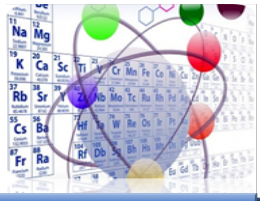
Indonesian Journal of Chemical Science and Technology (IJCST)

State University of Medan, https://jurnal.unimed.ac.id/2012/index.php/aromatika

IJCST-UNIMED 2026, Vol. 09, No. 2, Page; 198 – 202

Received : Oct 6th, 2025 Accepted : Jul 7th, 2026 Web Published : Jul 31st, 2026



FTIR Spectra Analysis to Confirm the Epoxidation Reaction of Castor Oil

Trilita Putri Halasson Sihite*, Marham Sitorus

Department of Chemistry, Faculty of Mathematics and Natural Sciences, Universitas Negeri Medan, Medan 20221, Indonesia

*) Corresponding Author: Email : panderajatrilita@gmail.com

ABSTRACT

Study This aim For confirm success reaction epoxidation oil distance (Ricinus *communis Linn*) through analysis Epoxidation FTIR spectroscopy done use sour synthesized performance in a way *in situ* from formic acid with hydrogen peroxide . Reaction done using catalyst sour sulfate at a temperature of 70 ^{o}C and a time of 90 minutes . The reaction epoxidation is transformation group alkenes become epoxide or oxirane that is something ether cyclical member three . FTIR analysis can used For identify change group function main reactants and products .. From the results FTIR analysis then alkene (C = C) absorption at 1655 cm $^{-1}$ is qualitatively transformed into castor oil epoxy with the appearance of C - O - C (epoxy ether) absorption at 1015 cm $^{-1}$ for stretching and 858 cm $^{-1}$ for bending . The decrease intensity absorption C=C alkene in epoxy oil caster based on FTIR spectra no seen in a way significant , because FTIR does not accurate used For analysis quantitative Because No common determine concentration compounds analyzed .

Key words : epoxidation ; oil castor ; cluster function ; epoxy ; FTIR

1. INTRODUCTION

Oil isolated casters from seed plant castor (*Ricinus) communis Linn* .) is oil non - food vegetable oils distance contains 85–90% acid ricinoleate with One bond double bond at C12 and the group hydroxyl at C12 [1] . In overall Ricinoleate have three group functional that is alkenes , hydroxyls , and esters that can transformed become other compounds that are more useful . Transformation third group function This Good in a way individually or simultaneous will produce many products used in industry chemicals , plastics , lubricants , surfactants and environmentally friendly polymers environment [2.] In research This done conversion bond double (C=C) becomes epoxy (oxirane) through reaction epoxidation with reagents sour percarboxylate [3.] In research This reagents used sour synthesized performance in a way *in situ* from formic acid and hydrogen peroxide . Product epoxy from oil vegetable including from oil caster can used as a plasticizer for PVC, resin stabilizer , material standard surfactants , as well as epoxy and polyurethane resin precursors [4] [5] .

e-ISSN : 2622-4968, p-ISSN : 2622-1349 © 2026 State University of Medan

Reaction epoxidation is reaction between sour peroxide organic and bonded compounds duplicate (including unsaturated fatty acids fed up in oil vegetable) for form compound oxirane (epoxide). Basically There is four method epoxidation that is with sour percarboxylate , with peroxide organic and inorganic , with halohydrin , and with molecule oxygen free [6]. Epoxidation process aim For change double become ether ring three or known with oxirane [7] .

Study previously has report epoxidation oil vegetable use sour peroxide as oxidizer . Epoxidation oil palm , jantropha , and pimmation with sour peroxide produce significant conversion , marked with decline amount number iodide and the emergence group epoxy [3 8 9]. In research others , epoxidation oil distance done with sour peracetate produce compound epoxy , but the conversion relatively low Because characteristic group less methyl reactive [10]. Therefore that , research This use sour synthesized performance in a way *in situ* from formic acid and hydrogen peroxide with catalyst sour sulfate , where the reagent postman This more reactive and will increase efficiency reaction epoxidation [11] .

Verification ongoing reaction epoxidation , in qualitative done through analysis Fourier Transform Infrared (FTIR) Spectroscopy . Epoxidation is C=C transformation on absorption around 1600 cm^{-1} to ether cyclical three (oxirane) C – O – C. With thus ongoing reaction epoxidation so FTIR spectra will appear absorption new and distinctive For ring epoxy namely on absorption approximately 856 cm^{-1} for bend and about 1015 cm^{-1} For span [12 13] **.** For complete verification sustainability reaction epoxidation is based on measurement number Iodine . Changes group alkenes become epoxy will happen decline number Iodine in the results epoxy oil caster [14] .

2. EXPERIMENTAL

2.1. Materials and Tools

Chemical material main used is oil castor (*Ricinus communis Linn.)* (class commercial), formic acid (CH_2O_2, 98%, Merck), hydrogen peroxide (H_2O_2, 30%, Merck), and acid sulfate (H_2SO_4, 98%, Merck). Sodium sulfate anhydrous (Na_2SO_4, class analytical , Merck) is used as substance dryer . Equipment the glass used covering round- bottomed pumpkin neck three , condenser reflux , thermometer , stirrer magnetic , and funnel separate . Instrument main For characterization is Spectroscopy Infrared Fourier transform (FTIR; Bruker, Invenio S, range number waves 4000–400 cm^{-1}).

2.2. Procedure Study .

Epoxidation oil distance done use sour the resulting performance in situ. Formic acid and hydrogen peroxide mixed with molar ratio 1:2 with a drop sour sulfate as catalyst For form sour performance . Substance oxidizer Then added slowly to in oil distance while stirred continuously at temperature controlled (60–70 °C) during time the reaction that has occurred determined . After reaction , mixture washed with distilled water and neutralized For remove remainder acid , then dried with sodium sulfate anhydrous . The resulting product analyzed with FTIR. FTIR spectrum of oil distance early and oil distance epoxidized compared to For identify change group function . The loss of or decrease absorption alkene (C=C) at around 1600 cm^{-1} and the appearance of new bands at 856 cm^{-1} and 1015 cm^{-1} which correspond to with vibration stretch oxirane (C–O–C) is used as confirmation success epoxidation .

3. RESULT AND DISCUSSION

3.1. Analysis Infrared Fourier Transform (FTIR)

Based on FTIR analysis obtained , the group function shown in the sample oil caster commercial and oil caster epoxidized . FTIR results show existence peak typical from group the function formed . The peaks new on results epoxidation oil distance appear consequence transformation bond double become ring epoxide , so that produce absorption

e-ISSN : 2622-4968, p-ISSN : 2622-1349 © 2026 State University of Medan

in the environment different chemicals . In the beginning , oil caster commercial show FTIR spectra with peak typical that represents group function natural . Peaks the related with existence bond double and cluster hydroxyl in the structure sour ricinoleate before undergo an epoxidation process [15 5.] Next This obtained pattern absorption diffraction IR rays on a number of wave certain as shown in the picture following .

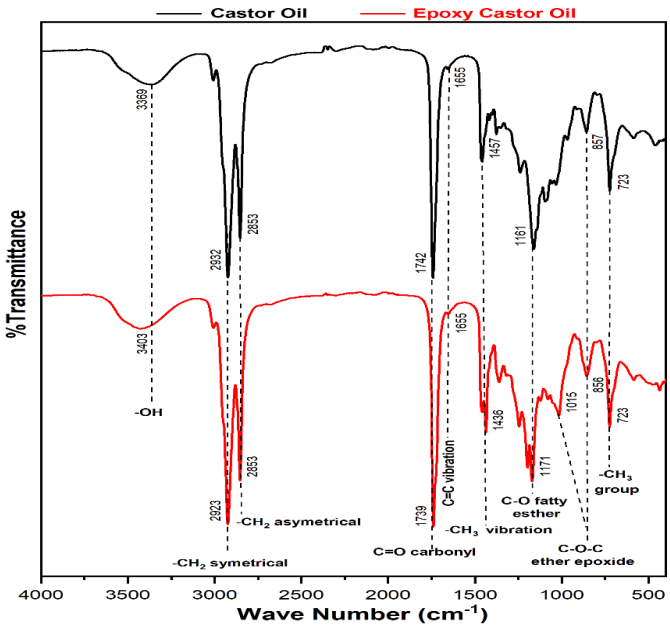


Figure 1. Comparison FTIR Spectra of Castor Oil and Epoxidized Castor Oil

Figure 1 shows FTIR spectra , on oil caster seen number identified 3369 cm^{-1} wave as OH group , then at the number waves 2923 cm^{-1} and 2853 cm^{-1} were identified as CH_2 group asymmetric and CH_2 symmetrical . Furthermore , in the numbers waves 1742 cm^{-1} and 1655 cm^{-1}, identified as C=O group and C=C group . These groups is bond double in oil caster supported by the presence number waves at 1171 cm^{-1} and 1436 cm^{-1} as CO ester group and CH_3 vibration . Finally , at the number 723 cm^{-1} wave identified as CH_3 group [16] .

While in oil caster results epoxidation , FTIR spectra show existence significant changes . Absorption bands at numbers wave 3403 cm^{-1} identified as vibration strain –OH group . The emergence of peak new on numbers more waves tall This indicates existence change environment chemistry consequence formation group function new after the epoxidation process . On numbers waves 2932 cm^{-1} and 2853 cm^{-1} were identified as CH_2 group asymmetric and CH_2 symmetrical . Furthermore , in the numbers waves 1739 cm^{-1} and 1655 cm^{-1}, identified as C=O group and C=C group . It can be seen existence decline intensity in the cluster this . In addition , in the number waves at 1171 cm^{-1} and 1436 cm^{-1} were identified as CO ester group and CH_3 vibration .

Next , it looks like peak absorption new on numbers waves of 1015 cm^{-1} and 856 cm^{-1} which are characteristics existence group epoxy . The emergence peak the confirm that bond double in acid ricinoleate has succeed experience epoxidation [17.] Therefore that , on epoxidation oil caster there is group oxidation that appears as peak sharp . Here This is table reference For identification oil caster and results epoxidation oil caster .

Table 1. Comparison of FTIR Data of Castor Oil and Oil Epoxidation

Functional Group	Castor Oil	Oil Epoxidation	Reference
-CH_2 Asymmetric	2932 cm^{-1}	2923 cm^{-1}	2917 cm^{-1}

e-ISSN : 2622-4968, p-ISSN : 2622-1349 © 2026 State University of Medan

-CH $_2$ Symmetrical	2853 cm $^{-1}$	2853 cm $^{-1}$	2850 cm $^{-1}$
-OH	3369 cm $^{-1}$	3433 cm $^{-1}$	3443 cm $^{-1}$
CO	1161 cm $^{-1}$	1171 cm $^{-1}$	-
Vibrasi C=C	1655 cm $^{-1}$	1655 cm $^{-1}$	1653 cm $^{-1}$
Vibrase C=O	1742 cm $^{-1}$	1739 cm $^{-1}$	1744 cm $^{-1}$
COC Vibration	-	856 cm $^{-1}$ 1015 cm $^{-1}$	844 cm $^{-1}$
Group -CH $_3$	723 cm $^{-1}$	723 cm $^{-1}$	722 cm $^{-1}$

12 13 18

In the FTIR spectra, absorption bands appear. typical in the form of group epoxy (okisran). Visible peak absorption new 1 which is characteristics existence group epoxy . The emergence peak the confirm that bond double in acid ricinoleate has succeed experience epoxidation [17.] Therefore that , on epoxidation oil caster there is group oxidation that appears as peak sharp . Here This is table reference For identification oil caster and results epoxidation oil castor . This group formed Because change structure from linear chain becomes chain cyclic . In addition , the existence of group oxidant as spectrum important has indicated For success synthesis epoxidation in oil distance .

4. CONCLUTION

FTIR analysis was successful confirm occurrence epoxidation oil distance . Oil spectrum distance raw show absorption typical group hydroxyl , aliphatic C–H , carbonyl ester, and unsaturated C=C saturated . After epoxidation , observed disappearance C=C absorption at 1638 cm^{-1} and the appearance of an absorption band new at 856 cm^{-1} and 1015 cm^{-1}, as appropriate with stretching oxirane (C–O–C). Change spectral This with clear show conversion bond double in acid ricinoleate become group epoxy with still maintain structure bone ester back . Therefore that , FTIR spectroscopy proved become reliable method For confirm success reaction epoxidation oil distance .

5. ACKNOWLEDGEMENTS

The author would like to express sincere gratitude to the Chemistry Laboratory of Medan State University for providing the facilities and technical support necessary for this research. The author also extends heartfelt appreciation to the laboratory staff for their assistance in sample preparation and FTIR measurements. Special thanks are given to the academic supervisors for their valuable guidance, constructive suggestions, and continuous support throughout this study.

REFRENCES

1. Sitorus M, Situmorang M, Juwitaningsih T, Nia Hia MK, Hutabarat RF. Activity test of cla syntheszed from castor oil by in vivo white mice (rattus norveginus). J Phys Conf Ser. 2020;1485(1).
2. Román-Figueroa C, Cea M, Paneque M, González ME. Oil content and fatty acid composition in castor bean naturalized accessions under mediterranean conditions in Chile. Agronomy. 2020;10(8):1–9.
3. Ghozali M, Meliana Y, Fahmiati S, Triwulandari E, Darmawan A. Dengan Katalis Asam Asetat. 2018;40(2):63–70.
4. Listiana Y, Rosa Tampubolon H, Suriani Sinaga M. Effect of Catalyst Concentration and Reaction Time To Epoxy Production From Waste Cooking Oil. J Tek Kim USU. 2017;6(3):28.
5. Thirupathiah G, Satapathy S, Palanisamy A. Studies on epoxidised castor oil as co-plasticizer with epoxidised soyabean oil for PVC processing. J Renew Mater. 2019;7(8):775–85.
6. Kinasih NA. Kinasih, 2013. 2013;32(1):46–54.
7. Muhammad Khoirul Anam, Suryo Purwono, Supranto. Modification of Sodium Lignosulfonate Through Epoxidation of Kapok Seed Oil and Addition of Cosurfactant. J Process Engineering. 2015;9(No. 2):36–43.
8. Ifa L, Badawing M, SJ, Mustafiah M. Effect of Temperature and Weight of Palm Kernel Oil Hydrogenation Catalyst as a Softener for Rubber Compounds. J Chem Process Eng. 2021;6(1):24–30.
9. Sudradjat R, Ariatmi R, Setiawan D. AS RAW MATERIAL FOR LUBRICANT OIL (Processing of Jatropha curcas

e-ISSN : 2622-4968, p-ISSN : 2622-1349 © 2026 State University of Medan

L. Oil for Epoxy as Raw Material of Lubricant Base Oil). Forestry Research. 2007;25(1):57–74.
10. Ariatmi R, Mangunwidjaja D, Suryani A, Machfud, Sudradjat. Optimization of the Process and Kinetics of Epoxidation Reaction of Jatropha Curcas Oil (Jartropha curcas L.) with Hydrogen Peroxide. 2007;18(2):66–70.
11. Maisaroh, Susetya I. Optimization of Epoxidation of Oleic Acid as a Starting Material in the Synthesis of 9,10-Dihydroxy Stearic Acid (DHSA). J Agro-Based Ind. 2017;34:96–103.
12. Azumi BM, Suhendra D, Gunawan ER. Chemoenzymatic Epoxidation of Ketapang Fruit Kernel Oil. J Ilm Multidisciplinary. 2022;2(5):227–33.
13. Zaer Z, Gunawan ER, Suhendra D. Optimization of the Synthesis of Epoxy Compounds from Fatty Acids of Ketapang Seed Oil (Terminalia catappa L.). 2024;2(5):234–44.
14. Sugito S, Firmansyah A, Triana L. Analysis Of The Effect Of Addition Of Noni Fruit (Morinda citrifolia L.) In Used Fried Oil To Iodine Number. J Equatorial Lab. 2020;4(1):9.
15. Serhan M, Sprowls M, Jackemeyer D, Long M, Perez ID, Maret W, et al. Total iron measurement in human serum with a smartphone. AIChE Annu Meet Conf Proc. 2019;2019-November.
16. Alamsyah R, Susanti I, Siregar NC, Heryanti S. The Effect of the Ratio of Formic Acid and Hydrogen Peroxide in the Production of Epoxy Compounds from Palm Oil. War IHP. 2013;30:55–74.
17. Nugrahani RA, Firdaus FE, Widyawati Y, Firginia H, Purnama R. Kinetics of epoxy hydroxylation reaction of jatropha curcas oil using bentonite catalyst. J Tek Kim Indones. 2018;12(2):257.
18. Hartawan RA, Studi P, Teknik M, Kimia JT, Teknik F, Sriwijaya U. Hartawan (2022) journal collection. 2022;

e-ISSN : 2622-4968, p-ISSN : 2622-1349 © 2026 State University of Medan