Journal of Chemical and Pharmaceutical Sciences www.jchps.com ISSN: 0974-2115

OPTIMIZATION OF VARIOUS PARAMETERS ON *BOTRYOCOCCUS BRAUNII* FOR BIODIESEL PRODUCTION USING NANO CaO CATALYST

A.S.Arun Prasad[1], Arumugamurthi Sakthi Saravanan[1], S.Periyasamy[2], Pandian Sivakumar[3*]
[1]Department of Petrochemical Engineering, JCT College of Engineering and Technology, Coimbatore-641105. India
[2] Department of Mechanical Engineering, Government college of Technology, Coimbatore-641013. India.
[3] Department of Petrochemical Engineering, RVS College of Engineering and Technology, Coimbatore-641402. India.
***Corresponding Author: E-mail:sivakumarhap@gmail.com; sakthisaravanan89@ymail.com**

ABSTRACT

The aim of the study was to obtain high quality biodiesel from microalgae *Botryococcus braunii* through transesterification process using nano CaO as catalyst. The yield of 81.31% ester was obtained at an optimum catalyst of 0.5 wt %. The reaction temperature was optimum at 55°C and yields 82.33% ester. At an optimum reaction time of 50 min a maximum yield of 84.11% ester was obtained. The stirring speed was varied from 150 to 400 rpm and was optimum at 300 rpm yields maximum of 84.67% ester. The fuel properties of *B.Brunii* Biodiesel was determined as per the ASTM D6571 standard are density 853 kg/m^3, viscosity 5.34 mm^2/sec, flash point 138°C, acid value 0.46mg/gm, calorific value 39.28 MJ/Kg and sulfur content 15 ppm. The method used in this study may well be novel approach and great potential in the industrial production of biodiesel from microalgae.

Keywords: Botryococcus braunii, Transesterification, Biodiesel, Optimization.

INTRODUCTION

The most basic requirement for human survival and activities is energy. Nowadays petroleum based fuels has been serving the world to meet its need of energy consumption. The dependency of mankind is entirely on the fossil fuels and might leads to shortage in near future (I.M. Atadashi *et al*.,2010 and N. Chand.,2002). Whereas petroleum fuels plays an important role in the development of industrial growth, transportation purpose, agricultural area and also to meet other basic needs. The continuous use of fossil fuel is creating the environmental issues including emission of NO_2, SO_2 and CO_2 gases to atmosphere. Hence, the scientists are in search of an alternative fuels. (Shenbaga *et al*., 2012). Biodiesel is one of the most important components to reduce greenhouse gas emissions and substitute of fossil fuels. Biodiesel is a non-toxic and biodegradable with less pollutant and presently receiving high attention because of its potential as a sustainable and environmentally friendly substitute to petro-diesel (Vasudevan *et al*., 2008 and Lam *et al*., 2012). Biodiesel reduces net carbon-dioxide emissions by 78% on a lifecycle basis when compared to conventional diesel fuel (K. Gunvachai., *et al.*, 2007). Biodiesel produced from oil crops is a potential renewable and carbon neutral substitute to petroleum fuels. But biodiesel from oil crops, waste cooking oil and animal fat cannot satisfy even a small fraction of the present demand for transport fuels (Yusuf Chisti.,2007).

Biodiesel is a mixture of monoalkyl esters of long chain fatty acids resulting from a renewable lipid feed stock (A. Demirbas.,2002). It is composed of 90% - 98% triglycerides, and smaller quantity of mono and diglycerides and free fatty acids, as well as residual amounts of phospholipids, carotenes, tocopherols, sulphur compounds and water (K. Bozbas.,2008). The advantages of biodiesel are portability, readily available, lower sulfur content and aromatic content and high combustion characteristics. Biodiesel is considered as a potential replacement of conventional diesel fuel is normally, composed of fatty acid methyl esters that can be prepared from triglycerides in vegetable oils by transesterification with methanol.(V. Gerpen.,2005)

Microalgae are the most promising alternative supply of lipid for biodiesel production. Microalgae emerge as an only source of renewable biodiesel that has capable of meeting the global demand for transport fuels. Like plants, microalgae utilize sunlight to produce oils but they are highly efficient than crop plants. (Yusuf Chisti.,2007). Microalgae have been well known as a better feedstock for biodiesel production, mainly because of their faster growth rate (100 times than terrestrial plant) and their ability to double their biomass in less than 24 hours under certain culture conditions (Lam *et al*., 2012; Tredici *et al*., 2010). Oil content in microalgae may exceed up to 80% by weight of dry biomass (Metting, 1996; Spolaore *et al*., 2006). Microalgae which have high oil content are preferred for biodiesel production. Depending on the species, microalgae produce different kind of lipids, hydrocarbons and other complex oils (Banerjee *et al*., 2002; Metzger., *et al* 2005; Guschina., *et al* 2006).

There are several thousand algae species available, of these we need to select the species based on its high growth rate and high lipid content (Sforza et al., 2010). Microalgae species like *Botryococcus braunii* are capable to produce 15–300 times more oil than traditional crops for biodiesel production (Lam MK and Lee KT., 2012). Microalgae have a very short harvesting cycle (approximately 1 to 10 days depending upon the type of algae and process) when compared with the conventional crop plants which are generally harvested once or twice in a year. The aim my work is optimize the catalyst, reaction temperature, reaction time and stirring conditions for effective production of biodiesel from *Botryococcus braunii* using nano CaO.

MATERIALS AND METHODS

Chemicals: The reference standards of fatty acid methyl ester were procured from M/s Sigma-Aldrich. Methanol, Sodium Hydroxide, $Ca(NO_3)_2$, $4H_2O$ and Ethylene glycol (99%) were obtained from M/s Himedia. All the chemicals used for experiments were analytical reagent grade and were used without further purification.

Cultivation and Extraction of algae: The indigenous strain *B. braunii* was isolated from Kolleru Lake the largest fresh water lake in India, acclimatized and grown under laboratory condition. The stock culture was maintained regularly in both liquid and agar slants using modified CHU-13 medium (Yamaguchi K *et al*.,1987) and incubated under 30µE m^{-2} S^{-1} light intensity, 23 ± ºC and 16/8 light dark cycle. The algae oil is extracted by solvent extraction method.

Preparation of CaO nano-particles: 11.81 g $Ca(NO3)_2$. $4H_2O$ was dissolved in ethylene glycol solution (25 ml). 12.5 ml NaOH (2.10 g) was added into above mixture under vigorous stirring. In order to get uniform size nanoparticles, after it being stirred 10 min, the gel solution was kept about 5 h at static state. Then it was washed using water. After that, it was dried under vacuum drying. Finally, different sizes of CaO nano-particles could be obtained through calcining.

Transesterification process: The reactor was charged with a given amount of *B. braunii* Oil, which was stirred and preheated at different temperatures, meanwhile a solution of nano CaO in methanol (CH_3OH) was added. The reaction condition was varied; to obtain a large range of methyl ester yields. Heating and stirring was then stopped, neutralized with acetic acid and the product was allowed to separate into two phases. The optimum of each parameter involved in the process was determined while the rest of them remained constant. After each optimum was obtained, this value was considered to be constant during the optimization of the next parameter. Ester yield results (given as percentages) were related to the weight of oil at the start. (Weight of ester/Weight of oil).

RESULTS AND DISCUSSION

Catalyst optimization: The amount of alkali catalyst nano CaO used affects the conversion efficiency of the process. The catalyst amount is varied in the range of 0.2–0.7 wt.% for six different values. The effect of the catalyst amount on the yield is shown in Fig. 1. It is noted that during the present experiments, the excess addition of nano CaO increased the yield. The Optimum was achieved using 0.5 wt.% of CaO, which produced an 81.31% yield of transparent ester

Reaction temperature optimization: With increase in temperature the conversion takes place at a faster rate. The effect of the temperature on the yield is shown in Fig. 2. The optimum temperature for the reaction is found to be in the range of 55 °C. Maximum yield of 82.33% esters occurred at this temperature 55 °C. This result clearly shows that the rate of the reaction was strongly influenced by temperature (Ma and Hanna, 1999; Antonlin *et al*. 2002).

Reaction time optimization: It has been observed that the ester yield increases with the increase in reaction time. The effect of the time on the yield is shown in Fig. 3. The dependency of reaction time was studied at different time intervals ranging from 20–70 min. The maximum yield of 84.11% occurs at 50 min. The increase in reaction temperature speeds up the reaction rate and shortens the reaction time (Antonlin *et al*., 2002). The result of the time on the yield is shown in Fig.3.

Stirring optimization: The result of stirring on yield is shown in Fig. 5. Methanolysis is conducted with completely different rate of stirring like 150, 200, 250, 300, 350 and 400 rpm. The reaction is incomplete at the speed of 150-250 rpm and rate of blending was insignificant for methanolysis. The yield of biodiesel at 300 and 350 rpm was same when 30 min i.e. 84.67 %. The optimum of 300 rpm is usually recommended.

Fuel Properties of *B.Brunii* Biodiesel: The fuel properties i.e., relative density at 15 °C, kinematic viscosity at 40 °C, flash point, cloud point, acid value, sulfur content and calorific value of *B.Brunii* biodiesel were determined as per the ASTM (D6751). The results of fuel properties of *B.Brunii* biodiesel are summarized in Table 1. It can be

seen that the measured values of fuel properties of biodiesel are in the range of prescribed American and Indian biodiesel standards.

Table 1. Fuel properties of biodiesel obtained with optimized parameters.

Properties		Biodiesel standards
		ASTM D6571
Density at 15 C, kg/m3	853	-
Viscosity, 40 ºC (mm2/s)	5.34	1.9–6.0
Flash point, ºC	138	>130
Acid value, mg KOH/gm	0.46	0.8
Calorific value (MJ/kg)	39.28	-
Sulfur content	15 ppm	0.05% by mass, max

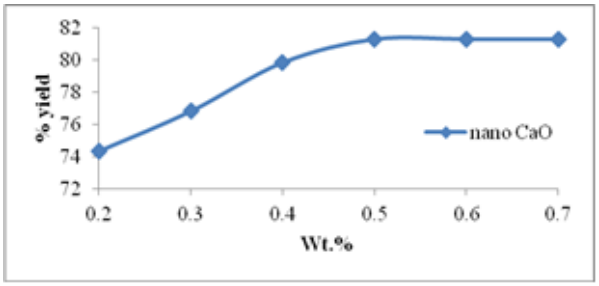

Fig. 1. Percentage yield of ester vs. catalyst wt.%.

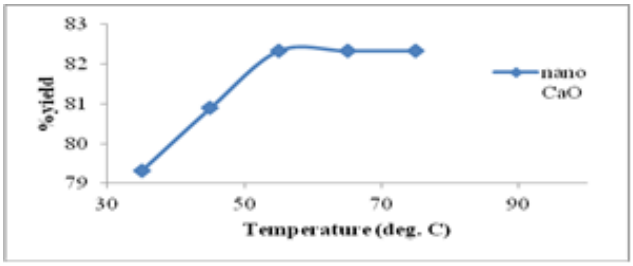

Fig. 2. Percentage yield of ester vs. Temperature.

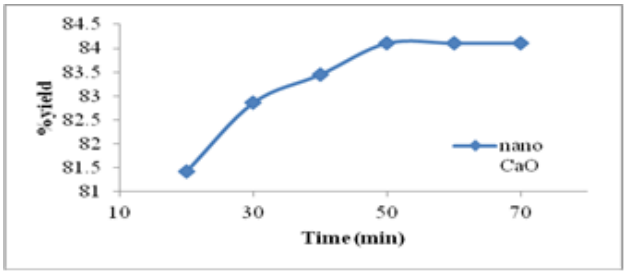

Fig. 3. Percentage yield of ester vs. Time.

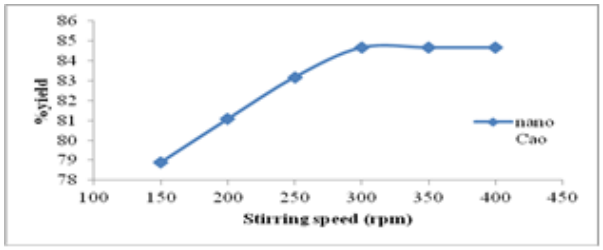

Fig. 4. Percentage yield of ester vs. Stirring rat

CONCLUSION

The biodiesel from *B.Brunii* oil was produced by nano CaO catalyzed transesterification reaction. The optimization of catalyst, reaction temperature, reaction time and stirring speed was done. The Fuel properties of biodiesel were estimated as per the ASTM D6571 standard.

REFERENCES

A. Demirbas, "Progress and Recent Trends in Biodiesel Fuels," *Energy Conversion and Management*, Vol. 50, No. 1, 2009, pp. 14-34.

Antonlin G, Tinaut FV, Briceno Y, Castano V, Perez C, Ramirez AI. Optimisation of biodiesel production by sunflower oil transesterification. Bioresour. Technol. 83(2), 2002, 111-4.

Guschina IA, Harwood JL. Lipids and lipid metabolism in eukaryotic algae. Prog Lipid Res 2006;45:160–86.

I.M. Atadashi, M.K. Aroua, A. A. Aziz, High quality biodiesel and its diesel engine application: A review, Renewable and Sustainable Energy Reviews 14 (2010) 1999–2008.

K. Bozbas, "Biodiesel as an Alternative Motor Fuel: Production and Policies in the European Union," *Renew- able and Sustainable Energy Reviews*, Vol. 12, No. 2, 2008, pp. 542-552.

K. Gunvachai, M.G. Hassan, G. Shama, C. Hellgardt, A new solubility model to describe biodiesel formation kinetics, I.Chem.E. 85(B5) (2007) 383–389.

Lam MK, Keat TL. 2012. Potential of using organic fertilizer to cultivate Chlorella vulgaris for biodiesel production. Applied energy 94, 303-308.

Lam MK, Lee KT. Microalgae biofuels: a critical review of issues, problems and the way forward. Biotechnol Adv 2012;30:673–90.

Ma F, Clements L D, Hanna M A. The effect of mixing on transesterification of beef tallow. Bioresour Technol 69(3), 1999, 289-93.
Ma, F, Hanna M A. Biodiesel production: a review. Bioresour. Technol. 70, 1999, 1-15.
Metting B, Pyne JW. Biologically-active compounds from microalgae. Enzyme Microb Technol 1986;8:386–94.
Metting FB. Biodiversity and application of microalgae. J Ind Microbiol 1996;17:477–89.
Metzger P, Largeau C. Botryococcus braunii: a rich source for hydrocarbons and related ether lipids. Appl Microbiol Biotechnol 2005;66:486–96.
N. Chand, Plant oils—Fuel of the future, J. Sci. Ind. Res. 61(2002) 7–16.
Sforza E., Bertucco A., Morosinotto T. and Giacometti G., 2010, Vegetal oil from microalgae: species selection and optimization of growth parameters, Chemical Engineering Transactions, 20, 199-204; DOI: 10.3303/CET1020034.
Shenbaga DA, Santhanam P, Rekha V, Ananth S, Balaji Prasath B, Nandakumar R, Jeyanthi S, Dinesh Kumar S. 2012. Culture and biofuel producing efficacy of marine microalgae Dunaliella salina and Nannochloropsis sp. Journal of Algal Biomass Utilization 3(4), 38–44.
Spolaore P, Joannis-Cassan C, Duran E, Isambert A. Commercial applications of microalgae. J Biosci Bioeng 2006;101:87–96.
Tredici MR. 2010. Photobiology of microalgae mass cultures: understanding the tools for the next green revolution. Biofuels 1(1), 143-162.
V. Gerpen, Biodiesel processing and production, Fuel Processing Technology 86 (2005) 1097–107
Vasudevan PT, Briggs M. 2008. Biodiesel production current state of the art and challenges. Journal of Industrial Microbiology *and* Biotechnology 35, 421–30.
Yamaguchi K, Nakano H, Murakami M, Konosu S, Nakayama O, Kanda M, et al. Lipid composition of a green alga, Botryococcus braunii. Agric Biol Chem 1987;51:493–8.
Yusuf Chisti, Biodiesel from microalgae, Biotechnology Advances, Science Direct, 25 (2007) 294–306