flammable materials.
- Earthing and Bonding procedure shall be followed as being done for Petroleum products.

- **Extinguishing media:** Carbon di-oxide, Dry Chemical Powder, Foam & water spray (Fog) for small fires.
- **Special fire-fighting procedures:**
  Use necessary protective equipment & breathing apparatus as would normally be used when fighting fires where there may be danger of breathing hazardous products during combustion.

- **Unusual fire and explosion hazards:**
  Oil soaked rags are flammable if not handled properly
- **Stability:**
  Product is stable and hazardous polymerisation will not occur
- **Conditions to avoid in normal use (incompatibility, material to avoid) :**
  May react with oxidizing material
- **Hazardous decomposition or by- products**:
  Combustion may produce CO_x, NO_x and thick smoke. Hazardous polymerisation will not occur.
- **Health hazards**:
  Routes of entry is through inhalation / skin contact / ingestion
- **Emergency and safety procedures:**
  If swallowed, induce vomiting. If inhaled, remove person to fresh air. Give artificial respiration if required and call a physician.
  If splashed in eyes splash water /wash immediately with water. If splashed on skin, splash water /wash immediately with soap and water.
- **Precautions for safe handling and use:**
  In case spilled or released out, eliminate all sources of ignition. Small spills shall be flushed with large quantities of water. Large spills shall be collected for waste disposal.
- **Precautions to be taken in handling and storage:**

i) Store in closed containers between 15 – 50 ° C
ii) Keep away from oxidising agents, excessive heat and ignition sources.
iii) Use with adequate ventilation;
iv) Use explosion-proof electrical equipment and
v) Non-sparking tools.

- Additional Precautions and First Aid:

	Don'ts	First Aid measures
1	Prolonged exposure to high concentration shall be avoided.	Move person to an open area. Give artificial respiration in case of breathing problem. Get medical attention.
2	Ingestion/swallowing shall be avoided	Induce vomiting immediately as directed by medical practitioner.
3	Skin contact shall be avoided to prevent absorption of toxic compound into body.	Immediately flush skin with plenty of water for at least 15 minutes. Remove all contaminated clothing and shoes. Wash & clean clothing & shoes before reuse.
4	Splashes and eye contact shall be avoided.	Immediately flush eyes with plenty of clean running water for at least 15 minutes, moving lower and upper eye lids occasionally.
5	In case of spill do not use combustive materials such as sawdust etc. Do not flush to sewage system. Remove all Sources of ignition through appropriate protective equipment.	Recover liquid in appropriate container or absorb with inert material like Paper towels, Oil dry sand or dirt.

Transportation of biodiesel:

- Biodiesel must be transported in a way that does not lead to contamination. Following precautions are recommended –
- Ensure that trucks are fabricated of aluminum, carbon steel, or stainless steel.
- Ensure proper inspection or washout (washout certificate) before loading.
- Check for previous load carried and residual. Generally only diesel fuel or biodiesel is acceptable as a residual.
- Ensure that there is no residual water in the tank.
- Check that hoses and seals are clean and made from materials that are compatible.
- Biodiesel is challenging to transport in cold weather. Ensure that while transporting the fuel does not freeze.

Way Forward:

The overall blending percentage of biodiesel in diesel has been less than 0.1 percent in the country, due to constraints pertaining to feedstock availability. Moreover, whatever biodiesel is coming for the blending programme is manufactured from imported sources.

As per FSSAI notification used cooking oil with TPC more than 25% is hazardous for human health. But in India currently no established collection chain for UCO. So, opportunity in production of biodiesel from UCO is huge and same is also in line with welfare of citizens of India.

Ministry of Petroleum & Natural Gas has announced National Biofuels Policy - 2018 based upon which Government of India has set a target of 5% blending of biodiesel in diesel by 2030. New Bio-fuel Policy-2018, emphasizes on indigenous feedstock for biodiesel production and identified Used Cooking oil (UCO) as a potential source of biodiesel production. Used Cooking Oil (UCO) can be converted to Fatty Acid Methyl Esters (FAME), which has fuel properties similar to crude based diesel and hence called Bio diesel. Thus UCO is a major source for the production of biodiesel.

To encourage entrepreneurs in setting up UCO based biodiesel plants, OMCs have floated Expression of Interest (EOI) for procurement of biodiesel produced exclusively from Used Cooking Oil.