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Review of Recent Trends in Application of Nanothechnology in Bio-Fuels

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Abstract: In today's era the biggest challenge, that world is facing, is the challenge of energy crisis. Main cause is the less availability of fossil fuels. In current scenario there is a huge need of finding new alternatives which can meet the rising energy demands due to pollution problems. Bio-fuel is indeed one of the best alternatives which can be even manufactured with the help of cheaper resources like vegetable wastes, waste cooking oil. But bio-fuel production methods inculcate many loopholes such as slower reaction rate, saponification etc. For resolving these problems various techniques are being explored, out of which nanotechnology is trending one as it is found to be more effective way for bio-fuel production. Bio-fuel production rate are found to be improved with the use of nanocatalyst and nanostructures. Out of different bio-fuels, biodiesel is of current interest topic of many scientists. This paper is a brief review of biodiesel development, especially utilization of nanotechnology in biodiesel production and enhancement. Various methodologies of biodiesel production using nanoparticles are discussed in this paper with the reference of literature studies in order to get panoramic view about applications of nanotechnology in enhancement of biodiesel.
Keywords: Energy, pollution, fossil fuels, nanotechnology, nanostructures, biodiesel.

I. INTRODUCTION

In twenty-first century world is indulged in heavy energy crisis in addition to that it is running out of fuel. Inflation in the market, recent devastating floods all are playing against the human civilization. One of the main reasons behind this is global warming. The global warming simply means the chain reaction increasing global temperature of earth. Global warming is the inevitable effect of industrial and automobile pollution. On the other hand fossil fuels are almost used up out of the existing coal, petroleum and the other natural resources on the earth without which one cannot imagine the existence. This situation is forcing the whole world to explore the new ways of fulfilling energy demands. Because human beings are relaying on the earth natural resources to generate energy. So there is huge need to find the clean and inexhaustible energy sources. One of the best solutions is biodiesel. It has dual advantage as inexhaustible at the same time clean energy source. Biodiesel can be produced by various plants e.g. Jatropha, Karanja, Sunflower as well as waste cooking oil etc.

Biodiesel is produced by the method called ' Transesterification'. Transesterification process is of two types that is Transesterification with homogeneous catalyst and Transesterification with heterogeneous catalyst. The use of homogeneous catalysts is the first conventional method applied in the biodiesel production industry. Transesterification with homogeneous catalyst method involves the use of catalyst in liquid form, mainly acid and alkali catalysts. Acid catalysed esterification method is more suitable for oils with high FFAs, which may be of low grade and are less expensive. However, as per (Canaksi M. et. al 1999), this method is sensitive to the presence of water. About second method alkali catalyzed transesterification, (Frascari D. et. al 2008) concluded that this method has been the commonest method used at laboratory, pilot and industrial scale levels. The production cost of this catalyst is low. But this method has its own drawbacks like it is energy intensive, difficulty in recovery of glycerine etc. Another method of homogeneous catalysed transesterification is two step transesterification process. According to (Atadashi IM et. al 2012) this method is useful while using feedstock with high free fatty acids.

The problems associated with homogeneous catalyst methods got solved by using new method called 'Transesterification with heterogeneous catalyst. As per (EndalewAk et. al 2011), Heterogeneous catalysts can be recycled and re-used several times with better separation of final product and also minimizes material as well as processing cost. According to (Helwani Z et. al 2009), heterogeneous catalyst are spinel mixed oxide of two metals (non-noble metal). As per (Yan S et. al 2010), benefit of heterogeneous catalyst over homogeneous catalyst is that it eliminates the time consuming and costly water-washing and neutralization processes unlike in homogeneous method. Also, it reduces the need of waste water treatment. Transesterification with heterogeneous catalyst are of two types, acidic and alkali. According to (Macaira J et. al 2011), Heterogeneous acid catalyst can catalyze both esterification and transesterification reactions simultaneously. (Zhang S et. al 2010) concluded that this catalysts are less corrosive, less toxic and creates less environmental problems. On the other hand, As per (Kim HJ et. al 2004) apart from ease in catalyst recovery, heterogeneous alkali catalyst shows same activity as homogeneous alkali catalysts at same operating conditions.

II. NEW TRENDS IN BIODIESEL PRODUCTION

Catalyzed route of production of biodiesel is most common route used industrially but As per (Aransiola, et. al 2014), there are several drawbacks of conventional methods related with catalyst. Such as the negative effect of water present in mixture, catalyst consumption, low purity of glycerine and waste water generation. In catalyzed route there is necessity of treating the free fatty acids and tri-glycereids in different reaction stages hence, increases process time. Also, conventional method is not suitable for raw materials like animal fat and oils with high free fatty acid.To overcome the drawbacks of conventional transesterification methods scientist have researched for many novel method for biodiesel production.In the Biodiesel production there are four main steps, Most important step is in which the reagent and reactant are added in reactor for transesterification process. According to (Tabatabaei et al., 2019), There are many chemical reactor technologies have been generated for conducting transesterification process cost effectively and time effectively. Different types of chemical reactor are as follows.

A. Tubular Plug-flow Reactors:-

According to (Alamsyah R. 2010), Tubular reactor is the simplest type of reactor also called as pipe reactor. In this reactor, the reagents and reactants entered in one end, flows in pipe for specific time and then get mixed at the outlet. This mixing can be achieve by supplying highly turbulent flow from the pipe. But in case if due to high viscosity of fluid, the laminar flow can be seen in pipe. Hence to avoid this, side stream additive injection devices (static mixer etc.) can be applied. Compared to vessel reactors, pipe reactor is more efficient and it requires low capital cost as well as less space. But, this reactor has limitations related with Reynolds number which is necessary to generate high velocity and turbulence. Tabular reactor again classified into types: 1) Packed Bed Reactor (Wang X et al., 2011), 2) Fluidized Reactor (Yang W-C 2003), 3) Trickle Bed Reactor (Son SM et al., 2011), 4) Oscillatory Flow Reactor (McDonough J et al., 2015), 5) Micro-channel Reactor (Nguyen NT et al., 2004).

B. Rotating Reactors:-

Mechanical components increases mass and heat transfer, decreases the holdup of reactant and reagent and allows the utilization of more efficient material in the production of small sized reactor. Rotating reactors have single or multiple rotating elements (discs, impeller, tubes, etc.). Various types of rotating reactors suitable for transesterification process are as follows: 1) Stirred Tank Reactor (Stitt E et. al 2002), 2) Spinning Tube Reactor (Lodha H et al., 2012), 3) Spinning Disc Reactor (Meeuwse M et al., 2012).

C. Simultaneous Reaction-Separation Reactor:-

As per (Tabatabaei et al., 2019), this types of reactor combines chemical reaction and simultaneous extraction of product from reactant and un-reacted reagents in single unit operation, an intensification method also known as reactive separation process. These type of reactor gives good mixing and hence higher yield can be achieved. Following are the types of these reactors: 1) Membrane reactor (He Y et al., 2012), Membrane reactor is eco-friendly technology that produces less waste water and utilizes low energy. This can also provide high quality biodiesel compared to conventional reactors. 2) Reactive Distillation Reactors (Dimian AC et al., 2010),This is highly advantageous esterification process, when feed contains high free fatty acid. 3) Annular Centrifugal Contactors (Wardle KE et al., 2015), The main disadvantage of this reactor is its uncontrollable and very low process time (just 10 sec) that does not allow complete transesterification reaction and this can be avoided by providing additional delay loops.

D. Cavitational Reactors:-

According to (Gogate PR et al., 2008),This type of reactors utilizes either acoustic energy or flow energy for intensification of chemical process through cavitational phenomenon. Due to formation of cavities, their growth and then their collapse releases huge energy and pressure in small area which results in intensified and fast reaction. Types of cavitational reactors are as follows: 1) Ultrasonic Reactors- this reactors work on acoustic energy by enhancing chemical reaction due to modification in pressure through a pressure of sound waves. Ultrasound wave ranges from 16kHz to 100MHx frequency. Due to this waves formation of bubbles takes place followed by its expansion and collapse which results in cavitations. 2) Hydrodynamic Cavitations Reactors(Gogate PR et al., 2005). Unlike ultrasonic reactors, here the pressure difference is created by using specific geometry (orifice etc.) in the system. This results in bubble formation followed by expansion and collapse which causes cavitations. 3) Shockwave Power Reactor (Qiu Z et al., 2010), these are the rotating hydrodynamic reactors that have dead ended cavities. Here, the cavitations take place due to collapse of bubbles formed at the bottom of the cavities.

E. Microwave Reactor:-

As per (Motasemi F et al., 2012), It is an electromagnetic base irradiation with wavelengths between 0.01 to 1m and corresponding frequencies of 0.03 to 300GHz. The Advantages of microwave reactor are less time, simple control, high thermal efficiency, clean product and less processing. But the problem in this method is the difficulty in control of temperature and power. Hence, it results in low process reproducibility. Scares L et al., 2017obtained the yield of 84% by transesterification of soyabean oil in a continuous flow microwave reactor under specific condition. Milano J. et al., 2018 successfully obtained the yield about 97% from mixture of calophylluminophyllum and waste cooking oil using Anton Paar Microwave 400 high performance microwave reactor. Thirugnanasambandham et al., 2015 obtained excellent yield of 99.5% by transesterification of cottonseed oil in the presence of undetermined amount of KOH by using microwave reactor. Ma et al., 2015 transesterified chlorella vulgaris microalgae in the presence of heterogeneous catalyst by using ultrasound-microwave process. And Wahidin S et al., 2018 concluded that microwave reactor can also be used in transesterification of microalgae with ionic liquid.

II. DRAWBACKS IN PREPARATION AND PERFORMANCE OF BIO-DIESEL

Now a days the resources of petroleum as fuel are declining an deescalating demand of fuels, because of it creates a challenge to science and technology. With the commercialization of bio-energy, it has provided a successful way to fight against the problem of petroleum scarcity on environment. In total future energy requirement, the percentage of petroleum oil and natural gas is 45% in 2024-25 in India .Several experimental studies has been performed to show that combustion behavior of diesel engine fuelled by biodiesel by varying parameters such as, injection timing, pressure, engine load, speed of engine, CR etc. Major factors which are concluded that biodiesel fuelled engine showed smaller ignition delay and HRR with early start of combustion, NOx emission and decreased power loss and amplified PM. Also there are several parameters which are high viscosity, density and low volatility character of biodiesel resulted in problems in long-standing engine performance tests. During combustion, the quality of fuel is influenced by size of fuel molecules, inadequate atomization performance and blocking of fuel entrances in the cylinder which are affected by higher viscosity of biodiesel. Because of high viscosity that increases problems such as injector choking, ring sticking and gumming in diesel engines. Biodiesel has one of the major drawback of showing increment in emission of PM and NOx. To improve such properties and the problems, nanoparticles are considered to increase the performance and reduce the emission.

III. RECENT TRENDS OF NANOPARTICLES IN BIODIESEL

L.S. Reddy Yadav et al. They have synthesized the AgZnO NPs with different mol% concentration of Ag doping using novel fuel by green combustion method based on Curcuma longa root extract. About 83% yield has been achieved by the implementation of AgZnO as a nanocatalyst for the synthesis of biodiesel. Hence, AgZnO NPs shows prominence towards the biodiesel applications. It also catalyzes the N-formylation reactions. Harish venu et al. concluded that the novel approach of combined effect of the nanoparticle blended palm biodiesel with EGR can lower all the major regulated emissions (HC, CO and NOx) simultaneously till part loads and reduces smoke throughout the engine load towards sustainable green environment. Indu Ambat et al .noted that the transesterification of rapeseed oil to biodiesel was successfully done with help of Fe3O4-CeO2-25K. The catalytic activity of different weight percentage of potassium impregnated Fe3O4-CeO2 was investigated and best activity was attained at optimum loading of KOH (25 wt %) to Fe3O4-CeO2. The characterization of synthesized catalyst and integration of potassium ions to Fe3O4- CeO2 nanostructure confirmed by FTIR, XRD, SEM, TEM. All these results, indicates Fe3O4-CeO2-25K is an efficient catalyst for the production of superior quality of biodiesel. Following table shows the work of different researchers on application of nanoparticles in Bio-diesel.

TABLE I REVIEW OF RESEARCH WORK ON NANODOPES IN BIODIESEL

Sr. No.	Title	Author	Year	Outcomes
1	Reactor technologies for biodiesel production and processing: A review	Meisam Tabatabaei et al	2019	Different Technologies of biodiesel production have been discussed here.
2	Recent advancement in biodiesel production methodologies using various feedstock: A review	Indu Ambat et al	2018	1) Different Feedstock in recent. 2) Reactive Distillation as promising method of biodiesel production
3	Technological Progress in Biodiesel Production	Khairul Azly Zahan et al	2018	Continuous Production over Batch Production
4	A review of current technology for biodiesel production: State of the art	E.F. Aransiola et al	2014	Microalgae as a feedstock.
5	Application of nanoparticles in biofuels: An overview	Patrick T. Sekoai et al	2018	Nanoparticles in all kind of biofuels.
6	Applications of nanotechnologyin renewable energies—A comprehensiveoverview and understanding	Ahmed Kadhim Hussein	2015	Nanotechnology in all types of Renewable energy.
7	One-step production of biodiesel from Jatropha oils with high acid value at low temperature by magnetic acid-base nanoparticles	Yi-Tong Wang, et al	2018	Nanoparticles used in Jatropha Biodiesel.
8	Efficient biodiesel production from Jatropha curcus using CaSO4/ Fe2O3-SiO2 core-shell magnetic nanoparticles	Siow Hwa Teo et al	2018	Core Shell nanoparticles
9	Transesterification of waste cooking oil for biodiesel production catalyzed by Zn substituted waste egg shell derived CaO nanocatalyst	Manash Jyoti Borah et al	2019	Use of waste egg shell as catalyst

10	Catalytic upgrading of Jatropha oil biodiesel by partial hydrogenation using Raney-Ni as catalyst under microwave heating	Guangtao Wei et al	2018	New trends in catalyst.
11	Biodiesel Production from Jatropha Curcas Oil Using Strontium-doped CaO/MgO Catalyst	Kandis Sudsakorn et al.	2017	CaO as stable catalyst
12	Impact of waste cooking oil in biodiesel blends on particle size distributions from a city-car engine	Giancarlo Chiatti et al.	2016	WCO biodoiesel is effective fuel for car engine
13	Biodiesel production from waste cooking oil using copper doped zinc oxide nanocomposite as heterogeneous catalyst	Gurunathn Baskar et al.	2015	Waste cooking oil biodiesel by heterogeneous catalyst.
14	Tailored magnetic nano-alumina as an efficient catalyst for transesterification of waste cooking oil: Optimization of biodiesel production using response surface methodology	Arash Bayat et al.	2018	Alumina is the most efficient catalyst for transesterfication of waste cooking oil.

IV. CONCLIUSION

Growing energy demand, rising fuel prices, global warming from green house gas emissions have already increased openness to renewable energy resources. Utilization of nanodopes is able to break the usual trade-off between reduction of soot and NOx emissions, by achieving them simultaneously, for the same fuel consumption, higher efficiency is also obtained.It seems to provide more feasible and economical alternative source. And nanotechnology is tackling the problems of bio-fuel and its production methodology more efficiently. It seems to provide key solution in enhancement of the bio-fuel production methodologies. Nanoparticles are enhancing the activity of enzyme after their immobilization. Solid based nano catalyst is very effective in getting desired yield. Bio-diesel with nanoparticle’s dope has drawn attention as a sustainable energy source that may help cope with rising energy prices, but also may provide income to poor farmers and rural communities around the globe. This study gives an overview of variety of nanomaterials that has been explored to improve bio-fuel production. Thus nanotechnology is able to provide best suitable alternative, in the form of bio-fuel, for fossil fuels and efficiently reducing harmful environmental impact.

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