HENSARD JOURNAL OF ENVIRONMENT

HJ

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Synthesis, Characterization, and Reported Catalytic Performance of a Dog Bone-Derived Material for Biodiesel Production

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Academic Editor: Professor Rashid

Received: 02-05-2026
Revised: 25-10-2026
Accepted: 02-11-2026
Published: 05-11-2026

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Abstract

This paper reports the preparation and characterization of a bone-derived material proposed for use in biodiesel production from refined palm kernel oil. The supplied manuscript describes wet processing and calcination at 650 °C, and reports XRF, XRD, FTIR, TEM, three reaction runs, and selected fuel-property values. The reaction table lists biodiesel-yield volumes of 17.0, 12.0, and 8.5 mL and product-yield volumes of 4.5, 3.0, and 3.0 mL. The XRF table reports SiO_2, CaO, Al_2O_3, and MgO, but the listed mole percentages sum to 86.71%. The source also claims a 54% yield, although it does not show how that percentage was calculated. In addition, the text alternates between dog- and cow-bone material, and the catalyst identity and experimental protocol are incomplete. The results therefore constitute a preliminary report that requires verification against laboratory records before catalytic performance or fuel quality can be established.

Keywords: dog bone; heterogeneous catalyst; biodiesel; palm kernel oil; transesterification; catalyst characterization

1. Introduction

Biodiesel is produced from fats and oils through transesterification, and catalyst selection, feedstock properties, and reaction conditions affect conversion, product separation, and fuel quality (Ma & Hanna, 1999; Meher et al., 2006). Heterogeneous catalysts have been studied as alternatives to homogeneous catalysts because solid catalysts can be separated from reaction mixtures, although their activity and reusability must be demonstrated under specified conditions (Helwani et al., 2009).

Animal bones have been investigated as mineral-rich catalyst precursors, and bone-derived hydroxyapatite has been characterized in materials research (Sobczak et al., 2009). Studies have reported biodiesel production using calcined animal-bone materials and reviewed preparation routes and catalytic properties across different bone sources (Obadiah et al., 2012; Hussain et al., 2021). Mengistu and Reshad (2022) examined a catalyst prepared from a mixture of waste animal teeth and bone for castor-oil biodiesel. These studies provide context for investigating bone-derived materials but do not establish the catalytic activity of dog-bone material under the conditions reported here.

The stated aim of this study is to examine the synthesis and characterization of dog bone-derived material and its reported use in biodiesel production from refined palm kernel oil. The interpretation below is limited to the supplied tables, figures, and method description because the source manuscript contains inconsistent sample labels, yield claims, and experimental details.

2. Materials and Methods

2.1. Materials and Sample Identification

The manuscript identifies dog bone as the catalyst precursor and refined palm kernel oil as the feedstock. It also refers to methanol, deionized water, and sodium hydroxide (NaOH). Supplier information, bone provenance, pretreatment records, palm

kernel oil properties, and the role of NaOH in relation to the bone-derived material are not consistently specified. The source photograph is captioned "Cow Bone Mixture and its Derived Catalyst," which conflicts with the dog-bone study description (Figure 1). The authors should confirm the species and sample identity from laboratory records.



Figure 1. Bone material and processed powder reproduced from the supplied manuscript. The source caption identifies the material as cow bone; sample identity requires confirmation.

2.2. Catalyst Preparation

The source describes a wet-processing step in which bone material was mixed with deionized water, stirred for 4 h at room temperature, dried, and heated at 50 °C for 30 min followed by 70 °C for 30 min. It then reports calcination at 650 °C for 4 h in a muffle furnace under airflow. However, the mass and particle size of the bone, water-to-solid ratio, heating rate, furnace airflow, and whether a calcium precursor was added are not stated. The text also refers to "calcium-impregnated CaO" without identifying the calcium reagent or impregnation ratio. These omissions prevent exact replication.

2.3. Biodiesel Production and Yield Reporting

The reaction table lists 60 mL of palm kernel oil and 150 mL of methanol per run, NaOH dosages of 2.5, 5.0, and 7.5 (unit reported as "gmol"), reaction times of 30, 45, and 60 min, and a calcination temperature of 650 °C. It does not specify the reaction temperature, catalyst mass or basis, alcohol-to-oil molar ratio, order of addition, separation and purification steps, or the formula used for biodiesel yield. The reported table values are presented in Results without converting them into percentages.

2.4. Characterization and Fuel-Property Analysis

The manuscript reports XRF, XRD, FTIR, and TEM characterization. It does not provide instrument models, operating conditions, sample preparation, calibration, or peak-assignment methods. The measurement methods and units for density, viscosity, flash point, acid number, octane number, pH, and calorific value are also incomplete. No validated FAME-content measurement is reported.

3. Results

The reported measurements are summarized as supplied. Because several labels, units, and claims conflict within the manuscript, no unreported values or corrections have been inferred.

3.1. Reported Reaction Conditions and Product Volumes

The three reported runs produced biodiesel-yield (BDY) volumes of 17.0, 12.0, and 8.5 mL, and biodiesel-product-yield (BPY) volumes of 4.5, 3.0, and 3.0 mL. Their sums are 37.5 mL BDY and 10.5 mL BPY (Table 1). Reaction time and the stated NaOH dose increase together across the runs, so their separate effects cannot be determined from these data.

Table 1. Reaction conditions and biodiesel volumes reported in the source manuscript.

Palm kernel oil (mL)	Catalyst (as reported)	Time (min)	Methanol (mL)	Calcination temperature (°C)	BDY (mL)	BPY (mL)
60	NaOH, 2.5 “gmol”	30	150	650	17.00	4.50
60	NaOH, 5.0 “gmol”	45	150	650	12.00	3.00
60	NaOH, 7.5 “gmol”	60	150	650	8.50	3.00
Total					37.50	10.50

3.2. Reported Density and Fuel Properties

The density table reports 0.023, 0.022, and 0.021 g/mL for samples A–C, respectively (Table 2). The accompanying property table repeats the same values in each of its three rows: viscosity 7.30 “mpd,” cloud point −33 °C, pour point −18.0 °C, flash point 125 °C, acid number 0.70 mg KOH/g, octane number 0.85, and a combined pH/calorific-value entry of 5.4/4.132 (Table 3). The table does not define whether each row represents a different sample or replicate.

Table 2. Run conditions and density values reported in the source manuscript.

Run	Sample	Agitation (RPM)	Catalyst dosage (as reported)	Catalyst temperature (°C)	Time (min)	Density (g/mL)
1	A	400	2.5	650	30	0.023
2	B	500	5.0	650	45	0.022
3	C	600	7.5	650	60	0.021

Table 3. Fuel-property values reported for each of the three samples; units and test methods are reproduced as supplied.

Viscosity (mpd)	Cloud point (°C)	Pour point (°C)	Flash point (°C)	Acid number (mg KOH/g)	Octane number (%)	pH at 65 °C / calorific value (kJ/kg)
7.30	−33	−18.0	125	0.70	0.85	5.4 / 4.132
7.30	−33	−18.0	125	0.70	0.85	5.4 / 4.132
7.30	−33	−18.0	125	0.70	0.85	5.4 / 4.132

3.3. Elemental Composition and Material Characterization

The XRF table reports four components for the sample labeled “Dog”: SiO_2, CaO, Al_2O_3, and MgO, with mole percentages of 19.12%, 4.83%, 11.75%, and 51.01%, respectively (Table 4). These values sum to 86.71%; the manuscript does not identify the remaining fraction or describe normalization. The surface-density unit and analytical basis are not explained.

Table 4. XRF composition values reported for the sample labeled “Dog.”

Sample	Component	Surface density (mg/cm²)	Mole percent
Dog	SiO_2	21.96	19.12
Dog	CaO	5.17	4.83
Dog	Al_2O_3	22.83	11.75

Sample	Component	Surface density (mg/cm²)	Mole percent
Dog	MgO	39.16	51.01

The source XRD pattern is reproduced in Figure 2. Although the manuscript assigns peaks to silica-, calcium-, and aluminium-containing phases, the XRD acquisition and phase-identification procedure are not given. The figure title identifies a dog-bone catalyst, while surrounding text refers to cow bone; sample identity and assignments require confirmation.

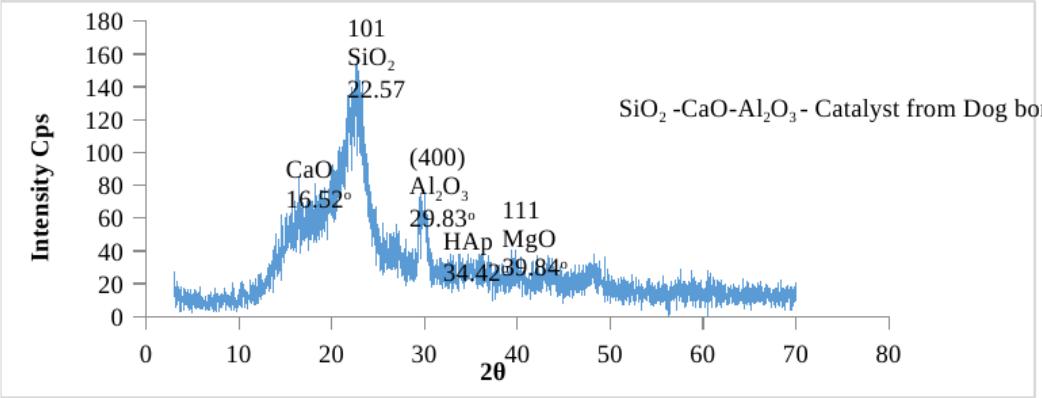


Figure 2. XRD pattern reproduced from the supplied manuscript and labeled as a SiO_2–CaO–Al_2O_3 catalyst from dog bone. Phase assignments have not been independently verified.

The supplied FTIR spectrum and its annotated bands are shown in Figure 3. The source assigns bands to hydroxyl, C–H, C=O, Si–O–Si, Al–O, phosphate, and Ca–O groups. The methods do not provide the instrument settings, sample preparation, or assignment criteria needed to validate those interpretations.

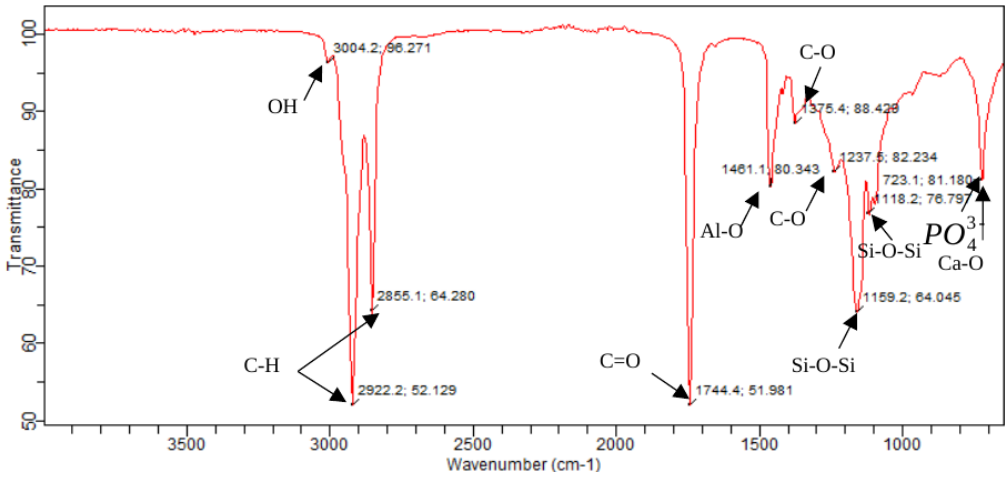


Figure 3. FTIR spectrum of calcined bone material, reproduced with the source annotations. The manuscript labels this as dog bone.

The TEM micrograph is shown in Figure 4 and includes image annotations between approximately 8.87 and 10.72 nm. The sampling protocol, image scale calibration, particle-selection criteria, and size-distribution analysis are not reported; the annotated measurements therefore cannot be treated as a validated average particle size.

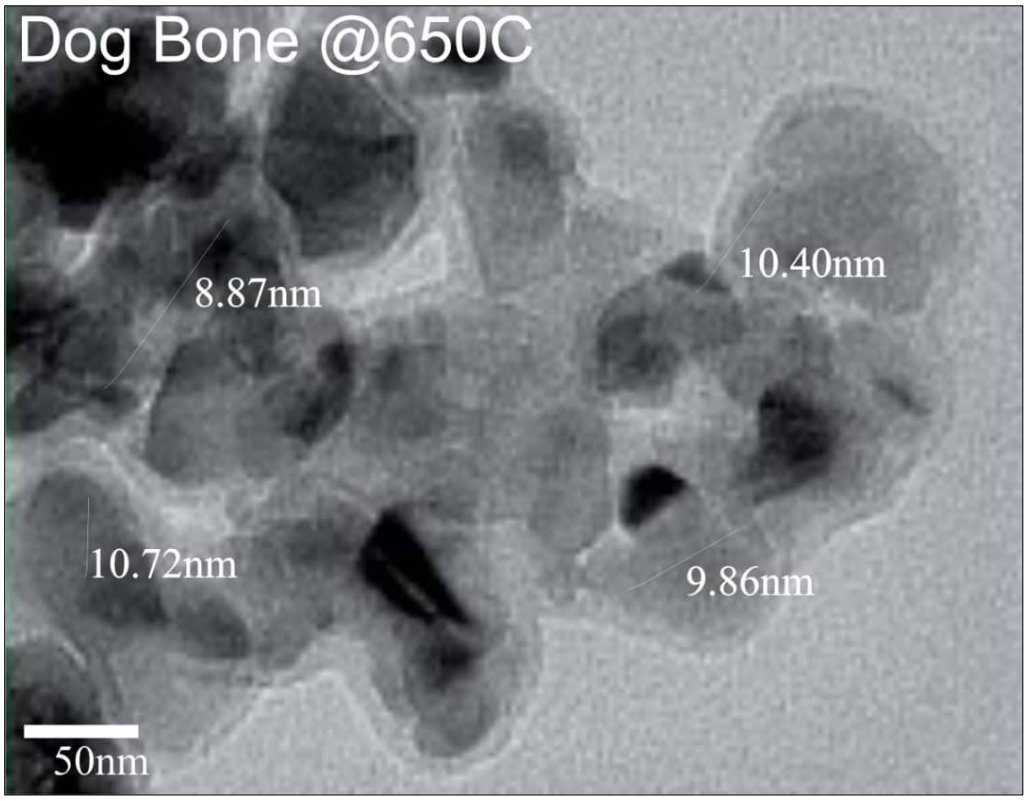


Figure 4. TEM micrograph labeled "Dog Bone @650C" in the supplied manuscript; the displayed annotations indicate selected particle-size measurements.

4. Discussion

The tabled BDY and BPY volumes do not support the 54% yield stated in the source abstract and conclusion. The manuscript does not define the yield denominator or show a calculation connecting the reported volumes to that percentage. The three runs also change the NaOH dose and reaction time simultaneously, and the catalyst identity is unclear because NaOH is listed in the reaction table while the study is framed around a bone-derived catalyst. The present results therefore do not isolate the catalytic contribution of dog-bone material.

Several reported fuel properties require verification before comparison with biodiesel specifications. In particular, the stated density values are unusually low for a liquid fuel if the unit is truly g/mL; "mpd" is not a sufficiently defined viscosity unit; and the pH and calorific-value entries are combined in one column. The repeated property rows provide no visible sample-specific variation. The authors should check the laboratory sheets, instrument printouts, units, and table-to-abstract calculations before making fuel-quality claims.

The XRF data list percentages that sum to less than 100%, and the surface-density basis is unspecified. XRF composition alone does not demonstrate catalytic activity. The XRD, FTIR, and TEM figures may support material characterization after sample identity, instrument settings, calibration, and analysis procedures are documented. Related studies on other animal-bone catalysts provide context, but they cannot validate the composition or performance of the material reported here (Hussain et al., 2021; Mengistu & Reshad, 2022; Obadiah et al., 2012).

A defensible follow-up should verify whether the precursor was dog or cow bone; define the catalyst and NaOH roles and dosage basis; specify reaction conditions; include no-catalyst and reference-catalyst controls; run independent replicates while varying one factor at a time or using a declared design; calculate yield from a stated mass or conversion basis; and quantify FAME using a validated method. Fuel-property measurements should use identified standard test methods and units.

5. Conclusions

The supplied manuscript reports calcined bone material, four XRF components, three biodiesel-production runs, and selected characterization and fuel-property results. However, the source contains unresolved contradictions in bone identity, catalyst

identity, yield percentage, density and property units, and method detail. The evidence as presented does not establish a 54% biodiesel yield or demonstrate that dog-bone material caused the reported conversion. The laboratory data and procedures must be verified before conclusions about catalytic performance or fuel suitability can be supported.

Author Contributions

Opara Victor Samuel: Conceptualization, methodology, investigation, data curation, formal analysis, visualization, and writing—original draft. Kotingo **W. Kelvin**: Supervision, validation, resources, project administration, and writing—review and editing. Both authors read and approved the final manuscript.

Funding

This research received no external funding.

Data Availability Statement

The data are available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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