Data Article

Data on the derived mesoporous based catalyst for the synthesized of fatty acid methyl ester (FAME) from ternary oil blend: An optimization approach

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A R T I C L E   I N F O

Article history:
Received 14 February 2020
Revised 21 March 2020
Accepted 23 March 2020
Available online 22 April 2020

Keywords:
FAME
Citrullus lanatus
Musa acuminate
Calcination
Cucurbita pepo
Optimization

A B S T R A C T

This work presents datasets on fatty acid methyl ester (FAME) synthesized from the ternary blend of Cucurbita pepo-chrysophyllum albidum -papaya mix oils via methanolysis of mesoporous CaO heterogeneous catalyst derived from the mixture of Citrullus lanatus and Musa acuminate peels. The oils were extracted from the milled powderized using the solvent extraction method. Ternary oil mixed ratio of 33:33:34 with low acid value and density was achieved using simplex lattice design software. Characterization of the mixed calcined catalyst powder (MCCP) at 700 °C for 4 h was carried out using scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), X-ray diffraction analysis (XRD), and BET analysis. The thermal decomposition of mixed calcined catalyst powder (MCCP) produced 78.74% CaO with a strong basic site of 143 (μmole.g⁻¹). Fatty acid methyl ester (FAME) was synthesized through the based catalyst transesterification of a derived catalyst by considering four variables data (reaction time, reaction temperature, catalyst amount and methanol/oil molar ratio) using response surface methodology (RSM). The maximum experimental FAME data of 94.29 (wt. %) was achieved at run 16, but the central

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https://doi.org/10.1016/j.dib.2020.105514
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Specifications Table

| Subject | Material Science Engineering |
|---------|-----------------------------|
| Specific subject area | Renewable and Sustainable Energy |
| Type of data | Table, Figure |
| How data were acquired | A ternary mixture of oil was acquired through a simplex lattice mixture design. The significance of the variables was confirmed through analysis of variance (ANOVA) table. Physicochemical properties of the ternary blended oil and FAME produced were determined via AOAC (1997) standard method, iodine value was determined through Wij’s method [1]. The developed catalyst from the mixture of calcined Citrullus lanatus and Musa acuminate peels were characterized using SEM, EDS, XRD, and BET analysis. Experimental design and process optimization route of converting the blended oil to FAME was achieved through the simplex lattice and central composite experimental design. Catalyst activities, reactor wall accumulation, and catalyst purification were performed through catalyst reusability tests. The produced FAME fuel properties were confirmed by comparing with [2] and [3] biodiesel recommended standard. |

Data format

| Parameters for data collection | Raw, Analyzed |
| Description of data collection | Oils were extracted from the powders through the soxhlet extractor using n-hexane as solvent. Excess n-hexane in the oil was recycled using a rotatory evaporator [4]. The ternary oil blend was achieved by experimental design using a simplex lattice mixture (Raw data); the mixture of the three oils was varied in five level-three factors design, and the response variables were the viscosity and acid value [7, 8, 9, 10, 11]. Citrullus lanatus and Musa acuminate peels were oven-dried to constant weight at 110 °C for 3 h using an electrical oven (model DHG-9101-02). The dried samples were milled and then separated into a particle size of 0.30 mm powders [5]. The fine powders were mixed in ratio 1:1, and then calcined at 700 °C for 4 h in a furnace with box-type resistance (model SX-5-12 with maximum control temperature of 1200 °C, 5 KW power rate). The calcined catalyst was then characterized by SEM, EDS, FTIR, and BET isothermal sorption (QUANTACHROME, 1 KE). |

(continued on next page)
Since the acid value (FFA < 1.50) of the blended oil was within the range of successful transesterification by a based catalyst, therefore, biodiesel was synthesized through the process route earlier adopted by [6] with few modifications. Catalyst reusability was stopped after 3rd usage due to a reduction in catalyst activity. The physicochemical properties of the blended oil and FAME produced were determined using the standard method of AOAC. The dataset obtained were compared with the biodiesel standard.

Data source location
Department of Chemical & Petrochemical Engineering, Akwa Ibom State University, Ikot Akpaden, Mkpat Enin L.G.A., Akwa Ibom State, Nigeria.

Data accessibility
With the article

Value of the Data

- Data on blend ratio can be used for the mixing of oils in the laboratory or industrial applications.
- Data on biodiesel synthesized can be modeled and optimized to examine the effect of variables on FAME yield.
- Data will show authors in the field of engineering that calcined mixed Citrullus lanatus and Musa acuminate peels powder can produce an active CaO based catalyst for successful transesterification of oil to FAME.
- Dataset obtained shows that both calcined Citrullus lanatus and Musa acuminate peels powder can be used as a catalyst for FAME synthesized, but it mixed produced higher CaO conversion.
- Data on the physicochemical properties of the mixed oil and FAME produced shows that the produced FAME can serve as an alternative to conventional diesel.

1. Data

The dataset in this article describes the oil blend ratio which was carried out through simplex lattice design (expert 6.0.8 trial version) with three-factors (oils)-five levels design. Table 1a and 1b shows the factors, the level and the results of the 16 experimental runs with response variables' (density and acid value), these values were used in the laboratory to obtain the experimental biodiesel yield. Table 2a and 2b shows the data on the ANOVA for a mixture of a cubic model as well as the point prediction, this was obtained through statistical analysis by a simplex lattice. Eqs. (1) and (2) showed the final equation in terms of real component generated by a design expert to show the density (d) and the acid value (AV) relationship with the variables data. Fig. 1(a-b) describes the ternary model blend ratio generated through the optimization technique of the design expert. Fig. 2(a) describes the results of the SEM used to determine the morphological characteristic of the derived catalyst, while Fig. 2b shows the FTIR used to confirm the presence of functional groups and verify the presence of characteristic absorption bands of CaO (Table 1c). Table 3 shows the data obtained for the BET surface, basicity, total pore

Table 1a
Five level three factors experimental design for oil blend.

| Variable | Units | Symbol | Levels | -2  | -1  | 0     | 1     | 2     |
|----------|-------|--------|--------|-----|-----|-------|-------|-------|
| CPO      | (ml)  | X₁     | 0      | 0.16667 | 0.3333 | 0.66667 | 1.0000 |
| CAO      | (ml)  | X₂     | 0      | 0.16667 | 0.3333 | 0.66667 | 1.0000 |
| PO       | (ml)  | X₃     | 0      | 0.16667 | 0.3333 | 0.66667 | 1.0000 |
Table 1b
Experimental runs with the response variables.

| R  | CPO | CAO | PO | CPO | CAO | PO | D (kg/m³) | AV (mg KOH/g oil) |
|----|-----|-----|----|-----|-----|----|-----------|-------------------|
| 2  | 1.0000 | 0.0000 | 0.00 | 100.0000 | 0.0000 | 0.00 | 918.00 | 0.53 |
| 9  | 0.6667 | 0.3333 | 0.00 | 66.6667 | 33.3333 | 0.0000 | 903.00 | 1.63 |
| 13 | 0.6667 | 0.0000 | 0.3333 | 66.6667 | 0.0000 | 33.3333 | 911.00 | 1.72 |
| 16 | 0.3333 | 0.6667 | 0.0000 | 33.3333 | 66.6667 | 0.0000 | 901.00 | 1.80 |
| 15 | 0.3333 | 0.3333 | 0.3333 | 33.3333 | 33.3333 | 33.3333 | 907.00 | 1.81 |
| 12 | 0.3333 | 0.0000 | 0.6667 | 33.3333 | 0.0000 | 66.6667 | 910.00 | 1.61 |
| 3  | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 100.0000 | 0.0000 | 890.00 | 3.02 |
| 10 | 0.0000 | 0.6667 | 0.3333 | 0.0000 | 66.6667 | 33.3333 | 908.00 | 2.07 |
| 6  | 0.0000 | 0.3333 | 0.6667 | 0.0000 | 33.3333 | 66.6667 | 906.00 | 2.18 |
| 8  | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 100.0000 | 920.00 | 2.61 |
| 14 | 0.6667 | 0.1700 | 0.1667 | 66.6667 | 16.6667 | 16.6667 | 907.00 | 1.82 |
| 5  | 0.1667 | 0.6667 | 0.1667 | 66.6667 | 16.6667 | 16.6667 | 907.00 | 1.88 |
| 4  | 0.1667 | 0.1667 | 0.6667 | 16.6667 | 16.6667 | 66.6667 | 908.00 | 1.86 |
| 7  | 1.0000 | 0.0000 | 0.0000 | 100.0000 | 0.0000 | 0.0000 | 918.00 | 0.53 |
| 1  | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 100.0000 | 0.0000 | 890.00 | 3.02 |
| 11 | 0.0000 | 0.0000 | 1.0000 | 0.0000 | 0.0000 | 100.0000 | 920.00 | 2.61 |

R= runs, V= viscosity, D = density and AV = acid value

Table 1c
Peak assignment in the spectrum.

| Wavelength (cm⁻¹) | Transmittance | Functional group | Peak assignment |
|-------------------|---------------|-----------------|-----------------|
| 1036.2 to 1442.5  | 44.962 to 76.401 | Bending vibration of | C-H for sp³ carbon, |
| 1555.5 to 1636.3  | 63.439 to 66.145 | O-Ca-O group. | C=O for sp² carbon |
| 2922.6 to 3338.7  | 74.179 to 53.157 | Presence of O-H of | carboxylic acid and C-H |
|                   |               | Presence of sp² in | aldehyde/ketone and ester |

Fig. 1. Plots of ternary model blend of oils.

volume, and the percentage composition of CaO obtained by EDX-nitrogen adsorption-CO2 TPD from the calcined catalysts (Citruslanus, Musa acuminate peels, and the mixed). The experimental design factor, the coded level, the experimental, the predicted and the residual data are presented in Table 4a. These datasets are used for experimental modeling and statistical analysis through CCD. Table 4b describes the results of the tests of a significant and fit statistic obtained through statistical optimization, while the final equation in terms of the coded value based on a
dataset that relates the response FAME with the variable data generated through the polynomial quadratic model are presented in Eq. (3). The results of the relationship between the predicted and experimental yield as well as the Box-cox plot for power transformation are presented in Fig. 3(a-b). These plots were used to know the difference between the real experimental value and the predicted value by the design expert. Fig. 4 (a-f) shows the three-dimensional interactive effect of data variables ($P_1P_2; P_1P_3; P_1P_4; P_2P_3; P_2P_4$ or $P_3P_4$) on the output (FAME), the plots explained the relationship that exists between the interaction of the variable factors on the response of FAME. Table 5 describes the qualities of the FAME and the blended oil obtained from a ternary mix of Cucurbita pepo oil (CPO), Chrysophyllum albidum oil (CAO) and Papaya oil (PO).

$$D = 918.43X_1 + 890.46X_2 + 920.37X_3 - 11.28X_1X_2 - 39.97X_1X_3 + 8.63X_2X_2 + 56.69X_1X_2$$

$$- 44.48X_1X_2(X_1 - X_2) + 7.28X_1X_3(X_1 - X_3) + 78.76X_3X_2(X_2 - X_3)$$

(1)

Fig. 2. (a) SEM image of a catalyst at different magnification. (b) FTIR analysis of the catalyst.
Fig. 2. Continued

Table 2a
ANOVA for a mixture of cubic model.

| Source       | Sum of squares | df | Mean square | F value | Prob > F |
|--------------|----------------|----|-------------|---------|----------|
| Source       | D AV           | D  |             |         |          |
| Model        | 1233.92        | 9  | 137.10      | 6.366 × 10⁻⁷  | < 0.0001 |
| LM           | 988.87         | 2  | 494.44      | 6.366 × 10⁻⁷  | < 0.0001 |
| X₁X₂         | 8.57           | 1  | 8.57        | 6.366 × 10⁻⁷  | < 0.0001 |
| X₁X₃         | 107.68         | 1  | 107.68      | 6.366 × 10⁻⁷  | < 0.0001 |
| X₂X₃         | 5.02           | 1  | 5.02        | 6.366 × 10⁻⁷  | < 0.0001 |
| X₁X₂X₃       | 3.90           | 1  | 3.90        | 6.366 × 10⁻⁷  | < 0.0001 |
| X₁X₂(X₁-X₂)  | 28.80          | 1  | 28.80       | 6.366 × 10⁻⁷  | < 0.0001 |
| X₁X₃(X₁-X₃)  | 0.77           | 1  | 0.77        | 6.366 × 10⁻⁷  | < 0.0001 |
| X₂X₃(X₂-X₃)  | 90.31          | 1  | 90.31       | 6.366 × 10⁻⁷  | < 0.0001 |

LM = linear mixture, D = density, AV = acid value

Table 2b
Point prediction.

| Name       | Prediction | SE Mean | 95% CI low | 95% CI high | SE pred. | 95% PI low | 1.81 |
|------------|------------|---------|------------|-------------|----------|------------|------|
| Acid value | 1.81       | 0.00    | 1.81       | 1.81        | 0.00     | 1.81       | 1.81 |
| Density    | 907.13     | 0.00    | 907.13     | 907.13      | 0.00     | 907.13     | 907.13 |

Component

| Name | Level | Low level | High level | Std. Dev |
|------|-------|-----------|------------|----------|
| X₁   | CPO   | 0.33      | 1.00       | 0.00     |
| X₂   | CAO   | 0.33      | 1.00       | 0.00     |
| X₃   | PO    | 0.34      | 1.00       | 0.00     |

Final equations in term of real component:

Table 3a
Experimental design for FAME synthesized.

| Variables          | Units                | Symbol | Levels |
|--------------------|----------------------|--------|--------|
| -2                 | -1                  | 0      | 1      | 2      |
| Reaction time      | (min)                | P₂     | 50     | 55     | 60     | 65     | 70     |
| MCCP amount        | (wt.%)               | P₂     | 3.0    | 3.5    | 4.0    | 4.5    | 5.0    |
| Reaction temp.     | (°C)                 | P₃     | 60     | 65     | 70     | 75     | 80     |
| MeOH/OMR           | (ml/ml)              | P₄     | 3      | 4      | 5      | 6      | 7      |

MeOH/OMR = Methanol/oil molar ratio
Fig. 3. (a) Predicted against Actual. (b) Box-cox plot for power transformation.
Fig. 4. (a-f): 3-D's plots.
Table 3b
Pro-catalytic activity of catalysts calcined at 700 °C for 4 h

| Catalysts | BET (m²g⁻¹) | Total pore volume (cm³g⁻¹) | %CaO | BS (μmole.g⁻¹) | TBS | BSD (μmole.m⁻²) |
|-----------|-------------|-----------------------------|-------|----------------|-----|----------------|
| CCL       | 0.80        | 5 × 10⁻³                    | 74.60 | -              | 30  | 146            | 182.50 |
| CMA       | 0.80        | 5 × 10⁻³                    | 62.80 | -              | 22  | 102            | 155.00 |
| MCCP      | 1.00        | 5 × 10⁻³                    | 78.74 | 8              | 32  | 143            | 183.00 |

BS = Basic site, TBS = Total basic site, BSD = Basic site density = TBS/N₂- AA, CCL = Calcined Citrullus lanatus, CMA = Calcined Musa acuminate, MCCP = Mixed calcined catalyst powder

Table 4a
FAME result of experimental run, predicted and the residual value

| Std | Run | Block | P₁ | P₂ | P₃ | P₄ | FAME (wt. %) | Predicted FAME (wt. %) | Residual |
|-----|-----|-------|----|----|----|----|--------------|------------------------|----------|
| 1   | 12  | 1     | -1.000 | -1.000 | -1.000 | -1.000 | 83.90 | 83.99 | -0.094 |
| 2   | 3   | 1     | 1.000  | -1.000 | -1.000 | -1.000 | 83.90 | 84.01 | -0.011 |
| 3   | 6   | 1     | -1.000 | 1.000  | -1.000 | -1.000 | 88.24 | 88.34 | -0.010 |
| 4   | 30  | 1     | 1.000  | 1.000  | -1.000 | -1.000 | 87.90 | 87.95 | -0.004 |
| 5   | 28  | 1     | -1.000 | -1.000 | 1.000  | -1.000 | 87.74 | 87.75 | -0.003 |
| 6   | 2   | 1     | 1.000  | -1.000 | 1.000  | -1.000 | 89.27 | 89.37 | -0.005 |
| 7   | 29  | 1     | -1.000 | 1.000  | 1.000  | -1.000 | 91.09 | 91.19 | -0.005 |
| 8   | 4   | 1     | 1.000  | 1.000  | 1.000  | -1.000 | 92.29 | 92.39 | -0.010 |
| 9   | 22  | 1     | -1.000 | -1.000 | -1.000 | 1.000  | 84.42 | 84.20 | 0.22 |
| 10  | 19  | 1     | 1.000  | -1.000 | -1.000 | 1.000  | 88.21 | 87.93 | 0.28 |
| 11  | 11  | 1     | -1.000 | -1.000 | -1.000 | 1.000  | 90.92 | 90.64 | 0.28 |
| 12  | 20  | 1     | 1.000  | 1.000  | -1.000 | 1.000  | 94.10 | 93.97 | 0.13 |
| 13  | 23  | 1     | -1.000 | -1.000 | -1.000 | 1.000  | 83.79 | 83.56 | 0.23 |
| 14  | 1   | 1     | 1.000  | -1.000 | 1.000  | 1.000  | 89.11 | 88.99 | 0.22 |
| 15  | 8   | 1     | -1.000 | 1.000  | 1.000  | 1.000  | 89.31 | 89.08 | 0.23 |
| **16** | **5** | **1** | **1.000** | **1.000** | **1.000** | **1.000** | **94.29** | **94.01** | **0.28** |
| 17  | 7   | 1     | -2.000 | 0.000  | 0.000  | 0.000  | 84.50 | 84.68 | -0.18 |
| 18  | 10  | 1     | 2.000  | 0.000  | 0.000  | 0.000  | 89.49 | 89.62 | -0.13 |
| 19  | 27  | 1     | 0.000  | -2.000 | 0.000  | 0.000  | 80.34 | 80.51 | -0.17 |
| 20  | 14  | 1     | 0.000  | 2.000  | 0.000  | 0.000  | 89.85 | 89.98 | -0.13 |
| 21  | 15  | 1     | 0.000  | 0.000  | -2.000 | 0.000  | 89.92 | 90.05 | -0.13 |
| 22  | 26  | 1     | 0.000  | 0.000  | 2.000  | 0.000  | 93.68 | 93.85 | -0.17 |
| 23  | 18  | 1     | 0.000  | 0.000  | 0.000  | -2.000 | 89.54 | 89.06 | 0.48 |
| 24  | 13  | 1     | 0.000  | 0.000  | 0.000  | 2.000  | 90.10 | 90.88 | -0.78 |
| 25  | 25  | 1     | 0.000  | 0.000  | 0.000  | 0.000  | 90.20 | 90.13 | 0.075 |
| 26  | 21  | 1     | 0.000  | 0.000  | 0.000  | 0.000  | 90.10 | 90.13 | 0.025 |
| 27  | 24  | 1     | 0.000  | 0.000  | 0.000  | 0.000  | 90.12 | 90.13 | -0.005 |
| 28  | 17  | 1     | 0.000  | 0.000  | 0.000  | 0.000  | 90.11 | 90.13 | -0.015 |
| 29  | 16  | 1     | 0.000  | 0.000  | 0.000  | 0.000  | 90.12 | 90.13 | -0.094 |
| 30  | 9   | 1     | 0.000  | 0.000  | 0.000  | 0.000  | 90.10 | 90.13 | -0.025 |

\[ AV = 0.53X_1 + 3.02 + 2.61X_3 - 0.25X_1X_2 \mp 0.44X_1X_3 - 3.11X_2X_2 + 2.23X_1X_3X_2 + 4.44X_1X_2(X_1 - X_2) + 5.44X_1X_3(X_1 - X_3) - 1.64X_2X_2(X_2 - X_3) \]  \hspace{1cm} (2)

Final equation in term of coded

\[ \text{FAME} = + 0.13 + 0.13X_1 + 2.37X_2 + 0.95X_3 + 0.46X_4 - 0.10X_1X_2 + 0.40X_1X_3 + 0.93X_1X_4 - 0.23X_2X_3 + 0.52X_2X_4 - 1.10X_2X_3 - 0.74X_1^2 - 1.22X_2^2 + 0.46X_3^2 - 0.038X_4^2 \]  \hspace{1cm} (3)
Table 4b
Test of significance for every regression coefficient

| Source         | Sum of squares | df | Mean Square | F-value | P-value |
|----------------|----------------|----|-------------|---------|---------|
| Model          | 303.37         | 14 | 21.67       | 215.57  | < 0.0001|
| $P_1$          | 36.61          | 1  | 36.61       | 364.15  | < 0.0001|
| $P_2$          | 134.52         | 1  | 134.52      | 1338.23 | < 0.0001|
| $P_3$          | 21.70          | 1  | 21.70       | 215.85  | < 0.0001|
| $P_4$          | 4.99           | 1  | 4.99        | 49.61   | < 0.0001|
| $P_5$          | 15.21          | 1  | 15.21       | 151.28  | < 0.0001|
| $P_6$          | 40.80          | 1  | 40.80       | 405.85  | < 0.0001|
| $P_7$          | 5.72           | 1  | 5.72        | 56.90   | < 0.0001|
| $P_8$          | 0.040          | 1  | 0.040       | 0.40    | 0.5361  |
| $P_9$          | 0.16           | 1  | 0.16        | 1.63    | 0.2209  |
| $P_{10}$       | 2.56           | 1  | 2.56        | 25.47   | 0.0001  |
| $P_{11}$       | 13.84          | 1  | 13.84       | 137.67  | < 0.0001|
| $P_{12}$       | 0.84           | 1  | 0.84        | 8.33    | 0.0113  |
| $P_{13}$       | 4.39           | 1  | 4.39        | 43.66   | < 0.0001|
| $P_{14}$       | 19.36          | 1  | 19.36       | 192.60  | < 0.0001|
| Residual       | 1.51           | 15 | 0.10        | -       | -       |
| Lack of Fit    | 1.50           | 10 | 0.15        | 104.94  | 0.3072  |
| Pure Error     | 0.00715        | 5  | 0.0014      | -       | -       |
| Cor Total      | 304.88         | 29 |             |         |         |

Fits statistics

- R squared: 99.51%
- Adjusted R squared: 99.04%
- Predicted R squared: 97.16%
- Adequate precision: 60.219

Table 5
Properties of TMO and FAME.

| Parameter                        | TMO       | FAME      | ASTM D6751 | EN 14214 [1] |
|----------------------------------|-----------|-----------|------------|--------------|
| Density (kg/m³) @ 25 °C          | 907       | 886       | -          | 860-900      |
| Viscosity @ 40 °C (mm²/s)        | 4.40      | 2.10      | 1.9-6.0    | 3.5-5.0      |
| Moisture content (%)             | 0.002     | 0.001     | -0.03      | 0.02         |
| %FFA (as oleic acid)             | 0.90      | 0.40      | 0.40 max   | 0.25 max     |
| Acid value (mg KOH/g oil)        | 1.80      | 0.20      | 0.80 max   | 0.5 max      |
| Iodine value (g I₂/100g oil)     | 98.20     | 80.52     | -          | 120 max      |
| Saponification value (mg KOH/g oil) | 172.00  | 140.20    | -          | -            |
| Peroxide value (meq O₂/2kg oil)  | 10.20     | 11.21     | -          | 12.85        |
| HHV (MJ/kg)                      | 40.91     | 42.47     | -          | -            |
| Cetane number                    | 55.93     | 67.10     | 57 min     | 51 min       |
| API                              | 24.51     | 28.21     | 39.95 max  | -            |
| Diesel index                     | 63.76     | 79.31     | 50.4 min   | -            |

TMO = Ternary mixed oil

2. Experimental Design, Materials, and Methods

Response surface methodology (Simplex lattice design) and central composite design (expert 6.0.8 trial version) were employed to determine the blend ratio and the effects of variation of reaction time, catalyst amount, reaction temperature and methanol to oil molar ratio on the FAME synthesized. Materials used include CH₃OH, Ethanol, Sulphuric acid, Wij’s solution, etc. (Chemis-Sciences Nig. Ltd.), Cucurbita pepo-Chrysophyllum albidum-papaya seeds, Citrullus lanatus and Musa acuminate peels. Equipment used are scanning electron microscopy (SEM) to examine the surface morphology of the calcined catalysts (CaO) derived from the mixture of Citrullus lanatus and Musa acuminate peels calcined powder, energy dispersive spectroscope for determination
of elemental analysis of the samples and the quantitative composition of the catalysts, X-ray diffraction analysis equipped with Kα and Cu radiation source, accelerated at 20 mA and 40 kV used to determine the angular scanning electron performed in the range of 20° <2θ <80° at speed of 2 °C min−1, Fourier transform infrared spectroscopy used for determination of the presence of functional group and verify the presence of characteristic absorption bands of CaO, and QUANTACHROME, 1 KE, BET isothermal sorption was used to determination of the surface area of the catalysts through N2-adsorption CO2 TPD thermal.

Cucurbita pepo-Chrysophyllum albidum-papaya seeds were washed with deionized water to remove dirt’s, sun dried for 15 days until a constant weight was achieved before milled to powders.

The solvent extraction method by the Soxhlet apparatus was used for oil extraction from the powders. 100 g each powder was measured, tightly placed in a muslin bag, and the solvent, n-hexane was measured into the round bottom flask of Soxhlet extractor. A 4-place combo heating mantle unit was loaded with four 500 ml capacity Soxhlet extractors. The reaction time was 60 min and the heating temperature was adjusted to the temperature range of 68-70 °C. At the end of the reaction, excess n-hexane in the extracted oil was recycled using an evaporator. The percentage of oil-free of n-hexane was determined using the ratio of the Eq. (4)

\[
\text{Oil yield} \% (v/v) = \frac{W_{\text{oil}}}{W_{\text{powder}}} \times 100
\]  

(4)

Ternary oil blend was carried out by using three variables (Cucurbita pepo oil, Chrysophyllum albidum oil, and papaya oil) as input factors and two response variables (density and acid value). The simplex lattice design predicted a ratio of 33:33:34 ternary blend, this was used for oil mixed and the oil was kept in the jar.

Citrus lanatus and Musa acuminate peels were washed to remove dirt, then oven-dried to constant weight in an electrical oven. The dried peels were milled into powders, separated into smaller particle sizes using a mesh shaker (mesh size: 125 mm-20 μm) to aid calcination. Each of the powder and the blend (100 g Citrus lanatus peel powder + 100 g Musa acuminate peel powder) were calcined at 700 °C for 4 h in an electrical furnace. After cooling, the calcined powders were characterized using scanning electron microscopy, energy dispersive spectroscopy, X-ray diffraction analysis equipped with Kα and Cu radiation source, accelerated at 20 mA and 30 kV, with angular scanning electron performed in the range of 20° <2θ <80° at speed of 2 °C min−1, Fourier transform infrared spectroscopy, and BET isothermal adsorption and Hammett indicator method [12].

For FAME synthesized, the predicted acid value of 1.81 mg KOH/g oil was validated as 1.80 mg KOH/g oil (FFA = 0.90) through the design, the ternary mixture of the oil (TMO) containing 33:33:34 of PO: CAO: PO blend meets the require conditions for biodiesel production via transesterification with catalyzed methanolysis of derived based catalyst CaO (d-CaO). FAME was synthesized through the procedure employed by [12] with little modifications on data factor varied and catalyst reusability steps as follows: A three-necked-reactor was used to carry out the FAME production, a total of thirty experimental runs was generated and carried out via four variable factors were considered namely; reaction time of 50-70 min, MCCP amount 3.0-5.0 (wt.), reaction temperature of 60-80 °C, and MeOH/OMR of 3-7, respectively. Initially, 80 ml of the oil was preheated at 60 °C for 1 h, a measured catalyst amount was added to a measured volume of methanol in 250 ml flask, heated at 65 °C for 20 min, and then transferred into the preheated oil in the reactor, and the reaction was monitored for a period of time until it reaches completion. At the end of the reaction, the catalyst was separated by decantation and the biodiesel phase was separated from the methanol phase by separating funnel. The leach catalyst in the biodiesel was removed by washing with a mixture of 2.0 g NaCO3 and 40 ml ethanol thermally heated for 2 h under agitation. The mixture was filtered, washed with distilled water trice before the separation of biodiesel through gravity settling was carried out. Washed biodiesel was then dried over anhydrous Na2SO4, and then separated by filtration to obtain pure biodiesel (FAME).

For catalyst reusability, the derived CaO was recycled for reuse at the end of the reaction with reduction in the 4th, 5th and 6th cycle. Hence, the catalyst reusability was stopped after
3rd usage. For experimental design for FAME synthesized, a central composite design was used to generate a total of 30 (thirty) experimental runs, which includes the plus and minus axial points, plus and minus factorial points and the central-point with factors low and high entered in terms of alpha. For every combination of categorical factor levels, central composite design was duplicated.

The density, viscosity, the moisture content, acid value, the iodine value, and the peroxide value of the mixed oil were higher than the FAME values confirming that the synthesized product is consistent with biodiesel and that the conversion of mixed oil to FAME was complete with negligible resistance to flow and reduce internal drag in engine.

The ternary mixed ratio of oil is shown in Table 1b and Fig. 1. The SEM image and FTIR of the calcined catalysts and the mixed catalyst are shown in Fig. 2(a-b). Compositions of the calcined catalyst by XRD and BET sorption are listed in Table 3. Variable factors, the experimental yield, and the predicted value data for FAME are illustrated in Table 4a, while the test of significant and fits statistics by CCD optimization are shown in Table 4b. Fig. 4(a-b), displayed the predicted against the actual FAME yield, as well as the three-dimensional plots that exist between the four factors and the FAME response. Table 5 provides the properties of the ternary mixed oil (TMO) and the FAME produced.

Acknowledgments

The authors would like to thank the Technologist, Chemical Engineering Department, Akwa Ibom State University, Nigeria for the assistance provided during the research work.

Conflict of interest

The authors declare that they have no competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

No financial institution. This research work receives no financial support from either Institution or government organization.

Supplementary material

Supplementary material associated with this article can be found, in the online version, at doi: 10.1016/j.dib.2020.105514.

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