Journal of Advanced Zoology

ISSN: 0253-7214
Volume 44 Issue S-6 Year 2023 Page 1919-1925

Novel Trends in The Development of Hydrogel from Plant Sources and Their Effect in Environment and Human Health: A Review

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Article History

Received: 28 September 2023
Revised: 21 October 2023
Accepted: 02 November 2023

Abstract

Increased demand for energy and the scarcity of fossil fuels has led to the search for an alternative source that is sustainable as well as environmentally friendly, has the potential to function similarly to conventional fuels, contributes to less air pollution, and utilizes the maximum number of available natural sources in order to reduce the cost of production while achieving a higher yield at the same time. One such popular alternative is biodiesel, a renewable, biodegradable, and portable fuel that is sulfur-free, has enough oxygen content, is less toxic, and has a comparatively easier manufacturing process. Biodiesel is produced through a Trans-esterification process that involves the conversion of triglycerides in the presence of a catalyst and alcohol producing mono alkyl ester of long-chain fatty acids, i.e., biodiesel, along with glycerol as a byproduct. Biodiesel can be produced from a versatile range of feed-stocks, from edible sources like Rapeseed oil, Peanut oil, Soybean oil, Sunflower oil, canola oil, Palm oil, etc. to non-edible tree-borne oilseeds such as Neem oil, Cottonseed oil, Castor oil, Jojoba oil, Ratanjyot, Mahua, etc. to even waste cooking oil, animal fat, and microalgal oil. Along with flexibility in feed-stocks, a variety of catalysts can also be used in the production of biodiesel via Trans-esterification. This study is an attempt to highlight the process of Trans-esterification, the impact of biodiesel on the environment and human health.

Keywords: *Hydrogel, Plant sources, Extraction, Health benefits*

1. Introduction:

The world is currently experiencing energy crisis as a result of resource depletion and worsening environmental issues. Finding an alternative fuel which is both sustainable and environment friendly has become necessary to overcome this situation. One such alternative fuel is a mono alkyl ester of long chain fatty acids produced from renewable feedstocks like vegetable oil or animal fats, known as Biodiesel (Barnwal and Sharma, 2005). Biodiesel is one of the popular alternatives of petroleum fuel as it is sulfur free with enough oxygen contented, having no aromatic chain as well as emits less greenhouse gas and the manufacturing process is comparatively easier (Tayari et al., 2020).Biodiesel can be used directly or in blended form with other conventional diesel. The blended biodiesel is labelled by the percentage of petroleum diesel (by volume) used and presented as Bxx where xx represents as amount of biodiesel

blended for e.g., B5 [5% biodiesel, 95% diesel (v\v)] and B100 i.e., pure biodiesel (Hanna et al., 2005). Up to 20% or B20 no change is required in the engine but afterward modification is needed.

The other properties of biodiesel which had drawn the attention of many researches includes, high flash point i.e., the minimum temperature at which enough vapor is released for spontaneous ignition in the presence of air (Santos et al., 2020). Then it has similar characteristics of fossil diesel fuel along with being renewable as well as biodegradable in nature (Mahmudul et al., 2017). In addition, biodiesel is portable, non-flammable, safer to handle, less toxic and an excellent lubricant with a higher cetane number. Trans-esterification process is mainly employed for the production of biodiesel which incorporates conversion of triglyceride in the presence of alcohol and catalysts in order to increase the rate of reaction.

A wide range of feedstocks can be used for the production of biodiesel which makes it economically potential alternative fuel. According to (Atabani et al., 2019) based on the type of feedstock used biodiesel can be grouped into three generation i.e., first, second and third generation. Where the first generation includes the edible oils of Peanut, Rapeseed, Sunflower, Soybean, Palm, Sorghum, Coconut etc. The second generation comprise ofnon-edible oils of Mahua, Neem, Cottonseed, Sal, Kusum, Ratanjyot (*Jatropha curcas)*, Karanja (*Pongamia pinnata*), Rubber seed, Castor bean seed,Jojoba etc. Other than the plant source waste cooking oil and animal fats are also included in the second generation of biodiesel which involves pork lard, fish oil, beef tallow, poultry fat or chicken fat. The third generationbiodiesel is obtained from microalgal biomass like *Chorella vulgaris, Scenedesmus dimorphus, Chorella sorokiana, Chlamydomonas rheinhardii,* etc. These microalgae are gaining much of attention because they have the ability to convert carbon dioxide into biomass through photosynthesis (Kumar et al., 2010). Moverover, dependence for the production of biodiesel is shifting towards more on the non-edible source as the edible sources affects the total cost of production, food prices, sustainability and reusability.

The upsurge demand of biodiesel and their utilization in various sectors, present study aims to review on the production of biodiesel from various plant sources and their effect on environment and human health.

2. Biodiesel production:

The development and progress in research have led to the production of biodiesel from several sources along with the availability of convenient methods. One such method is Trans-esterification which is mainly applied for the production of biodiesel over the other methods as it is inexpensive and more convenient method in compare to other methods which are dilution, pyrolysis and microemulsion.

2.1. Trans-esterification:

Biodiesel produced through Trans-esterification (or alcoholysis) involves the use of alcohol in the presence of a catalyst for the conversion of triglycerides which are obtained from vegetable oil or animal fat. And the procedure requires use of excess alcohol to maintain equilibrium as it is a reversible reaction (Banerjee and Chakraborty, 2009).

Three consecutive reversible reactions take place in trans-esterification i.e., the conversion of triglycerides into diglycerides which is next converted to monoglycerides and further converted into glycerol. And for each reaction of glyceride, ester (biodiesel) molecule is formed (Avhad and Marchetti, 2016).

Glycerol, also known as glycerin is the byproduct of trans-esterification which can be moreover used as raw material in different industries like food industry, cosmetics, pharmaceuticals, etc. (Tan et al., 2013).

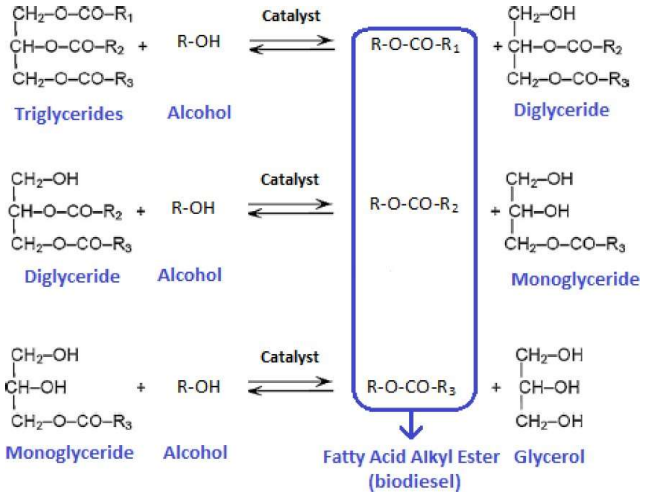

Fig: 1. Process of trans-esterification (Source: Avhad and Marchetti, 2016)

In Trans-esterification, different alcohols can be used for the production of biodiesel such as methanol, ethanol, propanol or butanol. Methanol and ethanol are the most commonly used alcohols and the products obtained from these alcohols are known as fatty acid methyl ester mixture [FAME] when methanol is used and in case of ethanol it is known as fatty acid ethyl ester mixture [FAEE] (Borges and Díaz, 2012).

Methanol is of low cost but itis volatile, more toxic, has lower ability to dissolve oil in compare to ethanol and the biodiesel produced by methanolysis is not considered as entirely renewable (Dalena et al., 2018). Whereas production from ethanol is regarded as renewable fuel (Sarkar et al., 2012). But the biodiesel obtained from ethanolysis has lower reactivity than methanol and the separation of FAEE from the coproduced glycerin is more difficult due to higher miscibility (Veličković, et al., 2016).

In order to increase the rate of reaction catalyst are used, which are mainly of two types. One is called homogenous catalyst that acts in the same phase of the reaction mixture and the other one is known as heterogenous catalyst which acts in different phase of reaction mixture. These catalysts can be further classified into basic (NaOH, KOH, alkaline metals and carbonates), acid or enzymatic(lipases) depending on their nature. In compare to heterogenous catalyst, homogenous catalyst takes less time for higher yield and conversion (Sharma et al., 2011). Yet when alcohol and oil are utilized under supercritical conditions, catalyst is not required for the production of biodiesel (Shahid and Jamal, 2011). However in recent years, heterogeneous nanocatalyst such as Li\ZnO-Fe_3O_4, CaO\MgO,SO_4\Mg-Al-Fe_3O_4, etc., has come into the play to reduce the cost and increase the production of biodiesel at the same time. The distinctive features of nanocatalyst i.e., high reusability, high reactivity, environment friendliness with high yielding capacity is what makes it different from other catalysts and become a sustainable as well as suitable alternative in the production of biodiesel (Zhang et al., 2022).

3. Production process of biodiesel

It is important to consider certain parameter in the production of biodiesel which includes the type and concentration of catalysts used, reaction temperature and time, mixing intensity, type of alcohol used along with its molar ratio employed, then the moisture and the water content along with the purification of the final product. The process starts with the mixing of alcohol and the catalysts followed by the separation of 2 products after the reaction i.e., glycerin and biodiesel. The next step is the removal of excess alcohol from the products via distillation or flash evaporation. Next the by product which is glycerin is neutralized to the purest form so that it can be further utilized for other purpose. After the separation glycerin, the biodiesel is further refined by gently washing in warm water this step is known as methyl ester wash. The final step is the analysis of the biodiesel to ensure the product quality.

4. Production from plant sources

In terms of plant source biodiesel are produced from both edible and non-edible plant sources. Most of the developing countries are more dependent on the non-edible source as it makes use of wastelands, provides a good yielding as well as more cost effective. The edible oils of Peanut, Rapeseed, Sunflower, Soybean, Palm, Sorghum, Coconut etc. can be used and the non-edible oils of Mahua, Neem, Cottonseed, Sal, Kusum, Ratanjyot (*Jatropha curcas*), Karanja (*Pongamia pinnata*), Rubber seed, Castor bean seed, Jojoba etc. as well as waste cooking oil. Some of the feedstock along with the alcohol, catalyst and yielding capacity is mentioned below:

Feedstock	Type of source	Alcohol used	Molar ratio methanol\ oil	Catalyst	Temperature	Reaction time	Rate of stirring	Yield	Reference
Rapeseed oil	Edible	Methanol	6:1	KOH (1%)	65ºC	2 hours	600 rpm	95-96%	Rashid and Anwar, 2008
Waste Sunflower oil	Non - edible	Methanol	3:1 –9:1	NaOH (1%)	60ºC	1-3 hours	300 rpm	80%	Thirumarimurugan et al., 2012
Melon	Edible	Methanol	6:1	NaOH (1%)	65ºC	1 hour	-	77.58%	Onyenze et al., 2021
Soyabean oil	Edible	Methanol	6:1	NaOH (1%)	65ºC	1hour	-	90.83%	Onyenze et al., 2021
Groundnut oil	Edible	Methanol	6:1	NaOH (1%)	65ºC	1 hour	-	78%	Onyenze et al., 2021
Neem oil	Non edible	Methanol	6:1	Ni doped ZnO (2%)	60ºC	80 minutes	150 rpm	80%	Noreen et al., 2021

5. Effect of biodiesel on environment and health

The major problem with the conventional fuels is their constituent as it contains toxic chemicals, that emits higher rate of particulate matter, greenhouse gases with other harmful gases which contributes to air pollution and severe health issues. On the contrary biodiesel is much more environment friendly and causes less health complications. The major air pollutants like carbon dioxide, particulate matter, hydrocarbon, nitrogen oxides and carbon monoxide are emitted less in case of biodiesel which also implies that biodiesel will cause less health complication too (Aljaafari et al., 2022).

6. Conclusion:

Biodiesel is an eminent biofuel not only in terms of being environment friendly but also on the economical aspect by making the use of its by product in different industry there by increasing the economy of a country. It is a biodegradable and portable fuel that is sulfur-free, has enough oxygen content, is less toxic, and has a comparatively easier manufacturing process. In addition, biodiesel causes less harm to human health by emitting less amount of disease-causing pollutants. Furthermore, barren lands can also be used for growing non edible plants from which biodiesel are produced. The versatile usage of feedstock for the production makes biodiesel a more sustainable biofuel with a greater reusability of the resources.

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