



# Study on the Lubricating Properties of Castor (*Ricinus communis*) and Hydroxylated Rubber (*Hevea brasiliensis*) Seed Oil

- Oyinlola Rukayat Obanla\*
- ,
- Farouk Usman Mohammed
- ,
- Olubunmi Samuel Alebiosu
- ,
- Modupe Elizabeth Ojewumi
- ,
- Temitayo Elizabeth Oladimeji
- , and
- Damilola Elizabeth Babatunde
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**Cite this:** *ACS Omega* 2021, 6, 43, 28471–28476

Publication Date: October 18, 2021

<https://doi.org/10.1021/acsomega.0c05810>

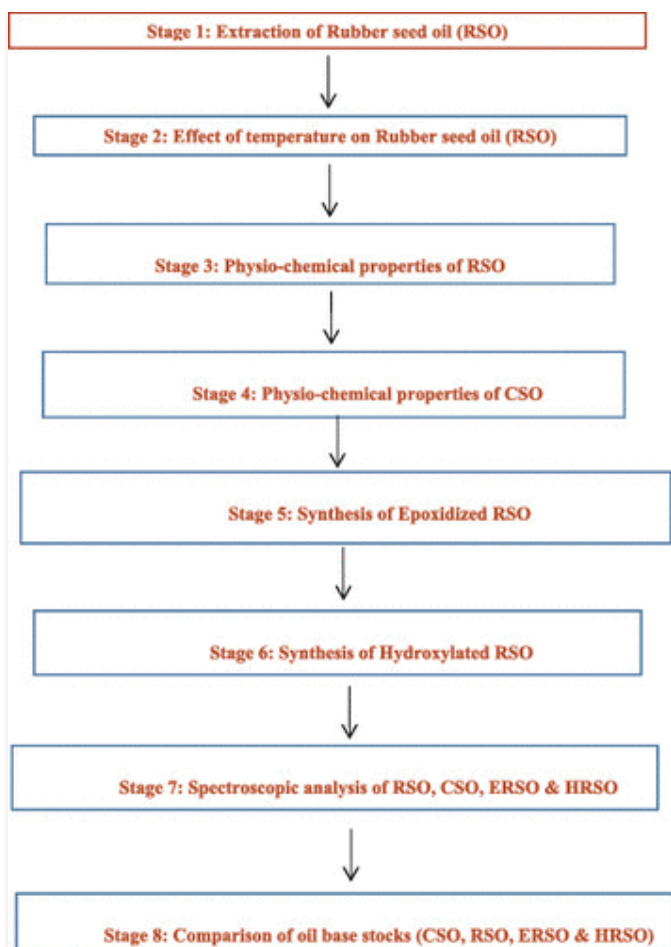
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## Abstract



Rubber seed oil (RSO) (*Hevea brasiliensis*) was extracted from rubber seeds by chemical means. The effect of temperature on the oil yield was investigated. The experiment suggested that the maximum yield of the oil occurs at 60 °C. This is a result of the proximity to the boiling point of *n*-hexane, which is about 68 °C. Epoxidized and hydroxylated RSOs were further synthesized by performic acid generated in situ by the reaction of formic acid with 30% hydrogen peroxide. The physiochemical properties of the epoxidized rubber seed oil (ERSO) and hydroxylated rubber seed oil (HRSO) were determined. A separate study was also carried out on castor seed oil (CSO). The improved products were characterized with respect to their configuration and properties. Spectroscopic analysis was carried out on the oil base stocks (RSO, CSO, ERSO, and HRSO). All of the experimental findings were compared with one another. The lubricating properties of CSO and HRSO are further studied as a result of their common hydroxyl nature to ascertain their suitability as a lubricant base. Both oils can be categorized as a nondrying oil with saponification values of 179.52 and 255.25 mgKOH/g, respectively, and as such possess advantageous properties for industrial application. When compared to one another, HRSO appears to be a more effective choice as a lubricant base. This is because of its higher viscosity index of 380.65. The outcomes of this study indicate that hydroxylated and epoxidized RSO with high oxirane content can be synthesized concurrently by one-pot multistep reactions.

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## 1.. Introduction

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As of late, the world has been affected by purposeful and inadvertent oil or lubricants losses to the environment because of spillage and dissipation of said lubricants. Lubricants are generally used to reduce the friction coefficient between bodies in contact. Their importance in the world of working machinery cannot be underestimated. The base oil is of utmost importance in the production of lubricants, as it makes up 75–90% of the lubricant. (5-7) The most common source of these base oils is mineral oil, which is nonrenewable and non-biodegradable. (1,9,13) Owing to this, other sources of base oils such as synthetic oils and vegetable oils have been discovered as alternatives to mineral oil. (8,10,13) Fifty percent of all lubricants currently sold are eventually released into the environment, 95% of these lubricants are mineral-oil-based. (14,15) Mineral-oil-based products are generally considered unfavorable because of their adverse effect on the environment and they cause serious hazards to the ecosystem at large because of their high ecotoxicity and low biodegradability, leading to an increasing interest in biodegradable and eco-friendly lubricant products. However, the creation of a biodegradable base liquid that could surpass or substitute most of the ordinary mineral oils has been troublesome. (11,20) To create such lubricant products, the scientific community has tuned its attention to the use of vegetable oils (natural or chemically modified). Vegetable oils have several advantages that make them favorable as a potential source of eco-friendly lubricant products. (19) Their combination of renewability, biodegradability, anticorrosion properties, good viscosity indices, high flash points, and excellent lubrication performance (21-23) that are way better than those of petroleum-based lubricants makes them decent candidates as mineral-oil-based products. (28)

However, a few prominent disadvantages limit their potential in the lubricant industry. These disadvantages include low thermal oxidation stability, weak performance at low temperatures, unimpressive cold flow behavior, susceptibility to hydrolysis, and oxidative attack. (9,13) To improve on these shortcomings that have limited the application of vegetable oils as lubricants, chemical modification via hydroxylation and epoxidation has been utilized in this research.

In Nigeria, vegetable oil subordinate generally depends on exceptionally costly imported oils such as soybean and linseed oil. Rubber seed oil (Figure 2) apart from being considered as a biodegradable lubricant (2,18,28) has been used as alkyd resin, (3) liquid soap, (16) an aid for the processing of polymers, (17,24) biodiesel, (27,28) and surface-coating binder. (3,4)

Statistically speaking, the rate at which castor seed oil (CSO) is produced currently cannot meet the great demand of the product and the hydroxyl nature of castor oil

([Figure 1](#)) makes it a natural polyol with considerable oxidative stability. ([15,23,25](#)) This uniqueness allows castor oil to be used in industrial applications such as coatings, paints, biodiesel lubricants, and inks. ([1,9,23,25,26](#))

## Figure 1



Figure 1. Castor seeds.

## Figure 2



Figure 2. Rubber seeds.

As a result of the close similarities between these two common seeds, their respective oils, CSO and hydroxylated RSO (HRSO), are closely compared with each other. Nigeria imports over \$85 million worth of castor oil each year. (26) However, there has been a gradual increase in the number of castor seed and rubber seed cultivations in Nigeria. For this study, Obanla et al. report the epoxidation of rubber seed oil (ERSO). HRSO is derived from ERSO but with an alteration of the final temperature. The spectroscopic data and physicochemical properties of the products, CSO, RSO, ERSO, and HRSO, were determined. The data obtained for HRSO was compared to that of crude castor oil (CSO). This research paper centers on synthesizing hydroxylated rubber seed oil (HRSO), studying physicochemical and spectroscopic properties, and comparing the lubricating performance of CSO and HRSO.

## 2.. Materials and Method

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### 2.1. Materials

Crude RSO used in this research was extracted from Rubber Plantation at the Rubber Research Institute of Nigeria, Edo State, Nigeria. Castor oil used was purchased from an oil mill industry in Ojota, Lagos state, Nigeria. Formic acid (AR grade: 99.9% purity) was obtained from Merck. Hydrogen peroxide (30% w/v) and hydrobromic acid were obtained from Sigma-Aldrich Chemicals purchased by Covenant University, Ogun state, Nigeria.

### 2.2. Synthesis of Hydroxylated Rubber Seed Oil (HRSO)

The hydroxylation reaction follows the same procedure as epoxidation described by Obanla et al. but with a slight adjustment, in the sense that at the end of the 3 h reflux during the epoxidation reaction, the temperature is increased to 80 °C and was maintained for another 14 h, as shown in [Figure 3](#). The resulting HRSO was then characterized using American Oil Chemist Society (AOCS) methods.

### Figure 3

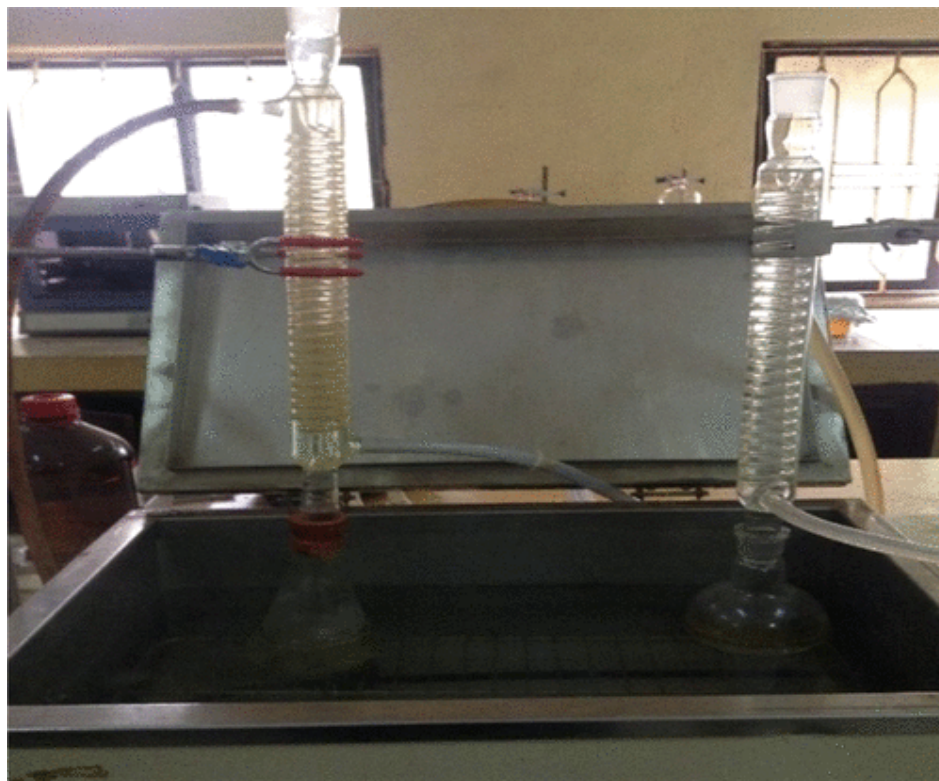


Figure 3. Epoxidation (3 h at 60 °C)/hydroxylation reaction (3 h at 60 °C then 14 h at 80 °C).

## 3. Results and Discussion

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### 3.1. Effect of Temperature on Extraction Yield

Apparently, the temperature had a substantial effect on the oil yield. In [Figure 4](#), the mean oil yield at 40 °C was about 33.3% and 38.8% at 50 °C, 44.4% at 60 °C, 43.8% at 70 °C, and 41.5% at 80 °C, all percentages are by weight. The oil yield of rubber seed was maximum at 60 °C as displayed in [Figure 4](#). When the extraction temperature was increased to 80 °C, it caused a decrease in yield to 41.50%. This simply implies that an increase in temperature above 60 °C does not favor the reaction conditions. Therefore, the optimum extraction temperature of rubber seed oil for maximum oil yield occurs at 60 °C.

### Figure 4

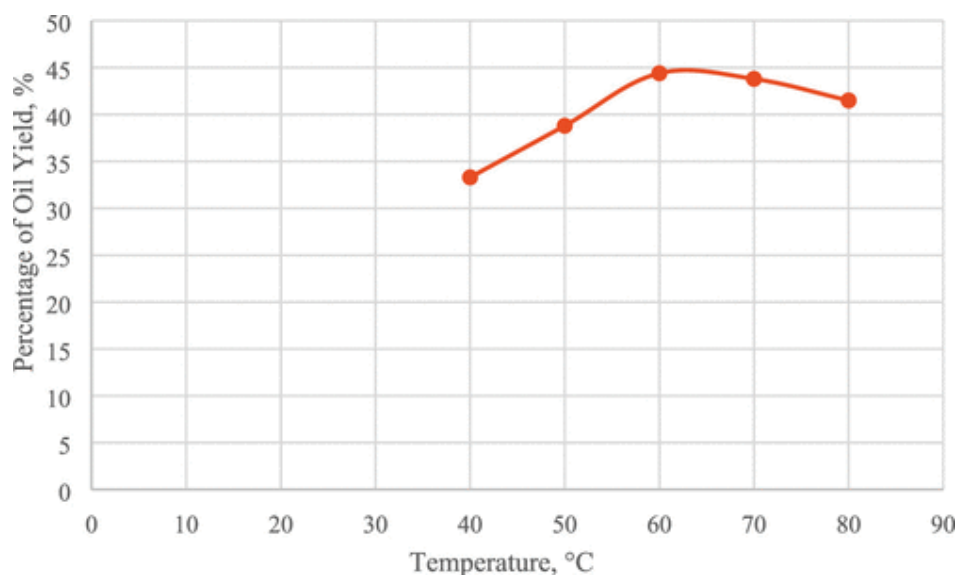



Figure 4. Effect of temperature on percentage oil yield.

## Author Information

[Jump To](#)

- Corresponding Author
  - **Oyinlola Rukayat Obanla** - *Department of Chemical Engineering, Covenant University, Ota, Ogun State 112233, Nigeria*;  <https://orcid.org/0000-0002-9075-9672>; Email: [oyinlola.oresegun@covenantuniversity.edu.ng](mailto:oyinlola.oresegun@covenantuniversity.edu.ng)
- Authors
  - **Farouk Usman Mohammed** - *Product Development Division, Rubber Research Institute of Nigeria, Benin City 300001, Nigeria*
  - **Olubunmi Samuel Alebiosu** - *Department of Polymer and Textile Technology, Yaba College of Technology, Lagos 101212, Nigeria*
  - **Modupe Elizabeth Ojewumi** - *Department of Chemical Engineering, Covenant University, Ota, Ogun State 112233, Nigeria*
  - **Temitayo Elizabeth Oladimeji** - *Department of Chemical Engineering, Covenant University, Ota, Ogun State 112233, Nigeria*
  - **Damilola Elizabeth Babatunde** - *Department of Chemical Engineering, Covenant University, Ota, Ogun State 112233, Nigeria*
- Author Contributions

O.R.O. prepared the manuscript. F.U.M. sourced all of the raw materials. O.S.A., M.E.O., T.E.O., and B.D.E. did the editing and reviewing of the manuscript.

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- Notes

The authors declare no competing financial interest.

# Acknowledgments

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The authors appreciate the management of Covenant University, Nigeria, for their full sponsorship of this study and Product Development Division, Rubber Research Institute of Nigeria, Edo state. This paper has neither been published nor submitted in any domestic or abroad journals.

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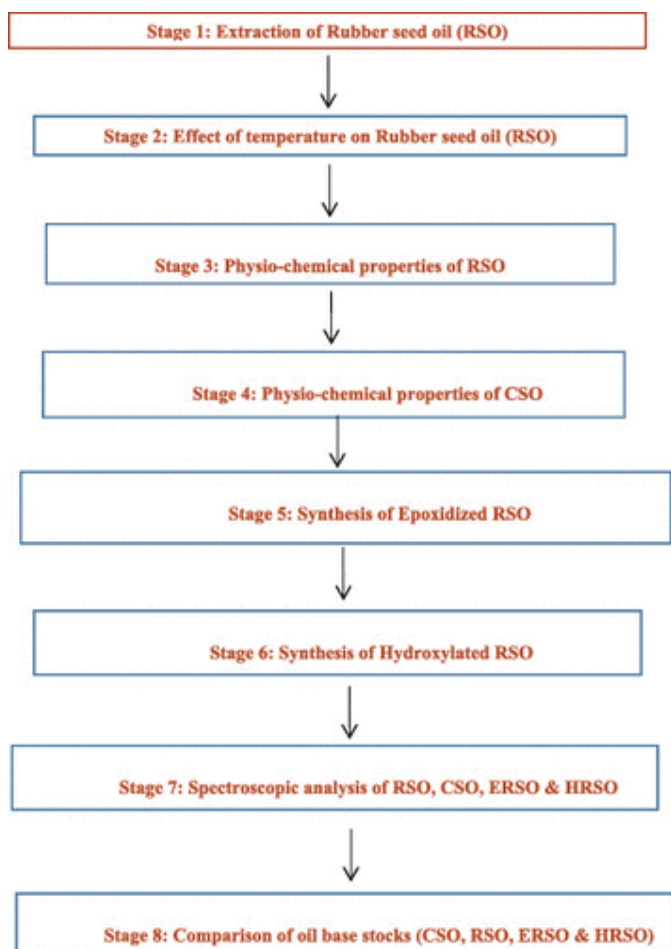
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## Abstract



**Figure 1**



Figure 1. Castor seeds.

## Figure 2



Figure 2. Rubber seeds.

### Figure 3

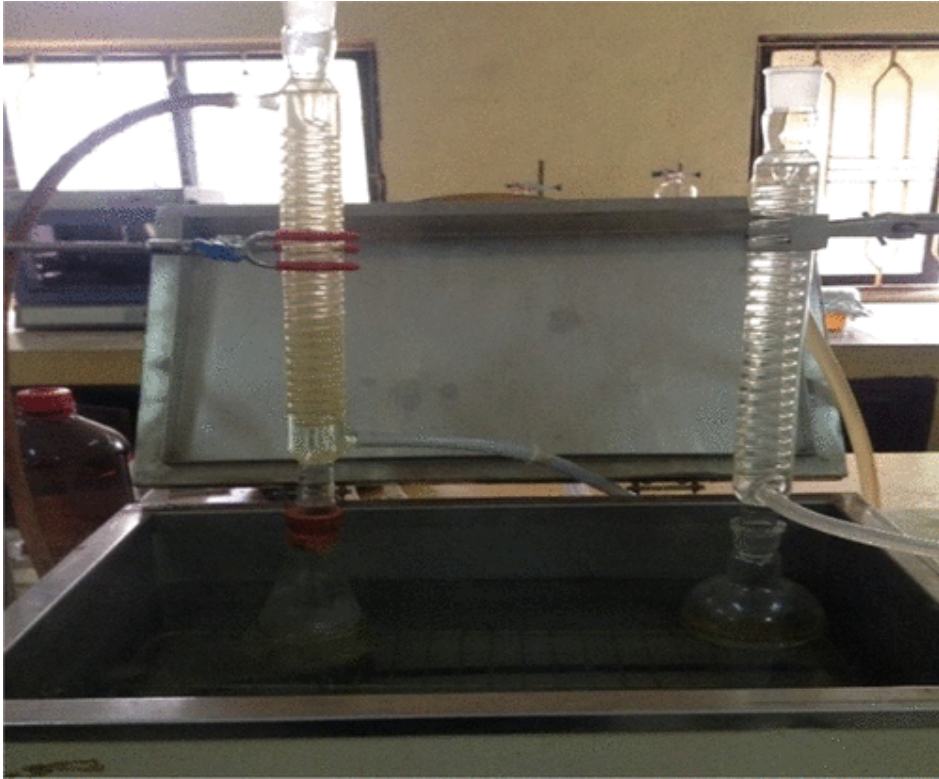


Figure 3. Epoxidation (3 h at 60 °C)/hydroxylation reaction (3 h at 60 °C then 14 h at 80 °C).

### Figure 4

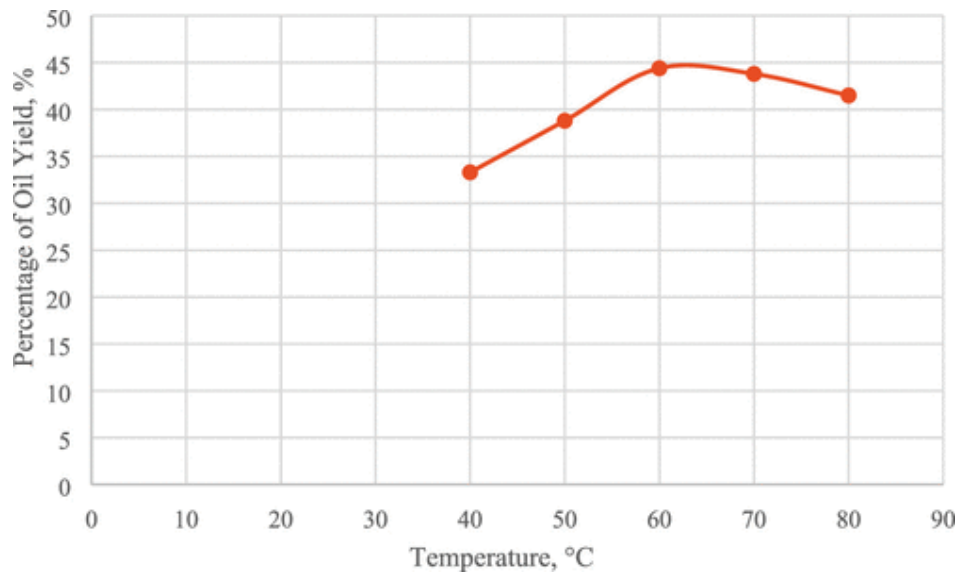


Figure 4. Effect of temperature on percentage oil yield.



**Figure 5**

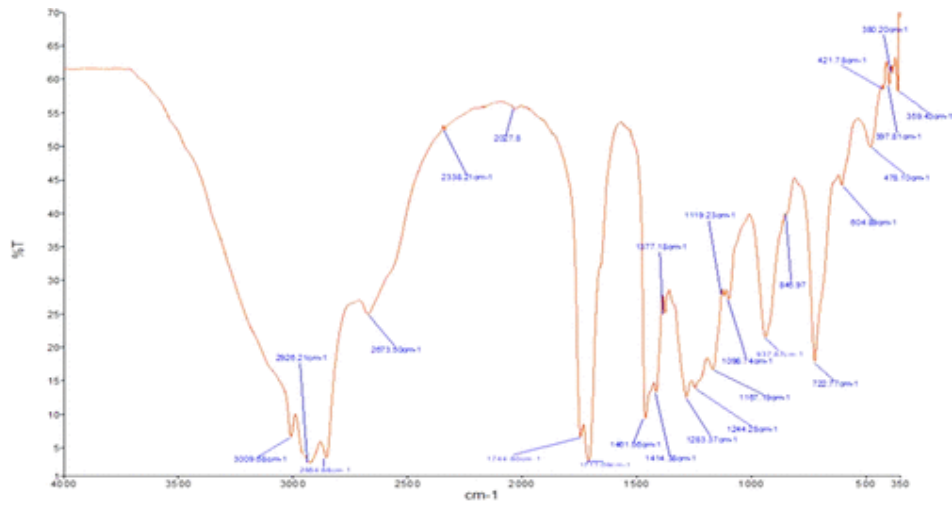


Figure 5. FTIR spectrum of rubber seed oil.

**Figure 6**

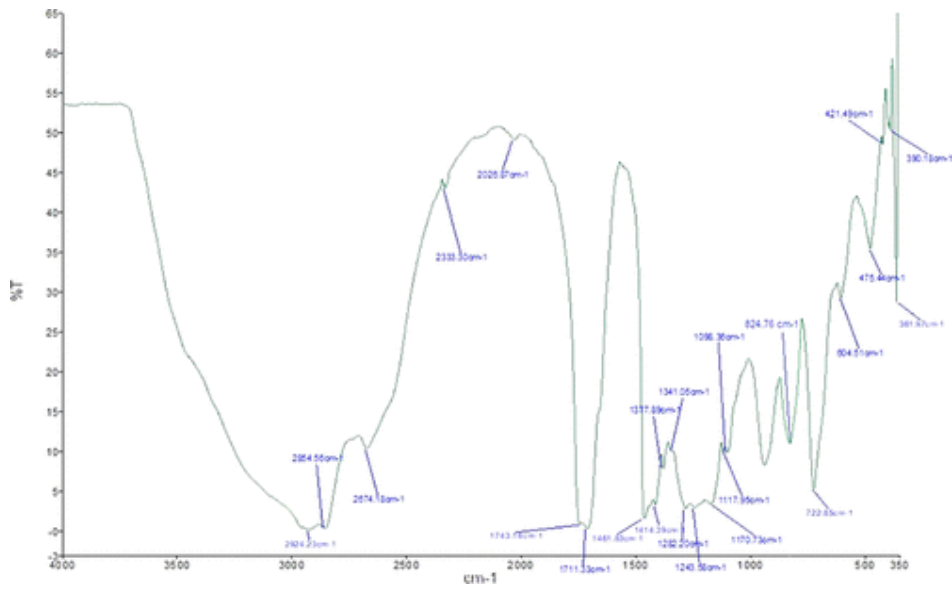


Figure 6. FTIR spectrum of ERSO.

**Figure 7**

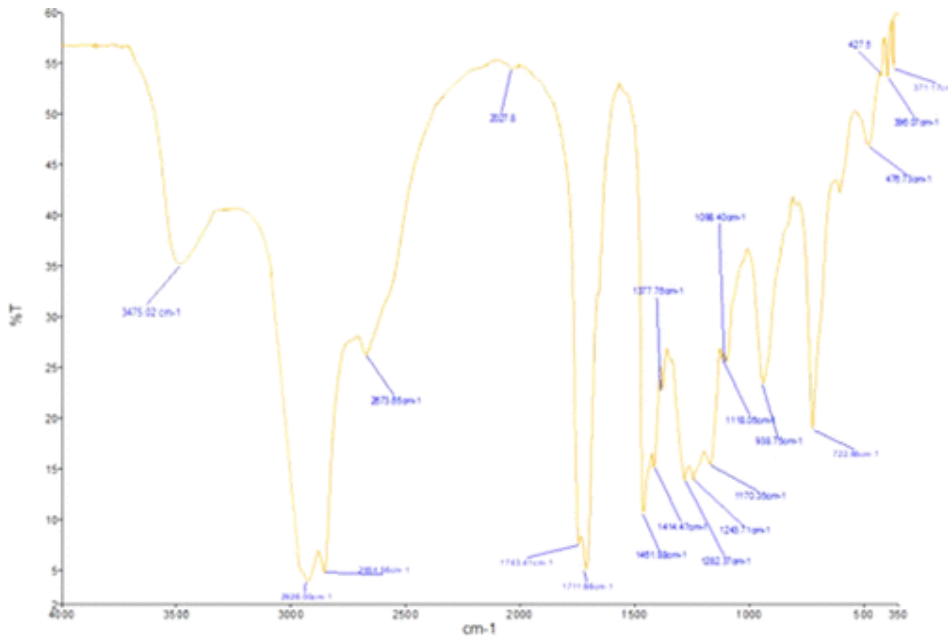


Figure 7. FTIR spectrum of HRSO.

## Figure 8

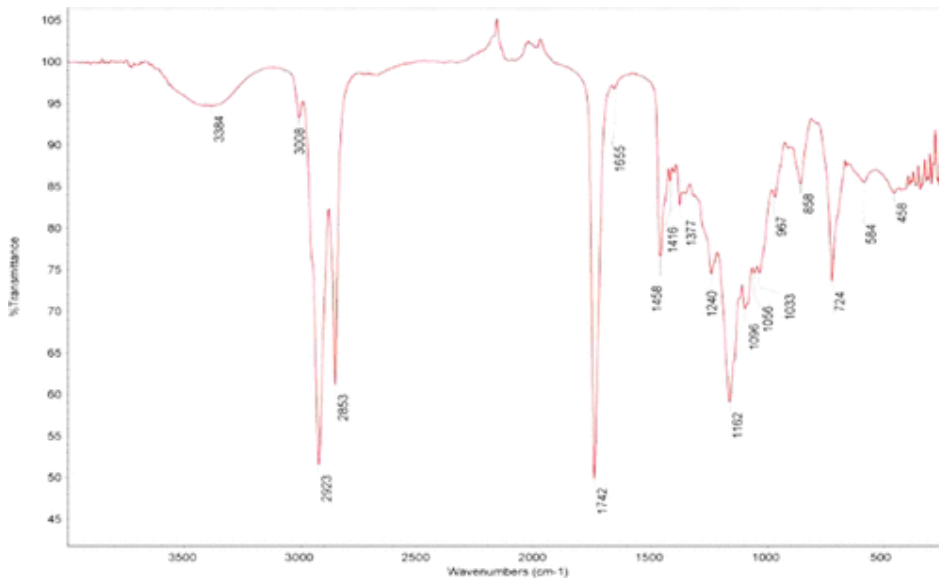


Figure 8. FTIR spectrum of castor oil (CSO).

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