Biorefining Crotalaria Juncea (Sunn-hemp): A Promising New Source for the Production of Biodiesel

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ABSTRACT

Nowadays, clean biodiesel can be produced from biomass based agricultural oils. Crotalaria Juncea, or Sunn-hemp, is a member of the pea family (Fabaceae) grown in many countries to be used as a green manure or forage crop. In our research work, biodiesel is produced by trans-esterification of bio-oil obtained from Crotalaria Juncea (Sunn-hemp) seed using methanol and different catalysts. Here standard solvent extraction method, using Soxhlet apparatus is done for oil extraction using crushed Crotalaria Juncea seeds. In order to obtain the maximum yield of bio-oil, two parameters such as extraction time and choice of solvents are optimized. Isopropanol solvent is best for obtaining maximum yield of oil at 3.5 hour time. Trans-esterification reaction is done using three types of catalysts like, KOH, CaO and sea shell with different oil-methanol molar ratio in the range of 1:9-1:13 at different time intervals. Maximum yield of biodiesel is obtained with KOH as catalyst at 4hour time with 1:11 oil-methanol mole ratio. The yield of biodiesel is 91.365%.

Keywords: Biodiesel; Crotalaria Juncea; Soxhlet apparatus; Isopropanol.

1. INTRODUCTION

Global warming presents the gravest threat to life on Earth in all of human history. The worldwide emissions of CO_2 and other harmful gases such as CO, SO_x, NO_x and particulates generated by fossil fuel combustion have led to serious crisis to the environment. Biofuels offer an attractive alternative to fossil fuel [1]. Numerous countries are moving towards the partial and gradual replacement of fossil fuels with biofuels, mainly ethanol and biodiesel. The demand for diesel is five times higher than the demand for petrol in India. While the ethanol industry is mature, the biodiesel industry is still in its infancy [2]. India's current biodiesel technology of choice is the trans-esterification of vegetable oil. Biomass based agricultural oils have a great potential towards production of cleaner biodiesel substitute. These bio oils are better than diesel fuel in terms of sulfur content, flash point, aromatic content and biodegradability [3-4]. Bio oil from Crotalaria Juncea (Sunn-hemp) seed is a promising new source for the production of biofuel.

Crotalaria Juncea, or Sunn-hemp, is a member of the pea family (Fabaceae) grown in many countries as a green manure or forage crop. Sunn-hemp (Crotalaria Juncea, L), a plant of sub-order Paplionaceae of order Leguminoseae is an annual shrub cultivated as multipurpose legume especially for its fine fibre in many countries including India. The crop is grown also for legume or as a fodder. The Sunn-hemp crop is native to India. It is generally considered to have originated in India, where it has been cultivated since prehistoric times. However, this is now widely grown throughout the tropics and subtropics. Sunn-hemp seeds contain moisture (8.6%), crude protein (34.6%), fat (4.3%), starch (41.1%), fibre content (8.1%), ash (3.3%), and oil (12.6%). The endosperm of Sunn-hemp seeds contains thin walled cells, enriched in oil [5]. The oil contains saturated fatty acids (20.3%), Linolenic acid (4.6%), Linoleic acid (46.8%) and Oleic acid (28.3%). The 60 days old crop accumulates about 170 kg N, 20 kg P and 130 kg K/ha.

2. MATERIALS & METHODS

2.1. Materials

2.1.1. Sunn-hemp

In this research work Sunn-hemp seeds (K-12 Yellow) were collected from Central Research Institute for Jute and Allied Fibers (CRIJAF), Kolkata, India. After cleaning, the raw seeds were dried and milled using a domestic kitchen mill (Make: Morphy Richards; Model: Cutie Mixer-Grinder; Power consumption: 500 W; Speed: 21,000 rpm).

2.1.2. Solvents

Four types of organic solvents like Iso-Propanol, Chloroform, Toluene and Hexane [Make: Merck Emparta; Grade: ACS; Purity (GC): P95%] are all purchased from local vendors.

2.1.3. Preparation of Catalysts

Here three types of catalysts were used. Potassium hydroxide and calcium oxide powder were purchased from local vendors. The sea shell (*capiz*) was obtained from local market. It was washed by water to remove dirt and other impurities. Then it was dried overnight at 100 ^{0}C. The shell was then crushed by mortar and pestle and calcined at 900°C for 2 h in a muffle furnace to convert $CaCO_3$ to CaO. After that the catalyst was removed from the furnace and kept in a desiccator to prevent any kind of contact with air.

2.2. Experimental methods

2.2.1. Bio-oil production

Oil extraction was done using Soxhlet Extractor with a round-bottom flask of capacity 1lt. The cylindrical Soxhlet extractor was placed onto the round-bottom flask containing the extraction

solvent. A bulb-condenser, operated on cooling water was fitted onto the top of the Soxhlet. The solvent was heated to reflux and then the vapour moved up a distillation arm and flooded into the chamber housing the thimble packed with crushed seeds. The solvent vapour was cooled, dripped back into the chamber and then emptied automatically. At that time the solvent was siphoned through a special side arm into the flask. This cycle was repeated many times in order to ensure completion of extraction.

2.2.2. Biodiesel production

All experiments were carried out in a 500 ml 3-necked round-bottom flask, equipped with a mechanical stirrer and a water-cooled condenser. The trans-esterification reaction was performed with 20g of oil at a temperature of 60°C and a stirring speed of 400 rpm. The reaction was carried out with different oil-methanol molar ratio in the range of 1:9 - 1:13 at different time intervals in the range of 2-6 hrs for three types of catalysts. The oil was charged into the flask and heated to the desired temperature. Then methanol and catalyst were added into the reactor. After the reaction was complete, the mixture was allowed to cool down and then transferred to a separating funnel for separating the phases. The upper methyl ester layer was taken and analyzed.

3. RESULTS AND DISCUSSION

3.1. Effect of use of different solvents on oil extraction

Table 1 describes the oil yield using four extraction solvents. Isopropanol gives highest yield (11.24%). From this result, it is shown that polar solvents like isopropanol and chloroform give better oil yield as compared to some of the non-polar solvents like hexane and toluene. Chloroform gives second best oil yield. After getting the best solvent, oil extraction time is optimized in order to get maximum yield. Fig. 1 predicts the maximum yield at 3.5 hours.

3.2. Effect of various process variables on the yield of biodiesel

In trans-esterification, the nucleophilic alkoxide from the alcohol attacks the electrophilic part of the carbonyl group of the triglycerides [6]. The polarization effect causes the carbon atom to be positively polarized and electrophilic. Triglyceride can break into three steps. First, an intermediate tetrahedral is generated from the attack of electrophilic carbon atom by nucleophilic alkoxide and then the breakdown of unstable intermediate tetrahedral to diglyceride ion and fatty acid ester would occur. Finally the catalyst is recovered by proton transfer.

The trans-esterification of Sunn-hemp oil was done using various parameters like choice of catalyst, reaction time and oil to methanol molar ratio. Table 2 describes the yield of biodiesel obtained for different catalysts (KOH, CaO and sea shell) at different oil to methanol molar ratio

1:9-1:13. Fig. 2 shows that the yield is maximum at 4h reaction time. With further increase of reaction time, it decreases. Here KOH catalyst gives best result as compared to other heterogeneous catalysts. The maximum yield of biodiesel obtained in this study was 91.365% at the operation condition: catalyst used 2% (w/w) KOH, oil to methanol ratio 1:11, reaction time 4hrs.

4. CONCLUSIONS

In this study, a bio oil was produced from Sunn-hemp seeds by solvent extraction method using a Soxhlet extractor. Since oil content is low (<20%), solvent extraction technique offers the only viable solution for the extraction of oil from the Sunn-hemp seeds. Biodiesel was produced using three types of catalysts. By using KOH catalyst maximum yield is obtained.

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Table 1

Variation of the yields (%) of Sunn-hemp seed oil using various extraction solvents (amount of seed taken: 107 g, amount of solvent taken: 500 ml).

Run	Name of solvent	Amount of seed used [gm]	Amount of oil obtained[gm]	Amount of oil [%]
1.	Iso-propanol	107	12.03	11.24
2.	Chloroform	107	10.4	9.72
3.	Toluene	107	7.7	7.2
4.	Hexane	107	2.46	2.3

Table 2: The effect of different process variable on the yield of biodiesel

Type of catalyst	Reaction time, h	Oil to methanol ratio	Yield of biodiesel (%)
KOH	4	1:9	78.274
		1:11	91.365
		1:13	65.32
CaO	4	1:9	52.313
		1:11	60.261
		1:13	56.63
Sea shell	4	1:9	43.621
		1:11	50.563
		1:13	35.264

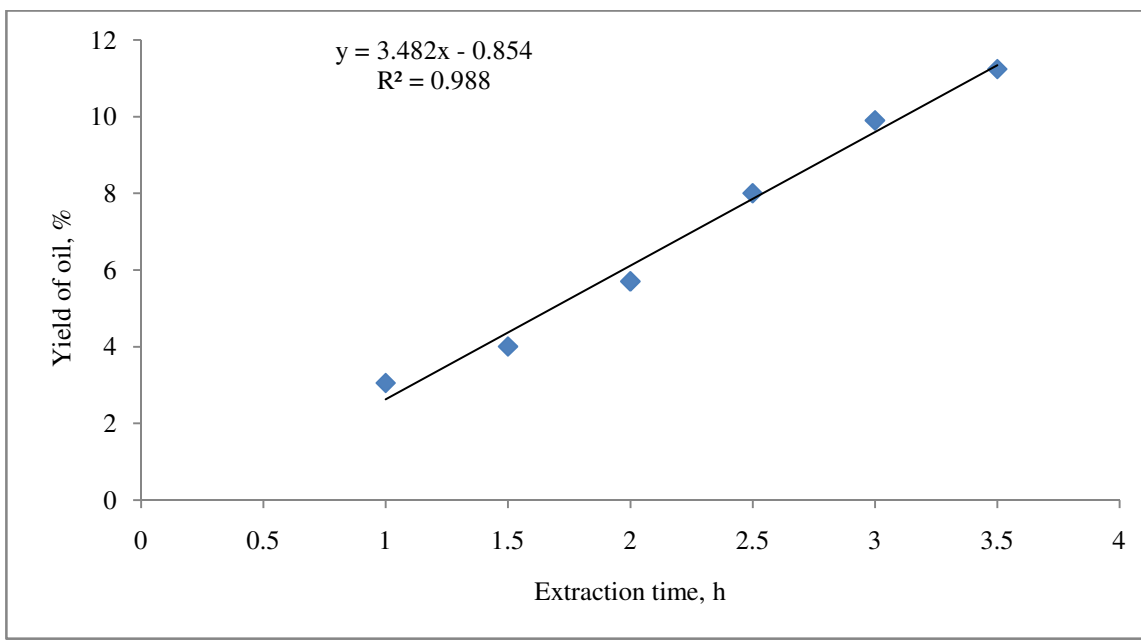

Fig.1. Variation of Sunn Hemp oil recovery with different extraction time for isopropanol solvent.

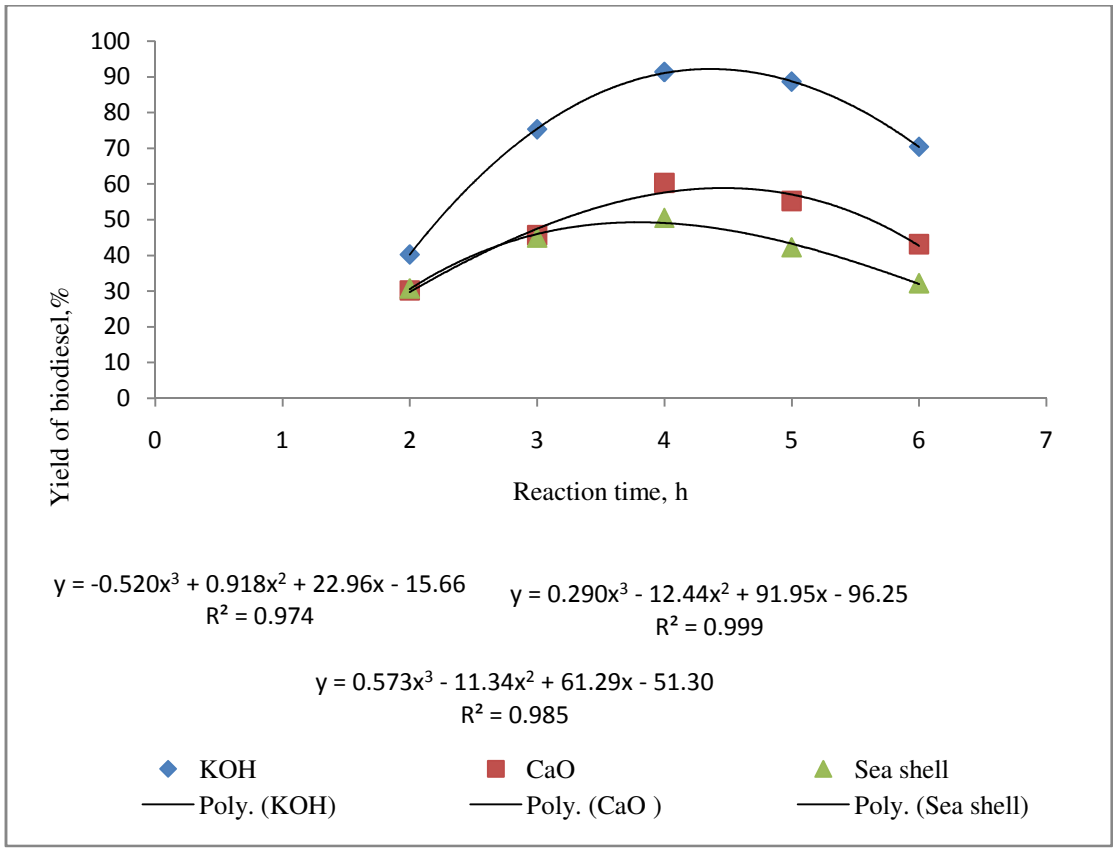

Fig.2. Yield of biodiesel for different catalysts at different time intervals.

Gas Hydrats as Upcoming Source of Energy

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ABSTRACT

Gas Hydrates are crystalline form of natural gas present in down sea and In the permafrost region. They are seen as new generation fuels. It is also known as burning ice. These are presents in KG, KK, and Mahanadi, Andaman nicabar regions in India and round the world in country like USA, Canada, and Japan etc. Lots of research is going on to exploit this source of energy. These are seen as substitute of the fossil fuel for future generation.