International Journal of Industrial Engineering, 2018;2(9):197-201.
ISSN: 2456-8449.
http://ijie.gjpublications.com

Research Article

Production of Biodiesel from *Cordiamyxa* seeds Biooil by Alkali-catalyzed Transesterification Reaction

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Abstract

Biodiesel is renewable alternative fuel to a diesel engine, comprised long-chain mono alkyl esters. The aim of the present study is to extract biooil from *Cordiamyxa* seeds by a solvent extraction method using a Soxhlet apparatus. The existing work reveals the results of a mini-scale experimental investigation into biodiesel recovery from *Cordiamyxa* oil using transesterification process via a heterogeneous catalyst. The effect of solvent extraction variables including time, moisture content and particle size was studied on biooil extraction. Biooil was analyzed by FT-IR and GC-MS methods and physicochemical properties estimated by ASTM methods under optimum conditions.

Keywords: *Cordiamyxa* biooil; Biodiesel; Characterization; Transesterification.

Introduction

Due to the large demand for transportation fuel, increase in global fossil fuel prices, global warming, climatic changes and issue with greenhouse emission leads to change in sustainability and increase in demand for renewable alternative fuels such as biodiesel [1,2]. According to that biodiesel is ultimate renewable and totally independent of fossil fuel and its derived from vegetable oils, animal fats, algae, edible and non-edible oils, beef tallow, cow dung trap grease and used cooking oil. Biodiesel is synthesized by transesterification of triglycerides react with alcohol in presence of catalyst [3].

Triglycerides + Monohydric alcohol ↔ Glycerin + Mono-alkyl esters

The catalyst used for transesterification can be in homogeneous or heterogeneous forms. For the commercial purpose, homogeneous catalysts are used, but the main disadvantage is corrosion occurs inside the equipment [4]. Compare to homogeneous catalyst, heterogeneous will perform faster and non-corrosive in nature, separation of liquid will be easy, with increased stability and longer life [5, 6]. Methanol is commonly used alcohol for transesterification reactions because of its low cost compared to other solvents like Ethanol, Propanol etc [7]. In the present study, the *Cordiamyxa* seed biooil was extracted, extracted biooil was characterized using FTIRand GC-MS. Biooil was converted into biodiesel using heterogeneous catalyst. Various process conditions affecting biodiesel yield was optimized.

Materials and methods

Extraction of Cordiamyxa biooil

Oil can extract from oilseeds by several methods including solvent extraction, expeller, and supercritical extraction method [8, 9]. To increase the extraction efficiency of oilseeds has crushed and decreases the particle size and lowering of mass transfers resistance of pure bio oil removal. Bio oil can extract from fresh *Cordiamyxa* seeds, using effective chemicals solvents hexane, ether, acetone, isopropanol, and chloroform [10]. Among these solvents, isopropanol has long been used as an oil extraction solvent and is relatively inexpensive via Soxhlet apparatus. Soxhlet extraction is a distillation extraction method by using chemical solvents, the extraction unit equipped with a heated solvent reflux system.

Received: 06.09.2018; Received after Revision: 21.09.2018; Accepted: 21.09.2018; Published: 28.09.2018

Transesterification reaction to Cordiamyxa bio oil

Transesterification also called as alcoholysis process, the reaction undergoes fat or oil triglyceride with an alcohol to esters and glycerol [11]. Biodiesel can do in several ways, their process could be either in batch or continuous via catalytically using strong acid or base as a catalyst. Biodiesel is derived from the transesterification reaction to triglycerides mix with alcohol like methanol. Before, starting the experiment the biooil was pretreated for the removal of dirt and other particulate matters in it. Acids reacts with biooil in the presence of alcohol converts free fatty acids into biodiesel [12,13]. After, preheating the oil sent to the reactor and mixed with methanol and NaOH as a catalyst. The methanol to molar oil ratio, temperature, catalyst % are maintained at appropriate level. Properties of biodiesel obtained from *Cordiamyxa* biooil was analyzed and compared with ASTM standard.

Results and discussion

The yield and aging of Cordiamyxa bio-oil extraction

The Fig. 1 indicates the percentage yield of *Cordiamyxa* seed oil using different extraction solvents. Result shows *Cordiamyxa* seed oil yield is better with polar solvents like isopropanol, chloroform, and ethanol when compared to nonpolar solvents like hexane and toluene. In the present study, isopropanol is found as the best solvent; its cost is comparatively low and reached the highest percentage of biooil yield. Toluene has a high boiling point; hexane is unsuitable for recovery of oil. An overall, isopropanol has concluded as the best solvent for the extraction of *Cordiamyxa* seed oil. The effect of aging of *Cordiamyxa* seed in the yield of biooil produced is also examined for the same variety of seeds as shown in the Fig. 2. Fresh seeds found to give maximum biooil yield using isopropanol as solvent for extraction whencomapred to other solvent and seeds age.

FT-IR and GC-MS analysis of Cordiamyxa bio oil

The results of FT-IR analysis of biooil is shown in the Fig. 3. The functional group identified with the FT-IR spectrum of *Cordiamyxa* biooil is shown in Table 1. Peak 1 (3370 and 3134 cm^{-1}) is mainly present in alkanes and peak 2 (1602 cm^{-1}) represents esters. The total ion present in the chromatography from GC-MS analysis represented in the Fig. 4. Based on the chromatography analysis only two fatty acids identified, it consumed saturated. Although, it concluded that the *Cordiamyxa* oil used in the present study has excellent oxidative and thermal stability [14].

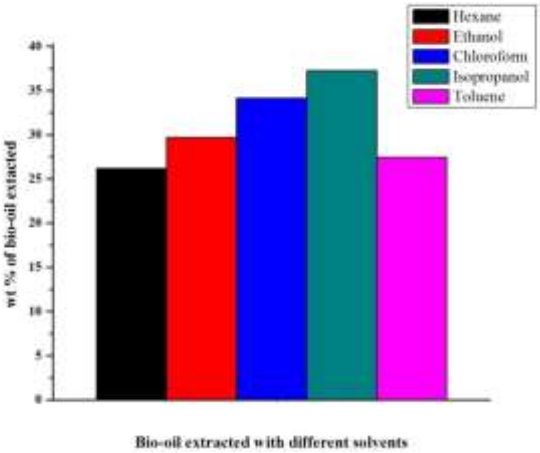

Fig. 1. Effects of different solvent on yield of biooil

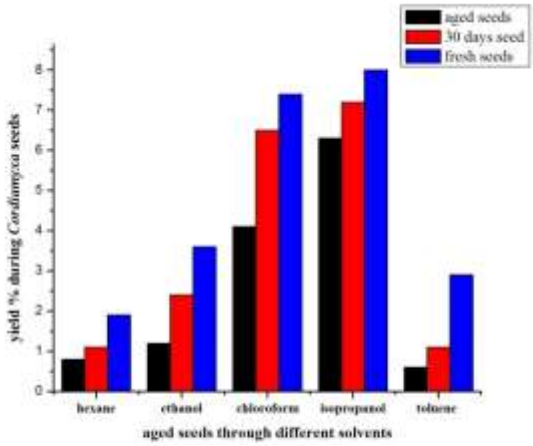

Fig. 2. Effect of aging of *Cordiamyxa* seed on yield of biooil

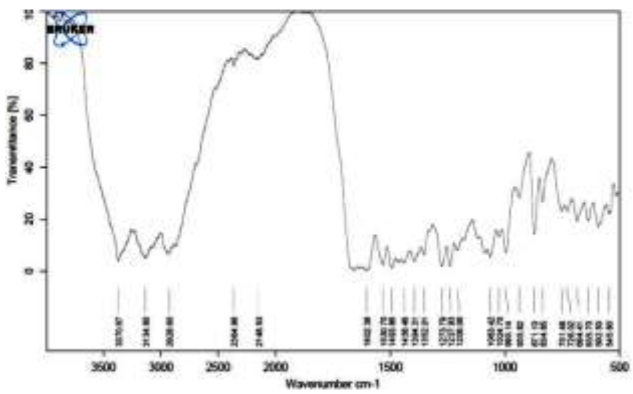

Fig. 3. FT-IR analysis of *Cordiamyxa* biooil

Physico chemical properties

Basic fuel and physico-chemical parameters of *Cordiamyxa* biooil results are shown in the Table 2 and their elemental compositions of *Cordiamyxa* seed and *Cordiamyxa* biooil are presented in Table 3.

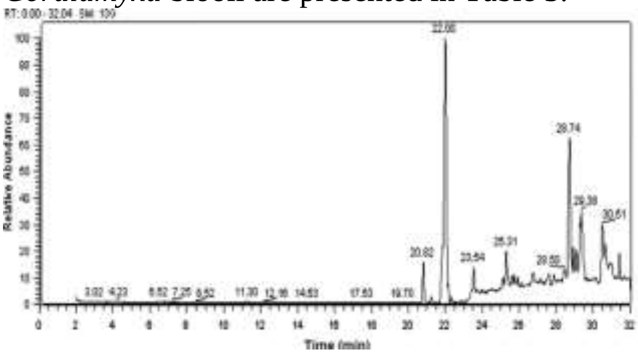

Fig. 4. Gas Chromatography analysis of *Cordiamyxa* biooil

Effect of catalyst

Catalyst plays important role in a transesterification reaction of fatty acids. Catalyst speed up the process of break triglyceride bonds. The effect of catalyst concentration was varied from 0.02, 0.03, 0.04, 0.05, 0.06 wt% of catalyst. The *Cordiamyxa* biodiesel yield is shown in the Fig. 5. It was observed that 0.05 wt% of the catalyst is best, high percentage biodiesel yield of 84.35 wt% was obtained at 65°C reaction temperature in 30 min reaction time and 400 rpm stirrer speed.

Effect of methanol to oil ratio

The effect of methanol to oil ratio was studied in different ranges from 3, 6, 9 and 12 and their results were shown in the Fig. 6. It is observed that yield of the process increases fro increase in oil to molar ratio. The maximum percentage biodiesel yield of 84.35 wt% was obtained at 9:1 molar ratio of oil to methanol at 65°C constant temperature around 30 min reaction time with 0.05 wt% of catalyst and 400 rpm stirrer speed.

Table 1. Functional groups present in *Cordiamyxa* biooil

S. No.	Frequency range, cm^{-1}	Group	Class of compounds
1	2980	C-H stretching	Alkanes
2	1653	C=O stretching	Esters
3	1580	C=C stretching	Alkenes
4	1470	$-NO_2$ stretching	Nitrogenous compounds
5	1300	C-H bending	Alkanes
6	910	C-O stretching, O-H bending	Alcohols
7	650	C-H in-plane	Aromatic compounds

Table 2. Physicochemical and fuel properties of biooil

S. No.	Fuel property	Unit	Value
1	Density	Kg/l	0.967
2	Iodine value	-	91.73 ±0.07
3	Saponification value	mg KOH/g	211.43 ±0.56
4	Calorific value	MJ/kg	31,85
5	Sulphur	Wt%	0.01
6	Flashpoint	°C	93
7	Fire point	°C	100
8	C/H	Wt%	7.42
9	Kinematic viscosity @ 40 °C	mm^2/s	24.51

Table 3. Elemental composition present in *Cordiamyxa* biooil

S. No.	Component	*Cordiamyxa* seed	*Cordiamyxa* seed oil
1	Carbon, Wt%	39.56	76.7
2	Hydrogen, Wt%	6.367	10.318
3	Nitrogen, Wt%	6.26	1.52
4	Sulphur, Wt%	0.156	0
5	Oxygen, Wt%	48.523	10.729
6	H/C, molar ratio	1.825	1.726
7	O/C, molar ratio	0.879	0.103

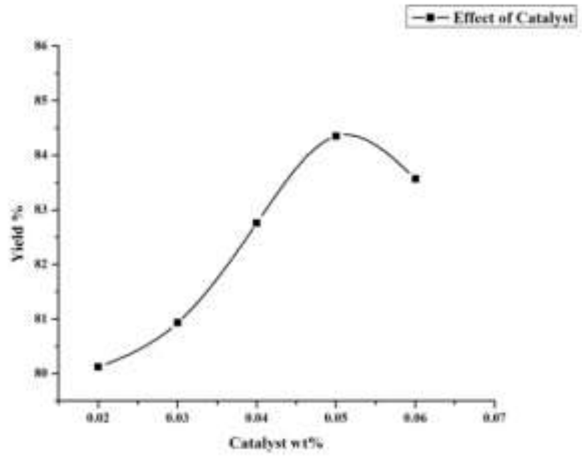

Fig. 5. Effect of catalyst on yield of biodiesel

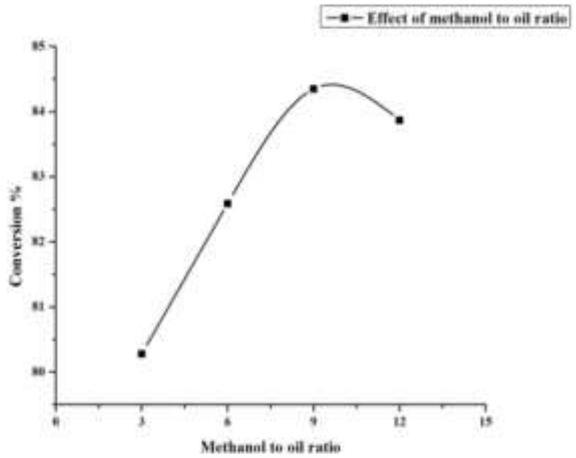

Fig. 6. Effect of methanol to oil molar ratio on yield of biodiesel

Effect of reaction temperature

The reaction temperature can influence the reaction rate and reported to increase the yield of biodiesel. When the transesterification reaction started at 45°C, the yield of biodiesel was 68.15 wt%; however, the biodiesel yield was increased to 84.35 wt% when reaction temperature increased to 65°C as shown in Fig. 7. Due, to the low reaction temperature, the energy consumes the lower amount of collisions present in reactant particles, whereas the high reaction temperature leads to improve the collision and yield the high reactant particles.

Properties of Cordiamyxa biodiesel

The produced biodiesel was purified after alkali-catalyzed transesterification of biooil. The fuel properties biodiesel from *Cordiamyxa* seed oil was analyzed to the aid of standard conditions and compared to ASTM D6751 method, results are given in Table 4. The biodiesel conversion at optimum condition was found to be 92.50%.

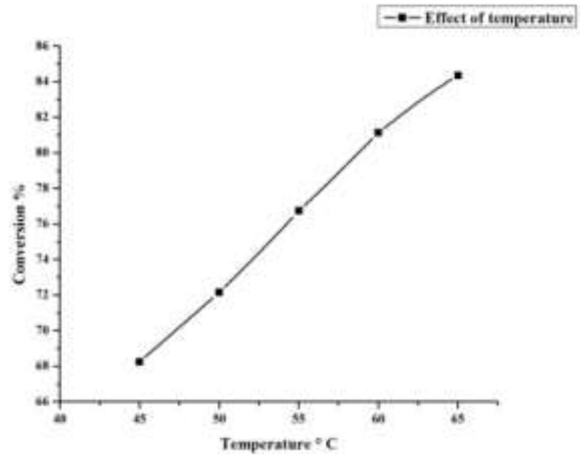

Fig. 7. Effect of temperature yield of biodiesel

Table 4. Fuel specification of *Cordiamyxa* biodiesel compared with ASTM D6751

Properties	Units	ASTM method	Limits	*Cordiamyxa* biodiesel
Specific gravity	-	D4052	-	0.896
Flashpoint	°C	D93	130 min	173
Cloud point	°C	D2500	Report	1
Kinematic viscosity @ 40 °C	mm^2/s	D445	1.9-6	4.18
Acid number	mg KOH/g	D664	0.05 max	0.038
Carbon residue	wt%	D4530	0.05 max	0.043
Water & sediments	vol%	D2709	0.05 max	0.033
Copper strip corrosion	-	D130	NO.3 max	1a
Sulphated ash	wt%	D874	0.02 max	0.01
Cetane number	-	D613	47 min	48

Conclusions

The biooil extracted from *Cordiamyxa* seed biooil is much like other biooil in chemical composition and basic fuel properties. The usage of *Cordiamyxa* seed to make biodiesel can generate benefits. Physico-chemical and basic fuel parameters *Cordiamyxa* seed oil was examined. *Cordiamyxa* seed oil is a clear fluid, pale yellow with sweet nutty odor. The acid value 0.42 oil is mg KOH/g. The transesterification reaction has effectively produced a good quality of biodiesel. Bioethanol yield of 92.50% was achieved at optimum conditions of 0.05 wt% catalyst, 9:1 molar ratio and at 65°C.

Conflicts of interest

Authors declare no conflict of interest.

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