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OPTIMIZATION OF BIODIESEL PRODUCTION FROM AMYGDALUS SCOPARIA USING ALKALINE CATALYST

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ABSTRACT

Biodiesel is unique among biofuels which defined as a mono alkyl ester of long chain fatty acids. In this research Amygdalus Scoparia oil, which is a member of the family of rosacea has been used as a cheap feed stock for biodiesel production. Special attention was paid to optimization of alkali-catalyzed transesterification process. The Taguchi method was adequate for interpreting the effects of the control parameters and optimize the experimental conditions from a limited number of experiments. The ANOVA analysis demonstrated that methanol/oil molar ratio is the most important transesterification factor, because it has the highest effect (45.475). An optimal biodiesel yield of 92.26% was obtained within 5 h at 60 ^{0}C by using 6:1 molar ratio (methanol: oil), 1% w/w catalyst concentration. The resulting biodiesel properties satisfied both the ASTM D6751 and EN 14214 biodiesel standards.

Keywords: Biodiesel, Amygdalus Scoparia, Optimization, Transesterification

INTRODUCTION

At present the environmental problems, dwindling fossil fuel have played the pivotal role to consider alternative energy sources to petro diesel.[1] Biodiesel is a promising and feasible substitute to fossil fuel which derived from vegetable oil or animal fat. Biodiesel is biodegradable, non-toxic, and environmental friendly.

Biodiesel fuel is produced via different techniques such as: direct/blends, micro emulsion, pyrolysis and transesterification.[2] Among these techniques, transesterification using alkali-catalysis gives high levels of conversion of triglycerides to their corresponding methyl esters in short reaction time.[1][3] Fig 1 presents transesterification of triglyceride to biodiesel.[2]

$$
\begin{array}{ccccccc}
CH_2\text{-}OOC\text{-}R_1 & & & & CH_2\text{-}OH & & R_1\text{-}COO\text{-}R' \\
CH\text{-}OOC\text{-}R_2 & + & 3\,R'OH & \longleftrightarrow & CH\text{-}OH & + & R_2\text{-}COO\text{-}R' \\
CH_2\text{-}OOC\text{-}R_3 & & & & CH_2\text{-}OH & & R_3\text{-}COO\text{-}R' \\
\text{Triglycerides} & & \text{Alcohol} & & \text{Glycerin} & & \text{Esters}
\end{array}
$$

Figure1: Transestrification reaction of triglyceride to biodiesel

The transesterification reaction occurs in three consecutive reversible steps. Triglycerides react with alcohol to produce diglycerides, and then diglycerides convert to monoglycerides and later monoglycerides react with alcohol to give glycerol as a byproduct[4]. Methanol is the most extensively used in transesterification because of its low-cost as well as physical and chemical properties. The alkaline catalysts such as KOH and NaOH due to their low market costs, comparative high reaction rates and mild reaction temperatures required most used in biodiesel industry [5][6] .

Different variables affect the transesterification such as reaction temperature, alcohol/oil molar ratio, catalyst concentration, level of agitation and reaction time.[7] In this study, the level of agitation and the reaction temperature were kept constant. The main aim of this study was to obtain the optimal reaction condition for biodiesel production by using taguchi method. Taguchi method requires a smaller number of experiments for statistical analysis.

2. Experimental Procedures

2.1. Materials

Amygdalus Scoparia seeds were collected from Bushehr. Iran. Then the oil extracted usingsoxhlet extractor. Potassium hydroxide 99% and methanol 99% were purchased from

Merck Company. All the chemicals used were analytical reagent grade.

2.2. Transesterification

A known amount of amygdalus Scoparia oil (50 g) was preheated to the desired temperature (60 ^{0}C). After that the required amount of KOH and methanol were weighed and dissolved completely. This mixture was added to the preheated oil. The reaction continued for 5 h under reflax and while the mixture was being stirred. At the end of process, the excess methanol was removed by rotary evaporator and other impurities were separated with the help of separating funnel. Biodiesel which collected from the upper layer was washed with deionized water. Finally, the biodiesel was dried with sodium sulphated to get the biodiesel with negligible impurities. The percentage of methyl ester yield was calculated as follows:

Yield of FAME(%)= Weight of esters (g)/ Weight of oil (g)

2.3. Design of experiment for the optimization of transesterification

The taguchi method is a structural approach for determining the best combination of inputs to produce a product which based on a Design of Experiments (DOE) methodology for determining parameter levels. Traditional Design of Experiments (DOE) focused on how different design factors affect the average result level [8, 9].

The best experimental conditions were determined by using taguchi method consisting three parameters and three levels. The basic parameters that are considered to affect the yield of production are methanol/oil molar ratio, catalyst concentration and reaction time. **Table 1** represents parameters and levels used for taguchi design method.

The taguchi method with an L9 orthogonal array was implemented to optimize the reaction parameters. Nine experiments which chosen to perform the experimental runs is shown in **Table 2**.

RESULTS AND DISCUSSION

3.1.Determination of optimal experimental condition by taguchi method

Each experiment was repeated two times to reduce error and average was considered. The mean yields of methyl ester under nine experimental conditions and signal to noise ratio are shown in **Table 3**. The signal to noise ratio (S/N) measures how to response varies to the nominal or target value under different noise conditions. In this analysis the case of “larger-the-better” was chosen. The mean values of S/N ratio obtained for each parameters at different levels are shown in **Table 4**. Based on the highest S/N ratio results, the maximum yield of methyl ester were 92.26% which obtained at 6:1 molar ratio, 1% wt catalyst and 5 h reaction time.

Transesterification reaction is reversible, therefore the yield of biodiesel was increased dramatically while the methanol/oil ratio was increased from 4:1 to 6:1. Farther increase resulted in lower yield. Based on **Table 3 and 4**, there is a direct relation between the amount of catalyst and oil conversion. Maximum amount of biodiesel obtained at level 2 (1%) since excess catalyst increase soap formation. It is clear that conversion rate increases with reaction time, hence 5 h was sufficient for completion of the reaction.

Analysis of Variance method (ANOVA) is used to quantitavely estimate the relative contribution and expressing it as a percentage [10]. The statistical analysis of ANOVA are given in **Table 5**. The ANOVA results indicate that the methanol/oil molar ratio is more effective than other parameters.

3.2. Fuel properties

It is important to know the basic properties of biodiesel before using it in to engine. Therefore, fuel properties were analyzed and compared with ASTM D6751 and EN 14214 standard methods.[11] Results are given in **Table 6**. As can be seen, biodiesel properties confirming the ASTM and EN specification.

Table 1: Parameters and levels used for taguchi design

Parameters	Level 1	Level 2	Level 3
Molar ratio (methanol/oil)-(A)	4:1	6:1	8:1
Catalyst concentration (wt%)-(B)	0.5	1	1.5
Reaction time (h)-(C)	1	3	5

Table 2: Orthogonal array L9 (3^3) of the experimental runs

Experiment number	A	B	C
1	1	1	1
2	1	2	2
3	1	3	3
4	2	1	2
5	2	2	3
6	2	3	1
7	3	1	3
8	3	2	1
9	3	3	2

Table 3: Mean yields of amygdalus Scoparia oil methyl ester and S/N ratio value

Experimental number	Mean yield	S/N ratio
1	81.63	38.2370
2	90.28	39.1118
3	87.32	38.8223
4	91.43	39.2218
5	92.26	39.3003
6	89.88	39.0733
7	90.37	39.1205

8	**88.64**	**38.9526**
9	**91.07**	**39.1875**

Table 4: Mean S/N ratio for the reaction parameters

Level	Parameter A	Parameter B	Parameter C
1	38.72	38.86	38.75
2	39.20	39.12	39.17
3	39.09	39.03	39.08

Table 5: methanol/oil molar ratio is more effective than other parameters.

Parameter	d.f	S.S	Contribution
Methanol/oil molar ratio	2	37.282	45.475%
Catalyst concentration (wt %)	2	10.217	12.462%
Time (h)	2	29.285	35.721%
Error		5.2	6.342%
Total		81.983	

Table 6: Characteristics of the amygdalus scoparia oil biodiesel

Characteristics	Unit	Measured value	Limits (ASTM)	Limits (EN)
Viscosity at 40^0C	mm^2/s	4.51	1.9-6.0	3.5-5.0
Density at 15^0C	g/cm^3	0.883	-	0.86-0.9
Flash point	^{0}C	137.5	130 min	120 min
Pour point	^{0}C	-10	-	-
Cetane number	-	52	51 min	47 min
Acid value	-	0.14	0.5 max	0.5 max

4. CONCLUSION

The influence of operation conditions (i.e. molar ratio of methanol to amygdalus Scoparia oil, catalyst concentration and reaction time) on the production of biodiesel via transesterification was analyzed. The taguchi method was employed to design experimental trials, with an ANOVA performed to analyze the relative importance of each parameter in the yield of biodiesel. It was observed that the optimum conditions for methanolysis of amygdalus Scoparia oil were 1% KOH as catalyst, methanol/oil molar ratio 6:1 for a period of 5 h. The yield of biodiesel under optimal conditions was 92.26%. The ANOVA analysis indicated that the contribution of molar ratio was larger than any other parameter. It was found that fuel properties met the ASTM D6751 and EN 14214 standards.

REFERENCES

[1] V. B. Borugadda and V. V Goud, “Biodiesel production from renewable feedstocks : Status and opportunities,” *Renew. Sustain. Energy Rev.*, vol. 16, no. 7, pp. 4763–4784, 2012.

[2] A. Abbaszaadeh, B. Ghobadian, M. R. Omidkhah, and G. Najafi, “Current biodiesel production technologies : A comparative review,” *Energy Convers. Manag.*, vol. 63, pp. 138–148, 2012.

[3] S. T. Keera, S. M. El Sabagh, and A. R. Taman, "Transesterification of vegetable oil to biodiesel fuel using alkaline catalyst," *Fuel*, vol. 90, no. 1, pp. 42–47, 2011.

[4] S. H. Shuit, Y. T. Ong, K. T. Lee, B. Subhash, and S. H. Tan, "Membrane technology as a promising alternative in biodiesel production : A review," *Biotechnol. Adv.*, vol. 30, no. 6, pp. 1364–1380, 2012.

[5] L. E. Rincón, J. J. Jaramillo, and C. a. Cardona, "Comparison of feedstocks and technologies for biodiesel production: An environmental and techno-economic evaluation," *Renew. Energy*, vol. 69, pp. 479–487, Sep. 2014.

[6] A. Talebian-kiakalaieh, N. Aishah, S. Amin, and H. Mazaheri, "A review on novel processes of biodiesel production from waste cooking oil," *Appl. Energy*, vol. 104, pp. 683–710, 2013.

[7] P. S. Dhote, V. N. Ganvir, Y. C. Bhattacharyulu, and P. Technology, "O PTIMIZATION OF M AHUA OIL M ETHYL E STER BY USING," vol. 6, no. 3, pp. 1140–1145, 2013.

[8] P. L. N. M. T. Student and D. C. K. Assistant, "Optimization of Effective Parameters of Pongamia Pinnata (Karanja) Biodiesel Using Taguchi Method," vol. 3, no. 4, pp. 701–706, 2013.

[9] C. Guerrero, J. Parra, and F. Sierra, "OPTIMIZATION OF BIODIESEL PRODUCTION PROCESS FOR HOMOGENEOUS CATALYSIS FROM USED COOKING OIL," no. 11, 2013.

[10] R. D. Gorle, D. B. Meshram, P. L. Naik, and V. S. Narnaware, "Optimization of Effective Parmeter of Jatropha Biodiesel Using Taguchi Method and Performance Analysis Using CI Engine," no. 5, pp. 46–52, 2013.

[11] M. Tariq, S. Ali, F. Ahmad, M. Ahmad, and M. Zafar, "Identi fi cation , FT-IR , NMR (1 H and 13 C) and GC / MS studies of fatty acid methyl esters in biodiesel from rocket seed oil," *Fuel Process. Technol.*, vol. 92, no. 3, pp. 336–341, 2011.