International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 07 July 2025, pp: 224-233 www.ijaem.net ISSN: 2395-5252

Optimization Study on Trans-esterification of Cottonseed Oil with Butyl Alcohol for Biodiesel Production Using Response Surface Methodology

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Date of Submission: 01-07-2025 Date of Acceptance: 10-07-2025

ABSTRACT: Cottonseed oil was extracted by solvent extraction method using N-hexane as an extracting solvent. Biodiesel was synthesized by transesterification of the oil with butanol using sodium hydroxide (NaOH) as catalyst. Influence of tranesterification process parameters including Catalyst concentration (wt%), Butanol/oil molar ratio, temperature, reaction time, and agitation speed on the yield of biodiesel were investigated and optimized using Central Composite Rotatory Design (CCRD) of Response Surface Methodology (RSM) and analysis of variance (ANOVA). Significance of different process parameters and their combined effects on the transesterification efficiency were established through a full factorial central composite design.The findings of the study agreed with results from studies on transesterification of the oil with other alcohols and for other vegetable oil. It was also in good agreement with various international standards for biodiesel fuel. Validation process perfomed based on the optimal conditions of Catalyst conc.(%wt oil) 0.5, Butanol/oil molar ratio, 19, Temperature (^{o}C), 40 and agitation speed (rpm), 300 achieved a yield of 75% which is in very close range with the predicted yield of 74.59% . Findings of this study showed that butyl alcohol is an alternative alcohol for the synthesis of biodiesel from cottonseed oil**.**

KEYWORDS: Butyl alcohol, Transesterification, Response Surface methodology, cotton seed oil, Biodiesel

I. INTRODUCTION

Extensive research into sustainable and renewable energy sources has been prompted by the rising global energy demand and environmental issues related to fossil fuels [1] .Because it is biodegradable, non-toxic, and emits less emissions than petroleum diesel, biodiesel a clean-burning alternative fuel made from renewable biological sources including vegetable oils, animal fats, and leftover cooking oils has become a viable option [2], [3].

It is a practical way to lessen dependency on traditional petroleum supplies because it can be utilized directly in standard diesel engines with little to no modification [4].The most popular process for producing biodiesel-transesterification, produces fatty acid alkyl esters (biodiesel) and glycerol by reacting triglycerides with an alcohol in the presence of a catalyst [5].

Although methanol and ethanol are commonly utilized alcohols in this process, research into other alcohols has been spurred by their drawbacks, which include high volatility, toxicity (methanol), and reduced energy density (ethanol). Butanol is a desirable substitute alcohol for transesterification because it has a larger energy content, is less volatile, and is less corrosive than methanol and ethanol [6].Research suggests that biodiesel made from butanol can provide better engine performance and lower emissions [7].

Cottonseed oil, a non-edible vegetable oil that is widely accessible because it is widely

International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 07 July 2025, pp: 224-233 www.ijaem.net ISSN: 2395-5252

cultivated, provides a sustainable and affordable feedstock for the manufacturing of biodiesel, thereby reducing the conflict between food and fuel [8].

However, a number of reaction parameters, such as the alcohol-to-oil molar ratio, catalyst concentration, reaction temperature,reaction time and mixing speed, have a substantial impact on effectiveness and economic feasibility the transesterification process [9].To maximize biodiesel yield and purity while lowering production costs, these factors must be optimized. Response Surface Methodology (RSM)- set of statistical and mathematical methods has shown promise as a tool for optimizing intricate procedures such as transesterification. RSM saves time and resources by enabling the simultaneous evaluation of several components, the identification of variable interactions, and the identification of optimal operating conditions with fewer experimental runs [10], [11]

The purpose of this study is to use Response Surface Methodology to optimize the transesterification of cottonseed oil with butanol for the manufacture of biodiesel. In particular, the impact of catalyst concentration, reaction temperature, reaction time, and butanol-to-oil molar ratio and agitation speed on the production and quality of biodiesel will be examined. The results obtained from this study will help create a more sustainable and effective method for turning cottonseed oil into butanol-based biodiesel.

II. MATERIALS AND METHODS`

2.1 Sample Collection

Cottonseeds were collected from Jatau Farms, Zaria, Kaduna state, Nigeria.. Laboratoy grade of Sodium hydroxide (NaOH), Sodium chlorde (NaCl), butyl alcohol (C_4H_7OH) with assay >99%,,sodium bisulphate (NaH_2SO4)with assay 97.5%, phenolphthalein indicatorwere purchased from Gerald Chemical Services Ltd, Ogbete Main Market.

2.2 Methods

2.2.1 Oil extraction

The seeds were washed and sun-dried for 72hrs and subsequently dried in an ovenset at a temperature of 130^{o}C where it was made to stand for 12hrs. The seeds were milled using Thomas Willey mill (Model ED-5). Oil was extracted by solvent extraction process using N- hexane as the extracting solvent

2.2.2 Characterization of extracted cottonseed oil.

The proximate compositions and physico-chemical properties of the oil were determined adopting the methods described by the Association of Official Analytical Chemists (AOAC, 2004)

2.2.3 Neutralization

The extracted cottonseed oil was heated in a flask to a temperature of 50^{o}C and 45% strong solution of sodium hydroxide (2M. Na0H) was introduced into the oil to neutralize the free fatty acid (FFA) content. While maintaining the temperature and agitation constant speed of 600rpm, progress of the neutralization reaction was monitored using phenolphthalein indicator. The neutralization was termed completed when, on introduction of phenolpthalin into a withdrawn sample, the color turned to pink. 20% of 1N solution of sodium chloride (1M .Nacl) heated to 90^{o}C was introduced into the neutralized oil and stirred. The mixture was transferred into a separating funnel and allowed to stand for 3hrs during which the mixture separated into two layers. The milk- colored lower layer was drained out while the upper layer was collected and washed with boiled water. The washing was continued and monitored with phenolphthalein indicator until the color did not turn to pink.

2.2.4. Dehydration

300g of neutralized oil was introduced into a beaker, weighed and put into an oven set at 100^{o}C to evaporate the moisture. Progress of dehydration was monitored by weighing the oil at time intervals of 30minutes until the weight remained constant. Thus oil loss in the process of neutralization and dehydration was estimated

2.2.5 Synthesis of biodiesel using butanol

The pre-treated cottonseed oil was reacted with butanol in the presence of NaOH to produce esters of fatty acids (biodiesel) and glycerol. The pe-treated cottonseed oil was precisely quantitatively transferred into a flat bottom flask placed on a hot magnetic stirrer. Specific amount of catalyst (by weight of cottonseed oil) dissolved in the required amount butanol was added. The reaction flask was kept on a hot magnetic stirrer under constant temperature with defined agitation speed throughout the reaction. At the defined time, the reaction mixture was withdrawn from the stirrer and allowed to cool overnight.The biodiesel (i.e. the ester in the upper layer) was separated from the by-product (i.e. the glycerol in the lower layer) by

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Volume 7, Issue 07 July 2025, pp: 224-233 www.ijaem.net ISSN: 2395-5252

settlement overnight under ambient condition. The percentage of the biodiesel yield was determined by comparing the mass of layer biodiesel with the mass of cottonseed oil used. The procedure was repeated by varying the factors affecting the transesterification reaction such as; time, catalyst concentration, temperature, alcohol/oil molar ratio and agitation speed.

$$Acid\ value\ (AV) = \frac{M*V*40}{W} \quad (1)$$

$$Y = 1 - \frac{AV_j}{AV_o} = 1 - \frac{V_j}{V_o} \quad (2)$$

Where M is molarity of NaOH, V is volume of NaOH, W is weight of cotton seed oil, AV_o and AV_j are the acid values of the mixture determined at the initial time (t=0) and later time t=j respectively while V_o and V_j are the corresponding volumes of NaOH(aq) used in the titration.

2.2.6 Characterization biodiesel from butanol

The ASTM D675- 08 (1986) [12], methods were used to determine the vital properties of the fuel such as Kinematic viscosity, Density, Pour point, Cetane number, Flash point and Acid number. The determinations were carried out at the PRODA LAB and Peace Oil Enugu. Most of the properties analyzed were used to determine the efficiency of a fuel for diesel engines. There are also other parameters which do not have direct bearing on the characteristic properties but are important for performance evaluations.

2.3 Modelling of Synthesis of biodiesel using butanol

The biodiesel production from cotton seed oil was modelled with response surface methodology (RSM) using design matrix generated by Design Expert version 9. The dependent variable is fractional conversion, (Yield) Y (%) while the independent variables are time (minutes), temperature (^oC), butanol/oil molar ratio,agitation speed (rpm) and catalyst concentration with a total of 32 experimental runs (Table 1).

2.4 Design of Experiment for Transesterification Reaction

Design Expert software (version 9) was used in this study to design the experiment and to optimize the reaction conditions. The experimental design employed in this work was a two-level-five factor fractional factorial design involving 32 experiments. Catalyst concentration, A, methanol/oil molar ratio, B, Reaction temperature, C, reaction time, D, and agitation speed, E were selected as independent factors for the optimization study. The response chosen was the butyl ester yields obtained from transesterification of cottonseed oil. Eight replications of centre points were used in order to predict a good estimation of errors and experiments were performed in a randomized order. The actual and coded levels of each factor are shown in Table 3.1 below. The coded values were designated by −1 (minimum), 0 (centre), +1 (maximum), −α and +α. Alpha is defined as a distance from the centre point which can be either inside or outside the range, with the maximum value of 2n/4, where n is the number of factors whereby the value of alpha is set at 0.5. It is noteworthy to point out that the software uses the concept of the coded values for the investigation of the significant terms, thus equation in coded values is used to study the effect of the variables on the response. The empirical equation is represented as:

$$Y = \beta_0 + \sum_{i=1}^{5} \beta_i X_i + \sum_{i=1}^{5} \beta_{ii} X^2{}_i + \sum_{i=1}^{5} \sum_{j=i+1}^{5} \beta_{ij} X_i X_j \quad (3)$$

Where β_0 is the intercept,β_i is the linear coefficient,β_{ii} is the squared coefficient, is the interaction coefficient, X_i and X_j are the factors.Selection of levels for each factor was based on the experiments performed to study the effects of process variables on the application of solid base catalysts for transesterification reaction of cottonseed oil.

2.5 Optimization of Transesterification using Central Composite Design

To optimize the transesterification of the cottonseed oil using butanol, Response Surface Methodology with Central Composite Design program was used to determine the optimum values of the process variables. The fractional factorial design was used to obtain a quadratic model, consisting of factorial trials to estimate quadratic effects. To examine the combined effect of the five respective factors (independent variables): catalyst concentration, butanol/oil molar ratio, reaction temperature, reaction time and agitation speed, on biodiesel yield and derive a model, a two-level-

International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 07 July 2025, pp: 224-233 www.ijaem.net ISSN: 2395-5252

five –factor (2^{5-1} + 2*5 + 6) Central Composite Response Design = 32 experiments were performed. The factors levels are shown in table 3.1. The matrix for the five variables was varied at two levels (-1 and +1). The lower level of variable was designated as "-1" and higher level as "+1". The experiments were performed in random order to avoid systematic error. Equations (5) represent the mathematical model relating the transesterification reaction using butanol with the independent process variables obtained with the Design Expert 9. The design of the experimental matrix of transesterification using butanol. The experimental and the predicted values, calculated by Equations (5), is presented in table 4. The response was expressed as % yield, calculated as

$\{(V_b)/V_o\}$ x 100 (4)

where V_o is the initial volume of oil and V_b is the volume of biodiesel produced.

Table 1 :Studied range of each factor in actual and coded form

Factor	Units	Low level	High level	-α	+α	0 level
Catalyst conc. (A)	Wt%	0.2(-1)	0.6(+1)	0.1(-2)	0.8(+2)	0.4
Butanol/oil ratio (B)	Mol/mol	18(-1)	20(+1)	16(-2)	24(+2)	18
Temperature, (C)	°C	35(-1)	45(+1)	30(-2)	50(+2)	40
Reaction time (D)	Hours	10(-1)	20(+1)	5(-2)	30(+2)	15
Agitation speed (E)	Rpm	250(-1)	350(+1)	200(-2)	400(+2)	300

III. RESULTS AND DISCUSSIONS

3.1 Characterization of the oil

Table 2: Physiochemical properties of the oil

Properties	Extracted(crude) Oil	Neutralized/Dehydrated Oil
Color	Reddish brown	Goilden Yellow
pH	4.82	7.0
Peroxide value (mEq/kg)	9.25	9.25
Viscosity (cp)	789	42.86
Acid Value (mgKOH/g)	11.32	0.20
Saponification Value	189	194
Free fatty acid	5.75	-
Idine Value (gI_2/100goil)	94.7	98.20
Moiture content (%)	7.21	-
Specific gravity	0.92	0.98

The results of the property evaluation of the extracted cottonseed oil and that of the further treated (neutralized and dehydrated) one is tabulated in Table 2. The colorshowed remarkable change from reddish brown to golden yellow color as a result of the neutralization and dehydration. The golden yellow color of the oil remained stable. The viscosity dropped from 789cP to 42.86cP. This is in trend with the drop-in acid value, moisture content and free fatty acid content. These drastically affected the specific gravity which appreciated from 0.91 to 0.98, the iodine value which improved from 74.90gI_2/100g oil to 98.20gI_2/100g oil and also the saponification value that increase from 189 to 194. These are attributable to the molecular condensation of the triglycerides following the loss of water molecules during dehydration and also loss of the free fatty acid converted to soap during neutralization. Obviously, the neutralization and dehydration processes imparted immensely on the iodine and saponification values of the oil.

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Table 3: Characterization of cotton seed oil, biodiesel from cotton seed oil and ASTM standard

PROPERTY	UNITS	ASTM METHODS	REFINED COTTONSEED OIL	ASTM LIMITS	COTTONSEED BIODIESEL
Density	kg/m^3	ASTM D-1298	912.1	830-880	867
Kinematics Viscosity	Cst	ASTM D-445		1.6-6.0	5.6
Flash Point	^oC	ASTM D-93		55	180
Pour Point	^oC	ASTM D-97		+15	-0.7
Cloud Point	^oC	ASTM D-2500			13
Acid Value	mgKOH/g	ASTM D-974	0.29	0.5	0.181
Low Heating Value	MJ/kg				40.1
Aniline Point	(^oC)	ASTMD4737			79.87
Higher Heating Value	MJ/Kg				43
Cetane number		ASTM D-130		47 min	55

3.2.2 Optimization of the process variables for biodiesel production

The design plan as shown in table 4 was used to optimize the yield of biodiesel production. The uncoded values of the test variables were used to optimize the variables namely catalyst concentration, methanol/oil molar ratio, reaction temperature, reaction time and agitation speed, and the predicted values of percentage yield were presented in Table 4

Table 4: Experimental Design Matrix For the Factorial Design of Biodiesel Production from Cotton Seed Oil using butanol.

Run	Catalyst concentration(A)	Alcool/oil molar ratio(B)	Reaction temperature(C)	Reaction temperature (D)	Agitation speed, (E)	Experimental Yield (Y)	Pred. Yield (Y)
	wt%	Minutes	^oC	mol/mol	rpm	(%)	(%)
1	0.3	10	35	18	350	60	60.51
2	0.6	10	35	18	250	63	62.09
3	0.3	20	35	18	250	57	57.09
4	0.6	20	35	18	350	62	61.84
5	0.3	10	45	18	250	54	53.84
6	0.6	10	45	18	350	62	61.59
7	0.3	20	45	18	350	68	68.59
8	0.6	20	45	18	250	58	57.18
9	0.3	10	35	20	250	60	59.01
10	0.6	10	35	20	350	59	57.76
11	0.3	20	35	20	350	58	57.76
12	0.6	20	35	20	250	55	53.34
13	0.3	10	45	20	350	56	55.51
14	0.6	10	45	20	250	65	63.09
15	0.3	20	45	20	250	60	59.09
16	0.6	20	45	20	350	65	63.84
17	0.15	15	40	19	300	64	63.56
18	0.75	15	40	19	300	63	65.89
19	0.45	5	40	19	300	60	61.56
20	0.45	25	40	19	300	62	62.89
21	0.45	15	30	19	300	63	64.06
22	0.45	15	50	19	300	66	67.39
23	0.45	15	40	17	300	67	66.39

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24	0.45	15	40	21	300	60	63.06
25	0.45	15	40	19	200	50	52.39
26	0.45	15	40	19	400	58	58.06
27	0.45	15	40	19	300	75	74.59
28	0.45	15	40	19	300	75	74.59
29	0.45	15	40	19	300	75	74.59
30	0.45	15	40	19	300	75	74.59
31	0.45	15	40	19	300	75	74.59
32	0.45	15	40	19	300	75	74.59

The percentage yield of biodiesel produced depends on the results if there is significant variation for combination of process parameters. The empirical relationship between yield (Y) and five variables in coded values obtained by using the statistical package Design-Expert 9 trial Version for determining the levels of factors which gives optimum percentage yield was given by the equation below. A quadratic regression equation that fitted the data is:

$$Y = 74.59+0.58A+0.33B+0.83C-0.83D+1.42E-1.37AB+0.50AC+0.25AD-0.23AE+1.50BC-0.50BD+1.75BE+0.88CD+0.63CE-1.38DE-2.47A^2-3.09B^2-2.22C^2-2.47D^2-4.84E^2 \quad (5)$$

Where Y is the response variable (percentage yield of biodiesel) and A-E are the coded values of the independent variables. The above equation represents the quantitative effect of the factors (A, B, C, D, and E) upon the response (Y). Coefficients with one factor represent the effect of that particular factor while the coefficients with more than one factor represent the interaction between those factors. Positive sign in front of the terms indicates synergistic effect while negative sign indicates antagonistic effect of the factor(Shahri and Niazi., 2015). The adequacy of the above proposed model was tested using the Design Expert sequential model sum of squares and the model test statistics.

3.2.3Statistical Analysis of Transesterification using Central Composite Design (CCD)

To optimize the transesterification of the cottonseed oil using butanol, Response Surface Methodology with Central Composite Design program was used to determine the optimum values of the process variables. The fractional factorial design was used to obtain a quadratic model, consisting of factorial trials to estimate quadratic effects. To examine the combined effect of the five respective factors (independent variables): catalyst concentration, methanol/oil molar ratio, reaction temperature, reaction time and agitation speed, on biodiesel yield and derive a model, a two-level-five –factor (2^{5-1} + 2*5 + 6) Central Composite Response Design = 32 experiments were performed. The factors levels are shown in table 3.1. The matrix for the five variables was varied at two levels (-1 and +1). The lower level of variable was designated as "-1" and higher level as "+1". The experiments were performed in random order to avoid systematic error. Equations (5) represent the mathematical model relating the transesterification reaction with the independent process variables obtained with the Design Expert 9. The design of the experimental matrix of transesterification. The experimental and the predicted values, calculated by Equations (5), is presented in table 4. The response was expressed as % yield, calculated as

$$\{(V_b)/V_o\} \times 100 \quad (6)$$

where V_o is the initial volume of oil and V_b is the volume of biodiesel produced.

3.2.4Model fitting

The design plan as shown in Table 4 was used to optimize the yield of biodiesel production. The coded and uncoded values of the test variables were used to optimize the variables namely catalyst concentration, butanol/oil molar ratio, reaction temperature, reaction time and agitation speed, and the experimental and predicted values of percentage yield were presented in table 4. The percentage yield of biodiesel produced depends on the results if there is significant variation for combination of process parameters. The empirical relationship between yield (Y) and five variables in coded values obtained by using the statistical package Design-Expert 9 trial Version for determining the levels of factors which gives optimum percentage yield was given by the equation below. A quadratic regression equation that fitted the data is:

$$Y = 74.59+0.58A+0.33B+0.83C-0.83D+1.42E-1.37AB+0.50AC+0.25AD-0.23AE+1.50BC-$$

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0.50BD+1.75BE+0.88CD+0.63CE-1.38DE-2.47 A^2-3.09B^2-2.22C^2-2.47D^2-4.84E^2 (7)

Where Y is the response variable (percentage yield of biodiesel) and A-E are the coded values of the independent variables. The above equation represents the quantitative effect of the factors (A, B, C, D, and E) upon the response (Y). Coefficients with one factor represent the effect of that particular factor while the coefficients with more than one factor represent the interaction between those factors. Positive sign in front of the terms indicates synergistic effect while negative sign indicates antagonistic effect of the factor[13]. The adequacy of the above proposed model was tested using the Design Expert sequential model sum of squares and the model test statistics.

Table 5:**Significance of regression coefficients the yield of biodiesel with butanol using the design-expert version 9 trial version.**

Source	**Coefficient estimate**	**Degree of freedom**	**Sum of square**	**F-value**	**P-value (Prob >F)**
Model	74.59	20	1413.46	17.27	< 0.0001
A	0.58	1	8.17	2.00	0.1854
B	0.33	1	2.67	0.65	0.4366
C	0.83	1	16.67	4.07	0.0686
D	-0.83	1	16.67	4.07	0.0686
E	1.42	1	48.17	11.77	0.0056
AB	-1.37	1	30.25	7.39	0.0200
AC	0.50	1	4.00	0.98	0.3440
AD	0.25	1	1.00	0.24	0.6308
AE	-0.23	1	1.00	0.24	0.6308
BC	1.50	1	36.00	8.80	0.0128
D	-0.50	1	4.00	0.98	0.3440
BE	1.75	1	49.00	11.98	0.0053
CD	0.88	1	12.25	2.99	0.1115
CE	0.63	1	6.25	1.53	0.2422
DE	-1.38	1	30.25	7.39	0.0200
A^2	-2.47	1	178.37	43.59	<0.0001
B^2	-3.09	1	280.24	68.49	<0.0001
C^2	-2.22	1	144.03	35.20	<0.0001
D^2	-2.47	1	178.37	43.59	< 0.0001
E^2	-4.84	1	687.41	168.01	<0.0001
Residual			**45.01**		
Cor. Total			**1458.47**		

Std. Dev. = 2.02; Mean = 63.28; C.V.% = 3.20; PRESS = 1119.60; R^2 = 0.9691; Adj. R^2 = 0.9130; Pred. R^2 = 0.9011; Adeq. Precision = 13.546

3.2.5 Analysis of variance (ANOVA)

The ANOVA results for the model terms are given in table 4.3c. Analysis of variance (ANOVA) was applied for estimating the significance of the model at 5% significance level and shown in table 4.3c. A model is considered significant if the p-value (significance probability value) is less than 0.05. From the p-values presented in table 4.3b, it can be stated that the linear term Eand interaction terms AB, BC, BE and DE and quadratic terms A^2, B^2, C^2, D^2, and E^2 are significant model terms implying that these variables impacted considerably on the yield of biodiesel from cotton seed oil.

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Based on this, the insignificant terms of the model were removed and the model reduced to the following equation:

$$Y = 74.59+1.42E-1.37AB+1.50BC+1.75BE-1.38DE-2.47A^2-3.09B^2-2.22C^2-2.47D^2-4.84E^2 \quad (8)$$

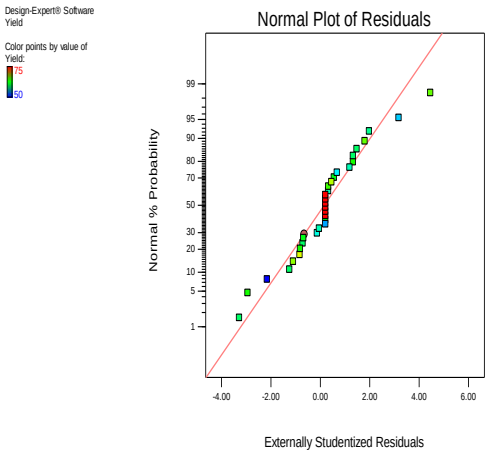

Figure 1: Plot of normal probability versus residuals for biodiesel yield.

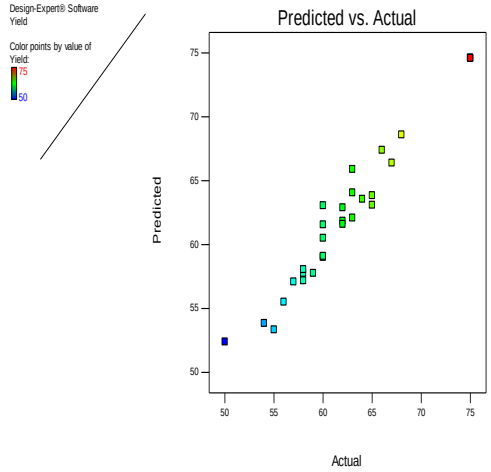

Figure 2: Plot of predicted values versus the actual experimental values for biodiesel yield .

The experimental data in table 4 were also analyzed to check the correlation between the experimental and predicted biodiesel yield and the normal probability and residual plot, and actual and predicted plot are shown in Figures 1 and 2 respectively. It can be seen from the Figures that the data points on the plot were reasonably distributed near to the straight line, indicating a good relationship between the experimental and predicted values of the response, and that the underlying assumptions of the above analysis were appropriate. The result also suggests that the selected quadratic model was adequate in predicting the response variables for the experimental data.

3.2.6. Three dimensional surface plots for biodiesel yield using butanol

The 3D response surface plots were generated to estimate the effect of the combinations of the independent variables on the biodiesel yield. The plots are shown in Figures 3, 4, 5 and 6. Figure 3 shows the dependency of yield on time and catalyst concentration. As can be seen from the figure, % biodiesel yield increases as both the butanol/oil molar ratioand catalyst concentration increases up to the mid point of these variables and then decreased. It is then observed in Figures 4, 5 and 6 that the % biodiesel yield increases with the combinations of the two independent variables up

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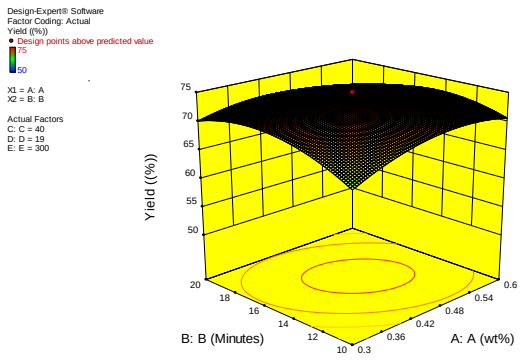
to the mid point values of the both variables and decreased.



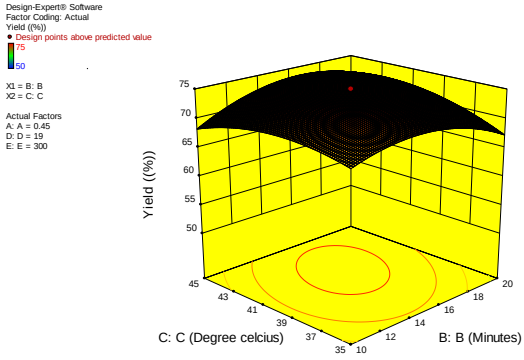
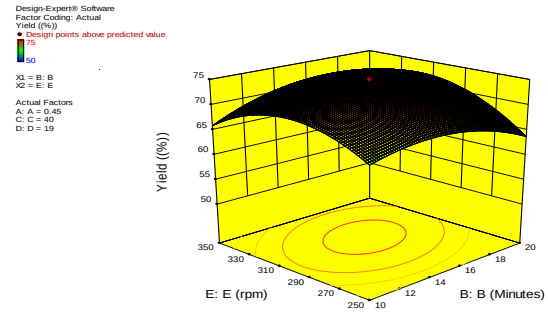


Figure 3: 3D Plot showing the effect time and catalyst concentration on the biodiesel yield Figure 4 : 3D Plot showing the effect of temperature and time on the biodiesel yield



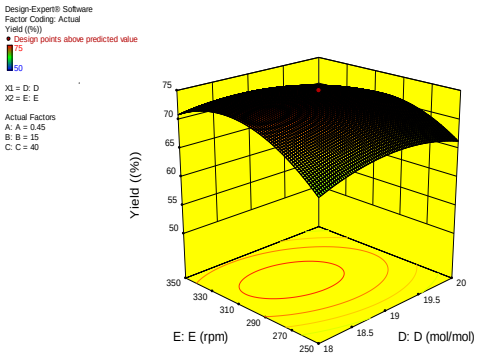


Figure 5: 3D Plot showing the effect of agitation speed and time on the biodiesel yield Figure 6: 3D Plot showing the effect of butanol/oil molar ratio and agitation speed on the biodiesel yield

A transesterification reaction under the obtained optimum operating conditions was carried out in order to evaluate the precision of the quadratic model; the experimental value and predicted values are shown in table 4.

Table 6: Results of the model validation (experiment 1 indicates the optimum reaction conditions and yield).

Experiment	Catalyst conc.(%wt oil) A	Butanoll/oil molar ratio B	Temperature (^{o}C) C	Time(Minutes) D	Agitation speed (rpm) E	Experimental Yield (%)	Predicted yield (%)
1	0.5	19	40	15	300	75	74.59

Comparing the experimental and predicted results, it can be seen that the error between the experimental and predicted is less than 0.6%, therefore it can be concluded that the generated model has sufficient accurancy to predict the amount of alkyl ester yield.

IV. CONCLUSION

This paper presented an investigation onoptimization of transesterification of cotton seed oil. The transesterification reaction parameters were optimized using response surface methodology (RSM). The parameters of the procedure (NaOH) catalyst concentration, temperature, reaction time, and butanol oil molar ratio were examined for the transesterification reaction. Aanalysis of variance (ANOVA) revealed that a desirable outcome was attained. Furthermore, a larger conversion rate was obtained by raising the temperature and NaOH concentration whereas time did not appear to have any discernible impact.The statistical modeladopted demonstrated a high

degree of agreement between calculated and experimental values (R^2 > 0.96), indicating the effectiveness of regression analysis as an optimization tool. According to the experimental findings, the ideal circumstance is as follows: ; 0.5% catalyst concentration, Moles of methanol to oil, 19:1; temperature, 40 °C; reaction time and mixing speed 300 rpm attaining a yield of 75%, thus indicating that transesterification of cottonseed oil with butyl alcohol would be a viable process for biodiesel production. However, engine performance investigation is hereby recommended for biodiesel produced by this process.

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