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EMERGING TRENDS IN BIO-DIESELS: A REVIEW

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ABSTRACT

The ever-increasing energy needs has led to oil reserves depletion causing increase in oil prices and surging environmental pollution. This issue has arised an interest to device alternative fuels such as biofuels. Bio-diesels are considered to be substitute for the depletion fuel reserves. Eco- friendly fuels can be produced using biomass and it is preferable to use bio-degradable waste biomass that not only contributes in production of desired fuel but also helps in managing the rising issue of municipal waste. The following paper reviews the newly emerged method of converting the biomass into bio-diesel by esterification of extracted oils from various biomass by listing various works being performed recently on different species of biomass.

Keywords: *Sustainable Energy, Biomass, Bio-diesel.*

INTRODUCTION

Due to growth in population and rapid urbanisation, the energy demand is ever-increasing. According to World Energy Statistics, the acceleration in energy consumption in 2017 was 2.3% whereas it was only 1.1% in 2016. The total energy consumption recorded were: 786 Mt in Middle-East; 805 Mt in Africa; 154 Mt in Pacific; 5,755 Mt in Asia; 847Mt in Latin America; 2,489 Mt in North America; 1,037 Mt in CIS and 1,857 Mt in Europe. The share of energy production by oil was 32%, coal was 27%, gas was 22%, biomass was 10% and electricity was 9%. The CO2 emissions hiked by 2.1% globally in 2017. At global level, the CO2 emissions recorded were 1,951 Mt in Middle-East; 1,259 Mt in Africa; 450 Mt in Pacific; 15,341 Mt in Asia; 1,629 Mt in Latin America; 5,697 Mt in North America; 2,391 Mt in CIS; 3,950 Mt in Europe [1]. This arises need to shift more towards energy consumption using eco-friendly fuels that help to control the CO2 emissions thereby reducing greenhouse effect. The aftereffect of petroleum originated fuels has caused vigourous exhausting of conventional energy sources along with excruciating air pollution. The quest for substitute fuel has led to many discoveries resulting in many alternative fuels variety at our disposal at present. Eco-friendly fuels can be produced using biomass and it is preferable to use bio-degradable waste biomass that not only contributes in production of desired fuel but also helps in managing the rising issue of municipal waste.

Bio-diesel

Thermochemical and biological methods are used to convert biomass into gaseous and liquid fuels which are bio-degradable and reduce greenhouse gas emissions. The primary difference between petro-diesel and bio-diesel is that later is derived through esterification of oil obtained from animals or plants fat unlike all petroleum sources derived from crude oil. Petroleum does not have any oxygen content but bio-diesels have 10-45% oxygen levels making it more suitable for complete combustion. Also, biofuels as compared to petrol have low sulphur and nitrogen contents thus making it sustainable and environment-friendly. The oil can be extracted by either of the two methods: (a) mechanical pressing, and, (b) solvent extraction.

Mechanical extraction

Continuous presses are used in which the pre-treated seeds, that generally involves mechanical sieving, size reduction and thermal pre-treatment, are fed. Flaking and crushing increase extraction by altering the permeability. The main step is pressing, it may be done using screw presses or hydraulic presses. The pressures feasible in case of hydraulic presses is in very high range of 50MPa to 100MPa for cocoa and above 40MPa for olive oil. Screw press was invented in 1902 by Anderson and has been advanced since then. Screw presses have helical screw that keeps rotating in a barrel. The seeds are driven between the screws and the progression of the seeds is ensured by the rotating barrel. The whole process causes compaction of the seeds to ultimately extract the oil by compression forces [2].

Solvent extraction

Extraction solvent is filled in a flask on which Soxhlet extractor is placed above. Over this whole setup a condenser is placed. When the apparatus is switched on solvent gets heated and vaporizes. The vapors of the solvent travel up via the distillation arm and get filled in the chamber that houses the solid thimble. The cooling of the solvent vapors is assured by condenser. This condensed solvent vapor then drips down back to the solid thimble housing chamber. Some amount of the desired compound gets dissolved in the warm solvent. The automatic emptying of chamber occurs through the siphon’s side arm down to the distillation flask as soon as the Soxhlet chamber gets completely filled. This cyclic process is repeated several times over hours, or even days. During each complete cycle some quantity of the non-volatile compound gets dissolved into the solvent. After repetition of the same cyclic process over many cycles the concentration of the desired compound in the distillation flask increases. The benefit of this process is that only one solvent batch is used over and over again by passing through the sample continuously rather than using several batches of warm solvent. After the complete extraction process, the rotary evaporator is used to remove the solvent from the extracted compound. The non-soluble portion of the extracted solvent is generally discarded that remains in the thimble [3].

LITERATURE SURVEY

The following table shows the various studies performed on various types of biomass to derive bio-diesel from the specimen sources.

CONCLUSION

There is an emerging need to shift more towards energy consumption using eco-friendly fuels that help to control the CO2 emissions thereby reducing greenhouse effect. The aftereffect of petroleum originated fuels has caused vigourous exhausting of conventional energy sources along with excruciating air pollution. From the literature survey, it can be concluded that bio-diesels are an effective substitute for petro-diesel. These have high flash point, less sulphur content, are less toxic, bio-degradable and also give low exhaust emissions, thus proving to be environmentally friendly. However, there are some challenges like low temperature tolerance oxidation problems, etc. which can be tackled by adding bio-based additives. So, there is a need for further research in this area.

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Table 1: *Various studies performed on different biomass for obtaining bio-diesels.*

Reference	Study area	Description of the study	Critical observation
W.M.J. Achten [4]	Bio-diesel production from JCL (JCL or physic nut of the Euphorbiaceae family maybe large shrub or small tree with height upto 5-7 m has life expectancy of 50 years.)	Overviewed the process steps involved in bio-diesel production from JCL, namely, cultivation requirements, seeds production, oil extraction, conversion to bio-diesel. The oil yield by using engine driven screw was 75-80%, by using manual ram presses was 60-75% whereas using chemical extraction with help	The calorific value ranged from 37.83-42.05 MJ/kg, cetane value between 38.0-51.0, carbon residue between 0.07-0.64%, sulphur content between 0-0.13%, flash point at 210-240°C. Composition of JCL oil was 75% unsaturated fatty acid dominated by linoleic acid (C18:2) and oleic acid (C18:1). The seed cake's crude protein content was 58% by weight and

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		of n-hexane in Soxhlet apparatus it amounted to 95-99%. JCL oil was transesterified to (m)ethyl esters (bio-diesel) as main product constituting 99.6% by weight, glycerol as by-product constituting 0.088-0.100 and water as 0.07-0.10%.	energy content 18.2MJ/kg. The characteristics and composition of the JCL (m)ethyl ester ranged as: caloric value from 38.45-41.00 MJ/kg, flash point from 170-192°C, cetane value from 50.0-56.1, carbon residue from 0.02-0.50%, sulphur content from 0.0036%.
Ronald Halim [5]	Marine *Chlorococcum* sp. of microalgae was used that showed lipid extracted with fatty acid profile as C18:1 (~63 wt%), C16:0 (~19wt%), C18:2 (~4 wt%), C16:1 (~4 wt%), and C18:0 (~3 wt%).	Compared extraction of lipids using hexane with supercritical carbon dioxide ($SCCO_2$). He found that $SCCO_2$ extraction for 80 minutes yielded 0.058g whereas with dynamic hexane lipid extraction using 5.5 hours yielded 0.032g with lower mass transfer coefficient.	Important inferences he stated were that firstly, dynamic mode increased lipid yield than static mode by 280% since through solvent refluxing in Soxhlet fresh batch of hexane was constantly exposed so the equilibria of mass transfer was continually re-established, secondly, he stated that hexane extraction through dry powder resulted in 33% more lipid extraction than from wet paste. He concluded that although $SCCO_2$ extraction was more efficient but also required pre-treatment step that was cost-intensive thus proving hexane extraction to be more promising.
Jahirul M.I. [6]	Beauty Leaf tree (*Calophylluminophyllum)* tree grows in 18-33°C temperature range particularly in climatic regions of tropical and subtropical type such as Australia, India and Sri Lanka.	He saw Beauty Leaf tree as biodiesel feedstock for future generations and compared mechanical with chemical oil extraction by using electric powered screw press and hexane as an oil solvent respectively.	He found that these trees contained useful oil amounting to 25-60% on basis of unit mass and stated that each tree could provide 18.4 kg oil yield approximately contributing to 4800 kg oil yield per hectare annually. He inferred that seed preparation including processing and drying in case of mechanical extraction

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			significantly affected oil yields such as highest yield was obtained by kernels prepared with 15% moisture. He concluded that chemical extraction yielded higher oil yields but would be better only if hexane could be recovered for reuse.
Farrukh Jamil [7]	Examined lipid extracts from date pits that were available as a waste in Omen.	Soxhlet apparatus was used and effects of various parameters namely temperature, time and solvent to seed ratio were analysed on the extraction process. Extracted oil was transesterified for 1 hour to produce biodiesel at 65°C reaction temperature using 6:1 methanol to oil ratio.	Highest yield obtained was 16.5%wt. of the yielded oil at 70°C temperature in 7 hours duration at 4:1 solvent to seed ratio. The extracted oil constituted unsaturated fatty acids about 54.85%. The characteristic fuel properties of the obtained bio-diesel were as follows: 44.10 MJ/kg calorific value, 58.23 cetane number, 137°C flash point, 870kg/m^3 density at 25°C and 0.014% free glycerin. Using ANOVA analysis he inferred that the most important parameter in controlling oil yield was temperature.
K. Vijayraj [8]	Neat mango seed oil was transformed into their respective methyl ester through the process of transesterification process.	Experiments were performed using various different blends of methyl ester of mango seed oil (MEMSO) with diesel in a vertical, 4 stroke, single cylinder, and air cooled Kirloskar diesel engine.	The experimental outcomes of this study showed that the MEMSO biodiesel has similar fuel property characteristics as compared to those of diesel. The smoke density, unburnt hydrocarbon and brake thermal efficiency were found to be lower in case of MEMSO biodiesel blends than that of diesel. The CO emission for B25, B50 and B75 was found to be lower than diesel at full load, whereas for B100 it was observed to be higher at all

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			loads. Whereas, BSFC and NOx of MEMSO biodiesel blends came to be higher than diesel. Also, it was found that the combustion properties of all blends of methyl ester of mango seed oil displayed similar trends with those of the baseline diesel. The density of the produced bio-diesel was approximately 8% higher to that of diesel fuel, and the gross calorific value was approximately 8.5% lower to that of diesel.
C. Dueso [9]	Bio-oil based natural anti-oxidant additive was incorporated with sunflower biodiesel.	Refined sunflower oil with acidity<0.5% with 1%wt of alkaline catalyst(KOH) and methanol mixed in ratio excess ratio of 1:6 was prepared by catalytic transesterification. Antioxidant additive was extracted by using isopropyl acetate as solvent through a two stage liquid-liquid extraction process of pinewood bio-oil and insoluble bio-oil fraction was removed using centrifugation. Final additive composed of 80% biodiesel concentration.	Increased oxidation stability by 172% by bio-oil addition (1.9%wt) into biodiesel due to phenolic compounds present in it. Brake power with biodiesel was lower, brake specific fuel consumption and brake thermal efficiency were higher as compared to diesel. Reduced NO_x, smoke opacity and increased CO, HC emissions by 3%, 4.4%, 0.7% and 14.3% respectively were found in case of antioxidant added biodiesel with respect to neat biodiesel.
P. Divajothi [10]	Trans-esterified ethyl esters of groundnut acid oil collected from vegetable oil refinery industrial waste	Blends of this with diesel were tested in single cylinder DI diesel engine at controlled speed of 1500 rpm using governor. AVL Digas 444analyzer was used to measure HC, CO and NO_x emissions and AVL 437 Smoke meter was used for	Increased SFC by 1.7%, reduced BTE in 1.1%, reduced HC, CO emissions to 2.2% and 1.1% respectively. Combustion parameters like cylinder pressure and heat rate were also decreased to 2.3% and 2.1% as compared to diesel.

		smoke density.	
L.P. Oliveira [11]	Pachiraaquatica (PA) Magoniapubescens A St-Hil (MP), fruits of two perennial tree species`were studied as potential triacylglyceride.	Two approaches namely, obtaining methyl fatty acid esters mixtures(bio-diesel) synthesised using esterification followed by trans-esterification and hydrocarbon mixtures (bio-oil).	Physical-chemical properties of MP methylic biodiesel (0.872density at 25°C, 39.44 $MJkg^{-1}$ heat of combustion) met requirements same as diesel whereas PA methylic biodiesel (with 0.872 density at 25°C, 39.4 $MJkg^{-1}$) did not met any specifications for diesel so would have to be used by blending with other bio-fuels in order to be viable.
A. Amin [12]	Castor biodiesel obtained by trans-esterifying methyl ester was blended with diesel.	Density, kinematic viscosity and calorific value were predicted using empirical correlations and several polynomials were fitted by least square method with experimental data.	Blending castor oil with diesel in the range of 20% would be viable for the required diesel engines specifications. Also, Kay mixing rule showed good prediction of fuel properties.
X. Aboubakar [13]	Vegetable oil was extracted from Tanzanian variety Jatropha	Two methods, first by traditional method using boiling water as solvent to extract oil from paste and second, mechanical extraction by direct pressing using Bielenberg press to extract oil from dried or heated seeds. Oils produced were burned for to boil 3L water for 32 min in suitable stoves with 3.07±0.4g/min combustion rate for ten flame stove.	Oil content yield obtained from traditional method was 22.02±2.1%, oil cake of 67.02±3.3%and water/paste ratio in mass was 0.36 with 1.01±0.05% volatile and water content and 0.884± 0.0014 kg/m^3 density. Oil content yielded from mechanical extraction was 26.15±2.74% with 0.19± 0.09% volatile and water content and 0.891±0.012 kg/m^3 density. Jatropha could be used as a cooking fuel but cost of Jatropha oil extraction was more than fossil fuels (like petroleum and gas oil).

I. Lawan [14]	Critical review on the effects of adding bio-based additives in biodiesels properties was reported.	Effects of bio-based additives and bio-oils, effects of cashew nut shell in liquid form on oxidative stability of bio-diesels were studied. Effects of bio-based additives and bio-oils and transesterification/esterification products on cold flow type of properties were studied. Effects of bio-based additives on distinct fuel properties like flash point, acid number, density, kinematic viscosity, and on CI engine characteristics were also reviewed.	Out of all the reviewed additives, *Pongamiapinnata*leaves extract had increased brake thermal efficiency, brake specific fuel consumption, emissions CO and HC and decreased NO_x emissions. Bio-oils from ethyl levulinate and non-edible sources were suitable additives that lowered temperature properties and improved oxidative stability respectively of biodiesels.