

Base-Catalysed Epoxidation of Cooking Oil via *In Situ* Peracid Formation

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Abstract

The conversion of vegetable oils into high-value epoxidised derivatives has gained increasing relevance as industries seek renewable and safer alternatives to petroleum-based materials; however, conventional acid-catalysed systems remain limited by corrosiveness, difficult separation, and environmental concerns. Addressing these challenges, this study evaluates the epoxidation of palm cooking oil via an *in situ* peracid mechanism using sodium hydroxide (NaOH) as a base catalyst and hydrochloric acid (HCl) as an acid catalyst, with the aim of elucidating their comparative performance and reaction behaviour. The reactions were conducted using formic acid and hydrogen peroxide under controlled conditions, with catalyst loadings varied to assess their influence on oxirane formation. Samples were collected at 10-minute intervals for titrimetric quantification of oxirane oxygen. Kinetic modelling was applied to determine rate constants and to interpret the mechanistic differences between the catalytic systems. NaOH achieved the highest relative conversion to oxirane (RCO), reaching 59.96 % at 40 min, compared with 50.12 % for HCl, while FTIR analysis confirmed the successful formation of epoxide functionalities in both pathways. These findings highlight the potential of base-catalysed epoxidation as a greener and operationally safer route for producing epoxidised vegetable oils suitable for downstream polymer applications.

Keywords

Epoxidation, palm oil, oxirane ring, kinetic study, biomass conversion

1 Introduction

The increasing depletion of fossil fuel reserves and growing environmental concerns have led to heightened interest in renewable and sustainable resources for industrial applications. Vegetable oils have emerged as a potential alternative to petroleum-based products due to their biodegradability, renewability, and favourable physical properties.¹ However, the high degree of unsaturation in vegetable oils, characterised by the presence of carbon-carbon (C=C) double bonds in their fatty acid chains, makes them susceptible to oxidation, thereby limiting their industrial applicability.^{2,3} One of the most effective chemical modifications for improving the stability and functionality of vegetable oils is epoxidation.⁴ This process involves converting C=C double bonds into epoxy groups, which enhances oxidative stability and broadens its application in coatings, plasticisers, lubricants, and other industrial products.⁵ Epoxidation can be catalysed by various types of catalysts, including acid and base catalysts, which influence reaction efficiency and selectivity.⁶

Acid catalysts, such as sulphuric acid, are widely used in epoxidation processes due to their high reactivity and ability to achieve high epoxy yields. However, their use poses challenges in terms of product separation and corrosion issues.⁷ On the other hand, base catalysts, such as sodium hydroxide, offer a safer and more environmentally friend-

ly approach, characterised by easier product recovery and less corrosiveness.⁸ This study investigates the effectiveness of both acid and base catalysts in the epoxidation of cooking oil to provide insights into their comparative performance and potential industrial applications. The choice of catalyst used in the epoxidation process plays a crucial role in both the reaction rate and the properties of the final product.⁹ Each catalyst interacts differently with the oil, influencing factors like oxirane yield and overall quality of the epoxide.¹⁰ Sulphuric acid, commonly used as an acid catalyst in epoxidation, presents significant drawbacks due to its corrosive nature, which can lead to equipment degradation and increased maintenance costs.¹¹ Furthermore, the disposal of acid waste streams contributes to environmental pollution.¹² In this study, NaOH was selected as the sole base catalyst owing to its strong basicity, high solubility in the reaction medium, cost-effectiveness, and wide availability. It effectively promotes the formation of the peracid intermediate and facilitates the epoxidation reaction without introducing complex side reactions.

Epoxidised palm oil has gained attention as a renewable intermediate for the production of bio-based polymers and plasticisers. Conventionally, palm oil epoxidation is carried out using acidic catalysts in the presence of peracids, which often results in undesirable side reactions such as ring opening, formation of by-products, and equipment corrosion. Despite the known advantages of base catalysts, such as lower corrosivity and potentially milder reaction conditions, their application in epoxidation via *in situ* peracid formation remains limited, largely due to the per-

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ceived incompatibility of basic environments with peracid stability and reactivity.¹³ This study aimed to explore the underutilised potential of a base-catalysed epoxidation system for palm oil using the *in situ* peracid mechanism. The novelty of this work lies in employing a base catalyst to promote *in situ* peracid formation and subsequent epoxidation, offering a potentially greener approach with reduced side reactions and improved operational safety. Therefore, the objectives of this study were: (1) to investigate the effect of a base catalyst on the relative conversion to oxirane (RCO) during the epoxidation of palm cooking oil; and (2) to develop a kinetic model for palm oil epoxidation with an applied base catalyst.

2 Materials and method

2.1 Materials

The cooking oil used in this study was palm oil obtained from EcoSafa. The oxidising agent was hydrogen peroxide (30–32 %) supplied by Chemiz. Formic acid (85 %, Chemiz) was used as the oxygen carrier, and acetic acid was 100 % glacial supplied by Chemiz. Sulphuric acid (96–97 %, Chemiz), NaOH, and HCl were used as catalysts. For the titration procedure, crystal violet and hydrogen bromide (48–50 % Chemiz) were used.

2.2 Epoxidation method

The epoxidation process was conducted using a water bath on a hot plate to maintain consistent reaction conditions. A measured amount of 50 g of cooking oil was mixed with hydrogen peroxide and formic acid at a molar ratio 1 : 1 : 1. A magnetic stirrer was added to ensure thorough mixing, and the beaker was immersed in the water bath. The reaction temperature was maintained at 80 °C, with constant stirring speed of 350 rpm to ensure uniformity. Two types of catalysts, sodium hydroxide (NaOH) and hydrochloric acid (HCl), were tested at various concentrations. NaOH was added in amounts of 0.5 g, 1.0 g, 1.5 g, and 2.0 g,

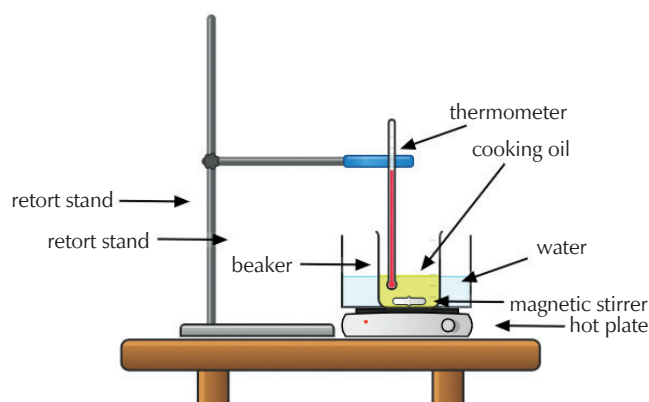


Fig. 1 – Apparatus setup for epoxidation process

while HCl was introduced at 0.2 g, 0.4 g, 0.6 g, and 0.8 g. The lower dosage range for HCl was selected due to its strong acidic nature and complete dissociation in water, necessitating stricter safety precautions than with NaOH. Throughout the experiment, temperature (80 °C) and stirring speed (350 rpm) were continuously monitored to ensure consistent conditions. Reaction progress was tracked by collecting samples at 10-minute intervals. Each sample was mixed with hydrogen bromide, and subsequently analysed through titration to measure the oxirane content.

2.3 Analytical method

In this section, the efficiency of the epoxidation process and the effects of acid and base catalysts were evaluated, the oxirane oxygen content (OOC) was measured using the standard formula.¹⁴ This involved reacting the sample with a hydrobromic acid (HBr) solution in glacial acetic acid to directly determine the OOC. The percentage conversion to oxirane (RCO) was calculated by comparing the OOC_{exp} with the OOC_{theo} value for palm oil, as shown in Eqs. (1)–(3).

$$RCO = \frac{OOC_{exp}}{OOC_{theo}} \cdot 100 \quad (1)$$

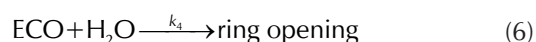
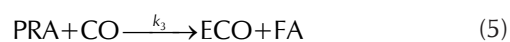
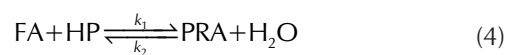
$$RCO = \left\{ \left(\frac{X_0}{A_i} \right) / \left[100 + \left(\frac{X_0}{2A_i} \right) (A_o) \right] \right\} \cdot A_o \cdot 100 \quad (2)$$

$$OOC_{exp} = 1.6 \cdot N \cdot \frac{(V - B)}{W} \quad (3)$$

where, X_0 is the initial iodine value, A_i is the molar mass of iodine, A_o is the molar mass of oxygen, N_o is the normality of HBr, V is the volume of the HBr solution used for the blank in millilitres (ml), V is the volume of HBr solution used for titration, and W is the weight of the sample.

2.4 Kinetic modelling of palm oil epoxidation

The epoxidation of palm oil was kinetically modelled by determining the reaction rate equation. This involved solving the numerical rate equation and computing the error between the simulated and experimental values.¹⁵ The kinetic constants of k_1 , k_2 , and k_3 are shown in Eqs. (4), (5), and (6). The kinetic data were represented by a model assuming constant volume in each phase throughout the epoxidation process, with all reactions considered homogeneous.



where FA, HP, PRA, CO, and ECO denote formic acid, hydrogen peroxide, performic acid, cooking oil, and epoxidised cooking oil, respectively. Based on the rate constants

k_1 , k_2 , and k_3 , a kinetic model for both the epoxidation process and epoxide ring degradation was formulated using a set of simultaneous differential equations, Eqs. (7)–(11).

$$\frac{d_{FA}}{dt} = -k_1[FA][HP] + k_2[PRA][water] + k_2[PRA]CO. \quad (7)$$

$$\frac{d_{HP}}{dt} = -k_1[FA][HP] + k_2[PRA][water] \quad (8)$$

$$\frac{d_{ECO}}{dt} = +k_3[ECO][FA] \quad (9)$$

$$\frac{d_{water}}{dt} = +k_1[FA][HP] - k_2[PRA][water] - k_3ECO.water. \quad (10)$$

$$\frac{d_{CO}}{dt} = -k_3PRA.CO. \quad (11)$$

$$\frac{d_{ECO}}{dt} = +k_3[ECO][FA] \quad (12)$$

$$\frac{d_{ring\ opening}}{dt} = +k_4[ECO][water] \quad (13)$$

Eq. (14) shows the objective function used in this kinetic model.

$$obj = \sum_{i=1}^n \frac{|ECO_i^{sim} - ECO_i^{exp}|}{n} \quad (14)$$

where, ECO_i^{sim} and ECO_i^{exp} indicate the predicted and tested epoxy concentrations. i is the i^{th} data point, and n is the total number of simulation and experiment data points.¹⁶

2.5 Fourier transform infrared spectroscopy (FTIR)

FTIR is an important analytical technique that provides a straightforward method for identifying the presence of specific functional groups in organic molecules by analysing their characteristic vibrational frequencies within the infrared frequency range.¹⁷ When an infrared signal passes through an organic compound, the functional groups vibrate at specific frequencies. In this study, the functional group present in the samples were identified using an FTIR spectrometer (Spectrum One, Perkin Elmer, USA). The FTIR spectra were recorded within a wavenumber range of 400–4000 cm^{-1} , which corresponds to the mid-infrared region associated with the fundamental vibration modes of the molecules.

3 Results and discussion

3.1 Effect of NaOH loading on RCO

Fig. 2 shows the epoxidation of cooking oil using NaOH as a base catalyst, with the reaction monitored over time for different NaOH amounts (0.5 g, 1.0 g, 1.5 g, and 2.0 g). At the start, the reaction proceeded rapidly for all NaOH amounts, with the product concentration (RCO) increasing

sharply during the first 20 min. This can be attributed to the catalytic role of NaOH in accelerating epoxide formation.¹⁸ At a NaOH loading of 0.5 g, the reaction rate was slower and the maximum RCO was lower. Increasing the NaOH amount to 1.5 g resulted in the highest concentration of the desired product at around 40 min. However, further increasing the NaOH amount to 2.0 g led to a lower peak RCO than that obtained with 1.5 g. This reduction may be attributed to excessive NaOH promoting undesirable side reactions or facilitating epoxide degradation.¹⁹

A decline in RCO was observed for all NaOH levels. This decrease was likely due to the breakdown of the epoxide, side reactions, or depletion of reactants. Based on these results, a NaOH amount of 1.5 g and a reaction time of 40 min appeared to provide the optimal balance between maximising product yield and minimising degradation. Further adjustments in parameters such as temperature and stirring speed may enhance process efficiency.

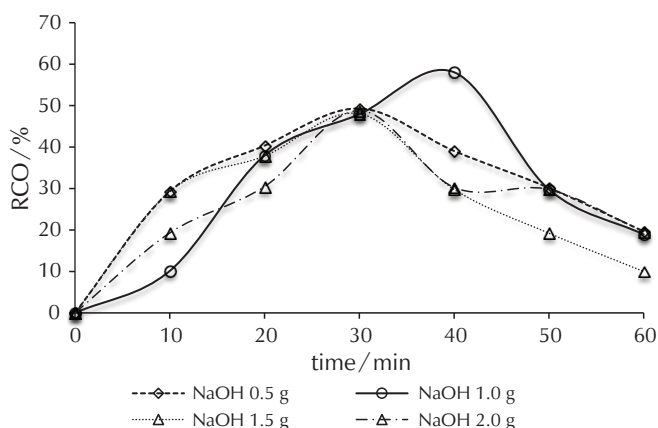


Fig. 2 – Effect of NaOH on RCO

3.2 Effect of HCl on RCO

Fig. 3 shows the epoxidation of cooking oil using HCl as a catalyst at different loadings of 0.2 g, 0.4 g, 0.6 g, and 0.8 g. The variation in catalyst loading in this experiment was to identify the optimum condition for the epoxidation process. The reaction progressed steadily for all parameters, with the product concentration increasing for all HCl amounts. The presence of HCl that acted as a catalyst accelerated the reaction, leading to the formation of the epoxide. The optimum reaction time for palm cooking oil epoxidation using HCl was observed to be approximately 40 minutes for all catalyst loadings, and the lowest was recorded at 10 min. The optimum amount of catalyst used in this experiment was 0.2 g HCl, with higher peaks and better efficiency. Higher HCl amounts, like 0.6 g, resulted in slower reaction rates and lower product formation, lower than those obtained at other catalyst levels, while the optimum amount like 0.2 g led to side reactions that reduced the product yield.

Beyond 40 min, a decline in RCO was observed for all HCl amounts, likely due to the breakdown of the product or

side reactions, especially with 0.8 g of HCl, where the drop was most pronounced.

Overall, an HCl loading of 0.2 g was identified as the optimal catalyst amount for this reaction, achieving the best balance between high product yield and minimal degradation within 40 min. This specific amount provided sufficient catalytic activity to generate the required *in situ* peracid for efficient epoxidation of palm oil without causing excessive acidity that could trigger unwanted side reactions.²⁰ Lower HCl loadings may result in insufficient peracid formation and lower conversion rates, while higher concentrations promote degradation of the epoxide through ring-opening reactions.

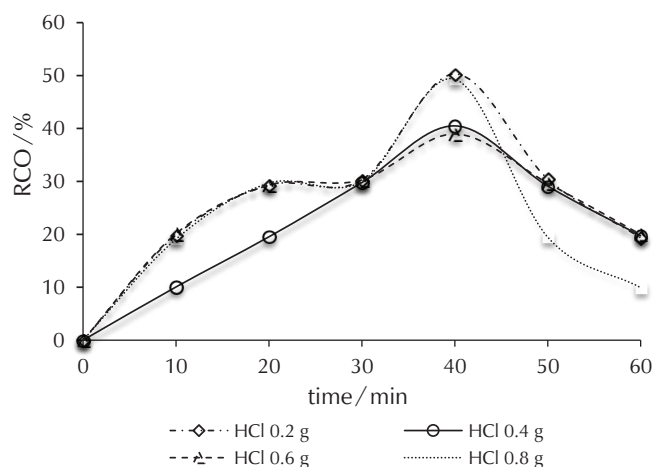


Fig. 3 – Effect of HCl on RCO

3.3 Comparison between optimum NaOH and HCl conditions

Fig. 4 compares the performance of NaOH (1.0 g) as a base catalyst and HCl (0.2 g) as an acid catalyst in the epoxidation of cooking oil, focusing on their relative conversion to oxirane (RCO) over a reaction time of 40 min. At the start (10 min), NaOH exhibited a stronger catalytic effect, achieving an RCO of 19.854 compared to 16.11 for HCl. However, at 20 min, HCl achieved an RCO of 30.272, slightly outperforming 29.3982 for NaOH. As the reaction progressed, the performance of both catalysts converged, and at 30 min, nearly identical RCO values were observed (38.3348 for NaOH and 38.945 for HCl).

At the 40-minute mark, both catalysts reached their peak performance; however, NaOH achieved a slightly higher RCO of 49.9609 compared to 47.314 for HCl. This result suggests that NaOH provided more consistent catalytic activity and was marginally more effective in driving the reaction towards its maximum efficiency. While both catalysts performed well under these conditions, NaOH proved to be the more effective option for optimising the epoxidation process.¹⁷ This outcome implied that NaOH maintained a steadier catalytic effect, possibly due to the milder and more stable reaction conditions it provides. The basic environment created by NaOH may help suppress unwanted

side reactions, such as the breakdown of the epoxide ring, which is more likely to occur in acidic media. Moreover, NaOH may enhance interactions between reactants and intermediates, contributing to a smoother reaction pathway. Consequently, NaOH stands out as a more effective catalyst in maximising the efficiency of the epoxidation process under the given conditions.

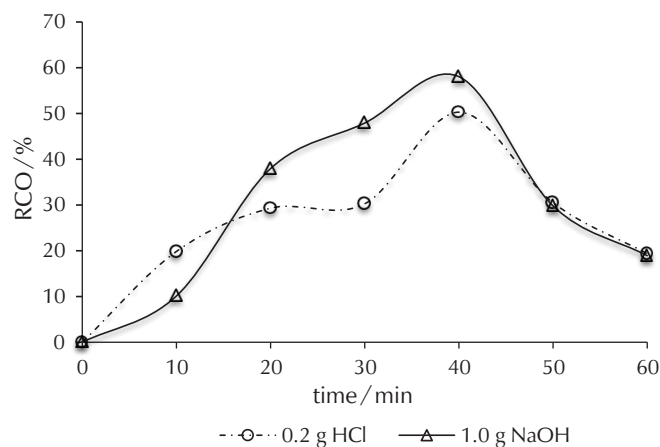


Fig. 4 – Optimum NaOH vs optimum HCl

3.4 FTIR analysis for NaOH

Fig. 5 shows the structural changes that occurred during the epoxidation of cooking oil, comparing untreated raw cooking oil (CO) with oil treated using NaOH. The x-axis represents the wavenumber, which corresponds to the energy of molecular vibrations, while the y-axis shows how much infrared light passes through the sample.

In the raw cooking oil, peaks observed around 1600–1700 cm^{-1} correspond to the presence of C=C bonds from unsaturated fatty acids. In the NaOH-treated oil, these peaks are less pronounced, indicating that a portion of the double bonds was successfully converted into epoxide groups during the reaction. The spectrum of the treated oil also shows changes in the range of 800–950 cm^{-1} , linked to the formation of epoxide groups (C–O–C). Additionally, variations in the 3200–3600 cm^{-1} range suggest the pres-

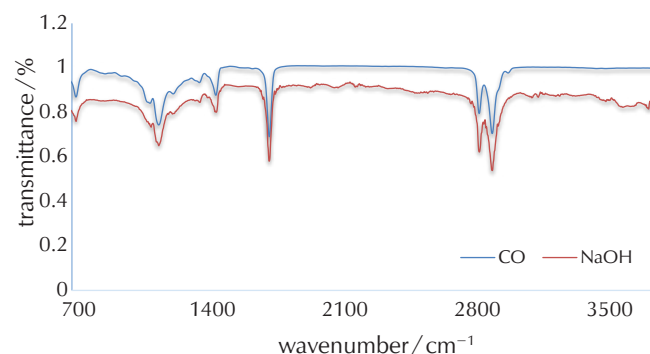


Fig. 5 – FTIR for NaOH

ence of moisture or hydroxyl by-products formed during the reaction. Peaks around 2800–3000 cm^{-1} , corresponding to C–H bonds in the fatty acid chains, were present in both spectra, confirming that the overall triglyceride structure remained intact. These results confirm that the NaOH catalyst effectively facilitated the epoxidation process by converting some of the double bonds into epoxide groups. However, the presence of residual peaks from the raw oil suggests that the reaction was not fully complete, highlighting both the efficacy of NaOH as a catalyst and the potential for optimisation of the reaction conditions to achieve higher conversion.

3.5 FTIR analysis for HCl

Fig. 6 presents the FTIR spectra comparing raw cooking oil (CO) with cooking oil treated using HCl as a catalyst, and revealing the changes that occurred during the epoxidation process. In the raw cooking oil, the peaks observed around 1600–1700 cm^{-1} , corresponding to C=C bonds in unsaturated fatty acids, are clearly visible. These peaks are less intense in the HCl-treated oil, showing that some of the double bonds were converted during the reaction. Additionally, new features in the 800–950 cm^{-1} range suggest the formation of epoxide groups, as this region is typically linked to C–O–C stretching vibrations.

The spectra also show differences in the 3200–3600 cm^{-1} region, associated with hydroxyl (–OH) groups. These changes may be due to moisture content or the formation of hydroxyl by-products during the reaction. Meanwhile, the peaks in the 2800–3000 cm^{-1} range, corresponding to C–H bonds in the fatty acid chains, remained similar in both samples, indicating that the overall structure of the oil had been preserved.

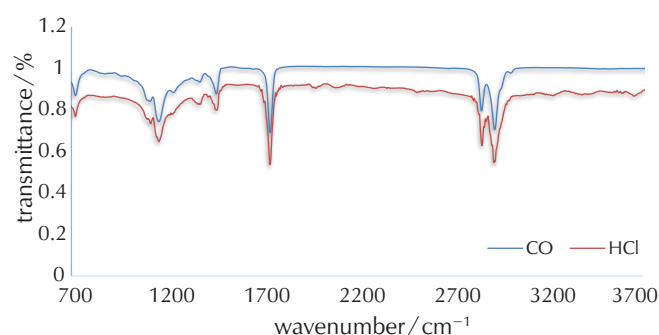


Fig. 6 – FTIR for HCl

3.6 Moisture content for cooking oil

Table 1 presents the moisture content of cooking oil and the catalysts (NaOH and HCl) before and after the epoxidation experiment. A slight reduction in moisture content across all samples was observed. For cooking oil, the moisture content decreased from 0.543 to 0.534 g, while NaOH and HCl showed reductions from 0.564 to 0.555 g and 0.586 to 0.578 g, respectively. The difference between before and after values ranged from 0.008 to 0.009, likely due to the elevated temperature maintained during the experiment, which was 90 °C.

Table 1 – Moisture content values

Sample	Moisture content/g	
	before	after
Cooking oil	0.543	0.534
NaOH	0.564	0.555
HCl	0.586	0.578

3.7 Numerical kinetic modelling

Table 2 outlines the kinetic parameters associated with the epoxidation of corn oil catalysed by NaOH and HCl. A key observation was the marked difference in the rate constant k_{11} , where HCl exhibited a significantly higher value (2.21 $\text{mol l}^{-1} \text{min}^{-1}$) compared to NaOH (0.04 $\text{mol l}^{-1} \text{min}^{-1}$). This suggests that the acid catalyst was more efficient in promoting the initial step, which likely involved the formation of a peracid or other oxidising intermediate. The faster generation of this species under acidic conditions supports the known reactivity trend where mineral acids enhance the formation of reactive peroxy compounds.

On the other hand, the values of k_{12} and k_2 remained consistent for both catalysts, at 15 and 30 $\text{mol l}^{-1} \text{min}^{-1}$ respectively. This uniformity may indicate that the subsequent steps in the mechanism, possibly the actual epoxidation and stabilisation of intermediates, were not significantly influenced by the catalyst. However, the rate constant k_3 , which could represent unwanted reactions such as ring opening, differed slightly between the two systems. NaOH showed a higher k_3 value (0.078 $\text{mol l}^{-1} \text{min}^{-1}$), hinting at a higher likelihood of side reactions that might lower the yield or purity of the desired epoxide.

When evaluating the model's performance, the error and coefficient of determination (R^2) provide further insight. Although the error value was marginally lower for the NaOH system (0.16 vs 0.21), indicating slightly better numerical fit, the R^2 values were relatively close (0.89 for NaOH and 0.85 for HCl). This implied that both kinetic models could reasonably describe the experimental data. Taken together, while NaOH may offer a tighter model fit, HCl demonstrated a stronger catalytic effect in the early stage, making it potentially more effective for faster epoxidation reactions if side reactions are adequately managed.

Table 2 – Kinetic constant for formation of epoxidised corn oil

Rate constant	NaOH/ $\text{mol l}^{-1} \text{min}^{-1}$	HCl/ $\text{mol l}^{-1} \text{min}^{-1}$
k_{11}	0.04	2.21
k_{12}	15	15
k_2	30	30
k_3	0.078	0.04
error	0.16	0.21
R^2	0.89	0.85

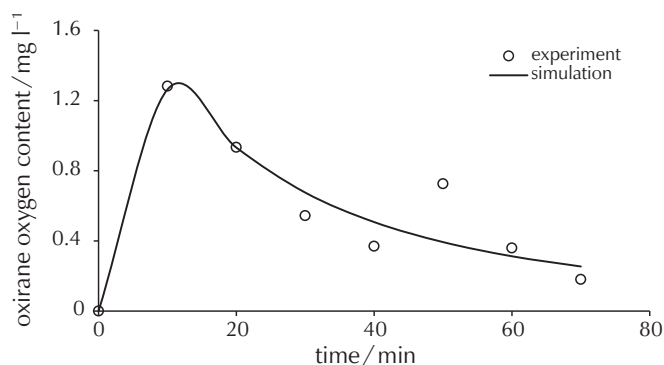


Fig. 7 – Comparison of epoxidised oleic acid concentration between simulation and experimental data with applied natural zeolite

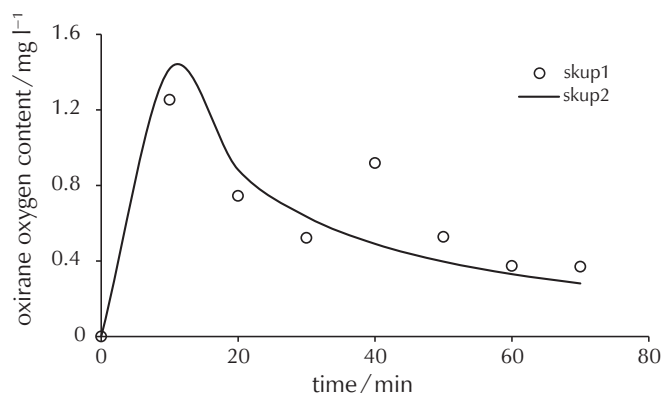


Fig. 8 – Comparison of epoxidised oleic acid concentration between simulation and experimental data with applied sulphuric acid

Figs. 7 and 8 present the comparison between simulated results and experimental data for the epoxidation of oleic acid, using natural zeolite and sulphuric acid as catalysts. In both cases, the oxirane oxygen content increased rapidly during the early phase of the reaction, reaching a peak within the first 15 min. This was followed by a gradual decline, which may be attributed to ring-opening reactions or the consumption of available double bonds. With natural zeolite (Fig. 7), although the simulation captured the overall trend, it slightly underpredicted the oxirane content at later time intervals. The differences suggested that, while the model reflects the general reaction behaviour, it may not fully account for the slower kinetics or secondary effects associated with the zeolite catalyst.

In comparison, the data from the sulphuric acid system (Fig. 8) showed a closer alignment between the experimental and simulated values. The peak oxirane oxygen content was higher than that of the natural zeolite system, indicating that sulphuric acid was more effective in catalysing the epoxidation process. The simulation curve also followed the experimental trend more accurately over time, pointing to a better model fit. This improved consistency suggests that the model parameters were more representative of the reaction dynamics under acidic conditions.²¹ Overall, sulphuric acid not only enhanced oxirane formation but also offered a more predictable pattern that was better captured by the kinetic model.

4 Conclusion

Based on experimental observations and kinetic modelling, both acid and base catalysts successfully promoted the epoxidation of palm cooking oil. NaOH displayed more consistent catalytic activity and slightly higher epoxide yield at the optimal reaction duration, while HCl, though initially faster, showed a tendency toward side reactions that could reduce overall product quality. The maximum RCO was observed at 40 min, with NaOH attaining 59.96 % and HCl 50.12 %. Beyond this point, both systems declined due to possible epoxide degradation, with NaOH and HCl dropping to 30.12 % and 29.88 %, respec-

tively, by 50 min. FTIR analysis supported these outcomes by indicating epoxide formation in both systems. The data suggest that NaOH offers a viable route for epoxidation with advantages in operational safety and environmental compatibility. This study contributes valuable insight into the comparative behaviour of acid and base catalysts and highlights the potential of base-catalysed processes for greener chemical modifications of vegetable oils.

Funding Declaration

Not applicable

Competing Interest

Not applicable

Authors' contributions

Mohd Jumain Jalil*: writing and experiment work; Norin Hafizah Rahim: Data curation; Intan Suhada Azmi, Mohammad `Aathif Addli, Muhammad Anwar Hamizi: Data curation.

Statement of Novelty

This study investigates the base-catalysed *in situ* epoxidation of cooking oil via peracid formation, presenting a sustainable and environmentally friendly route that eliminates the need for external epoxidising agents. By integrating reaction optimisation and kinetic modelling, the research aimed to enhance oxirane yield, minimise ring-opening side reactions, and introduce a scalable, low-waste process. The novelty lies in employing a base-catalysed mechanism – less commonly explored compared to acid catalysis – for efficient epoxidation, opening a new pathway for greener epoxide synthesis from low-cost feedstocks such as used cooking oil.

Statement of Industrial Relevance

The proposed base-catalysed epoxidation approach offers strong industrial relevance in the development of bio-based polyols, plasticisers, and polymer precursors. By improving conversion efficiency and reducing by-products, this method aligns with industry goals for cost-effective, eco-friendly, and renewable material solutions. The process utilises

abundant waste-derived oils and avoids corrosive acidic catalysts, potentially lowering equipment degradation and operational hazards – making it attractive for applications in coatings, adhesives, and biodegradable plastics where sustainable inputs are increasingly demanded.

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SAŽETAK

Bazno katalizirana epoksidacija jestivog ulja putem *in situ* nastajanja peroksikiselina

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Pretvorba biljnih ulja u visokovrijedne epoksidirane derivate sve više dobiva na važnosti jer industrija traži obnovljive i sigurnije alternative materijalima dobivenima iz nafte. Međutim, konvencionalni sustavi katalizirani kiselinama ograničeni su zbog korozivnosti, otežanog odvajanja i negativnog utjecaja na okoliš. Da bi se odgovorilo na te izazove, u ovom radu ispitata se epoksidacija palmina jestivog ulja putem *in situ* mehanizma nastajanja peroksikiselina, rabeći natrijev hidroksid (NaOH) kao bazni katalizator i klorovodičnu kiselinu (HCl) kao kiseli katalizator. Cilj je bio usporediti njihovu učinkovitost i reakcijsko ponašanje. Reakcije su provedene uz mravlju kiselinu i vodikov peroksid u kontroliranim uvjetima, pri čemu je količina katalizatora varirana da bi se ispitaio njezin utjecaj na nastajanje oksiranskih skupina. Uzorci su uzimani u intervalima od 10 min, a količina oksiranskog kisika određivana je titrimetrijski. Kinetičko modeliranje primijenjeno je za određivanje konstanti brzine reakcije i tumačenje mehanističkih razlika između katalitičkih sustava. NaOH je pokazao najveću relativnu konverziju u oksiran (RCO), dosegnuvši 59,96 % nakon 40 min, u usporedbi s 50,12 % za HCl, dok je FTIR analiza potvrdila uspješno stvaranje epoksidnih funkcionalnih skupina u oba slučaja. Ti rezultati ukazuju na potencijal bazno katalizirane epoksidacije kao ekološki prihvatljivijeg i operativno sigurnijeg pristupa za proizvodnju epoksidiranih biljnih ulja pogodnih za daljnju primjenu u polimernim materijalima.

Ključne riječi

Epoksidacija, palmino ulje, oksiranski prsten, kinetičko istraživanje, pretvorba biomase

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