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VEGETABLE OIL BASED EPOXIDIZED OIL: A SUSTAINABLE APPROACH

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Abstract: *The fatty acid content in vegetable oil will undergo epoxidation reaction to produce epoxide. The epoxidation reaction was to modify the structure of carbon-carbon double bond by removing unsaturated content into oxirane oxygen ring by using the oxidizing agents, that improved the oxidative stability of epoxide. The study of a greener epoxidation by using vegetable oil to produce an eco-friendly epoxide was increasing every year. Epoxidation of oleic acid was carried out by in situ performic acid to produce epoxidized oil. Since epoxide ring is highly reactive, the degradation of the oxirane was examine using water. Then, kinetic study was carried by developed a single-phase kinetic model to determine the value of kinetic rate constant, k for every reaction via MATLAB simulation. From the results of simulation data, it was proved that, epoxidtion have different reaction rate for different catalyst applied in epoxidation process.*

Keywords: *Vegetable Oil, An Eco-Friendly, Epoxidized Oil*

Introduction
Palm oil tree is a wild plant grow which originated from West Africa and give scientific named as Elaesis guineensis. The plant has been introduced to Malaysia in early 1870 during British Coronel as ornamental plant and change to commercial plant by 1970 as economy purpose (Jalil et al., 2019). Palm oil tree in naturally can be produce hundreds small shape fruit from several bunch in a time which divided into four type of structure which are exocarp, mesocarp, endocarp and kernel (Sardari et al., 2019) as hown in Figure 1. As in 1970, Malaysia government begin to encourage for increasing the industrial of refining crude palm oil by introduce the incentive the export of refined palm product. The Malaysia palm oil production is significantly increase over the years, just in 1985 the total production is 4.1 million tonnes rises about 2 million in 1990 which is 6.1 million tonnes and in 2010, the production of palm oil recorded is 16.9 million tonnes (Vanags et al., 2018). Moreover, 1.3 million tonnes of the

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PKO production in 1999 and reached 4.7 million tonnes in 2011 (Kushairi et al., 2019). In 2012, Malaysia currently dominated around 35% of world palm oil production and 43.1% of world palm oil export, the statistic made the small country of Malaysia have an important duty to fulfilling the demand of palm oil to more than 150 countries worldwide.

Figure 1: The cross-section of Palm Oil Fruit

Petroleum is a non-renewable resource (Hong et al., 2020). It gives a lot of benefits to human as human extract petroleum to produce many products for daily consumption such as fuel oil, plastic, and others. Large amount of this resources can give a bad impact whereas the extraction oil of fuel inhabits bad consequences especially aquatic life (Jalil et al., 2021). There will be the oil spillage everywhere on the top of the seas. In addition, the road and powerlines development will inhabit the impact of noise pollution, large amount of carbon produces from transportation industry and this impact give large consequences especially our eco-system (Jumain et al., 2022). Epoxidation is the result of extraction of palm fruit to produced epoxidized oil throughout chemical reaction. Epoxidized oil also known as oxiranes that contain cyclic with a reactive three-membrane ring where can be obtained by reaction of peroxyacid with vegetable oil (Riduan et al., 2021). The peroxyacid first needs to be generated *in-situ* by reaction of concentrated hydrogen peroxide with formic acid (Jalil et al., 2021). Epoxidized oil can be classified as biodegradable material and can be degraded as it comes from palm fruit. These epoxides are valuable intermediates for laboratory syntheses as well as chemical production as they can be easily transformed into required functionality by means of regioselective ring opening reaction (Hidayu et al., 2019)(Faujdar & Singh, 2021). The synthesis of epoxides has gained more interest when enzymes began to be used as catalyst with regards to the creation of environmentally friendly process. *In-situ* epoxidation of vegetable oil generate performic acid from a reaction of carboxylic acid in the presence of catalyst with formic acid (da Costa et al., 2022).

Research Methodology

Materials

The aqueous formic acid (85%), hydrogen peroxide (30%), catalyst sulphuric acid (95%) is all purchased from the Merck Sdn. Bhd. Other materials used for this experiment were crystal violet, hydrogen bromide (48%) and glacial acetic acid (100%) for the titration.

Experimental Set-up

The epoxidation process is carried out by preparing all the materials such as formic acid, hydrogen peroxide and oleic acid with certain molar ratio of concentration. In the process, the solution of catalyst, formic acid, and oleic acid are added simultaneously into the magnetic stirrer. The mixtures are stirred at certain fix feed speed at 300 rpm and heated at desired temperature which is constant. The hydrogen peroxide is being added dropwise to the mixture. The detail of experimental design in the production of DHSA and epoxidation process are tabulated in Table 1.

Table 1: Experimental design of reaction parameters

Reaction parameter	Range	Units
Temperature	75	°C
Catalyst	0.5	Gram
Speed	300	Rpm

The kinetic mechanism of epoxidation vegetable oil is described by the coupled that express of changing of the concentrations of reactors. Both reactions can be derived as Equation 3 and 4:

$$Formic\ acid + \ Hydrogen\ peroxide \underset{k2}{\overset{k1}{\rightleftarrows}} Performic\ acid + \ Water \quad (3)$$

$$Performic\ acid + Unsaturated\ fatty\ acid \overset{k3}{\rightarrow} Epoxy \quad (4)$$

Results and Discussion

Influence of formic acid to unsaturation oleic acid molar ratio

From this process, it clearly shown that the presence of hydrogen peroxide is important to form the epoxide and it can be used in the hydrolysis process which reacts with water to produce the DHSA as shown in Figure 1. The previous study stated that in water solution, the concentration of hydrogen peroxide can be increased because the fact that the water freezes and evaporates quicker than hydrogen peroxide which means that the higher reactivities can be achieved if the concentrations of hydrogen peroxide also increased (Janković et al., 2020). According to previous study as well, hydrogen peroxide is commonly used in bleaching as it is a strong reducing and oxidizing agent (Jalil et al., 2019). In addition, with organic compounds, the hydrogen peroxide also able to react well. Hence, the previous researcher has initiated the presence of hydrogen peroxide in the epoxidation of unsaturated acids and via this process able to produce the DHSA.

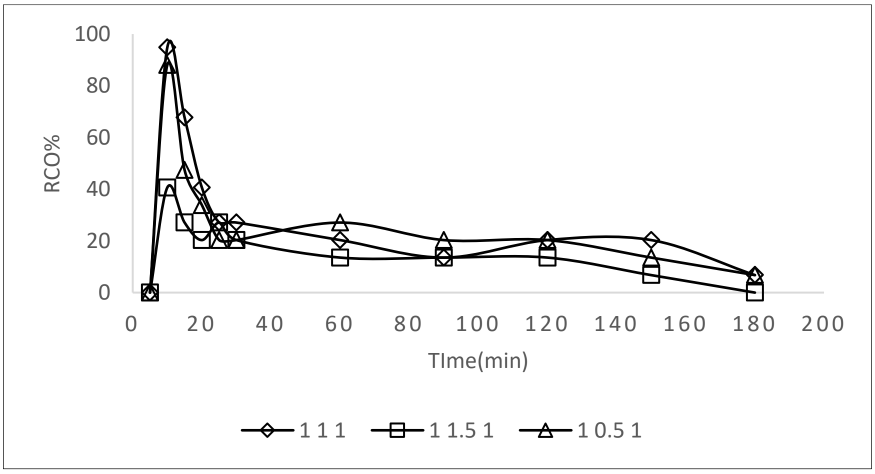

Figure 1: % RCO different based on different formic acid molar ratio

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Reaction rate determination

The epoxidation especially for vegetable with performic acid is way faster than the one with the peracetic acid. The epoxidation of palm oil is an example of a reaction with many stages. It is critical for energy and mass balance from the perspectives of energy integration and safety. As a result, a modelling method is required to solve this system in a way that minimises the number of parameters. Perhydrolysis and peroxyformic acid breakdown processes occur during the manufacture of peroxyboric acid using formic acid and hydrogen peroxide (Faujdar & Singh, 2021). When gaseous breakdown products spread to the gas phase, it is an exothermic liquid phase reaction system (Ren et al., 2015). By using ordinary differential equations, ODE45, to analyse the experimental data, can determine the kinetic optimization value. It can reduce the association between the proportional factor and the activation energy during the parameter supplied to the bare minimum. However, in the organic phase, the model tends to underestimate the concentration of oleic acid intermediates and epoxidized compounds. This is related to accurately estimating ring-opening (degradation) when the value of epoxy is constant and compounds that desire to degrade it are added as tabulated in Table 2.

Table 2: Best-fitting values of the parameters used in the kinetic model

	k_1	k_2	k_3	Sum of error
Heterogeneous catalyst	0.1801	40.000	0.9691	0.1127

Conclusions

Epoxidized vegetable oils have increased extraordinary significance as of late because of the way that they are gotten from inexhaustible and reasonable assets and in this manner saw as natural inviting. Although oil crops are sustainable assets, epoxide from fresh vegetable oil edits in extensive amounts has been esteemed unsustainable. Generation of bio-ointment from oilseed products will require huge zones endurable land. This has led to contend with the development of oilseed yields and along these lines is as of now a tremendous questionable issue. These issues feature the requirement for elective assets that could be more monetary than customary oilseed trims and wouldn't bring contention up in nourishment security. In this research project, the objectives on the experimental data on the effect of formic acid and agitation speeds to the epoxidation process of palm oil-based on oleic acid also the characterization of physicochemical properties DHSA production by hydrolysis of epoxidation.

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