UNIVERSITI TEKNOLOGI MARA

OPTIMIZATION OF EPOXIDIZED SUNFLOWER OIL-DERIVED LINOLEIC ACID (ESOLA) VIA IN SITU GENERATED PERACID

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ABSTRACT

Epoxidized vegetable oil is a versatile material with a wide range of applications. Studies relating to epoxidation of fatty acids have garnered much interest in recent years due to the rising demand for eco-friendly epoxides derived from vegetable oils. However, the epoxidation process is often inefficient and can produce undesirable by products. In this study, a Taguchi experimental design was used to optimize the epoxidized sunflower oil-derived linoleic acid (ESOLA) using in situ generated peracid. ESOLA was produced by using in situ formed peracids. Peracids was formed by mixing formic acid/acetic acid as the oxygen carrier with hydrogen peroxide as the oxygen donor. The four factors studied were hydrogen peroxide/linoleic acid molar ratio, stirrer speed, type of oxygen carrier and catalyst loading. The results showed that the optimum conditions for epoxidation were a hydrogen peroxide/linoleic acid molar ratio of 1:1, a stirrer speed of 300 rpm, oxygen carrier of formic acid and a catalyst loading of 0.2 oz. Under these conditions, the epoxidation yield was 63.8%. The order of significance of the process parameters were molar ratio of hydrogen peroxide to linoleic acid, followed by the type of oxygen carrier, stirring speed and catalyst loading. The presence of the oxirane ring was confirmed by its characteristic absorption peak at the wavenumber of 880 cm^{-1}. A mathematical model was developed using the Runge-Kutta 4th Order method, a numerical integration method. The model was then integrated with a genetic algorithm optimization method to determine the process model that best fit the experimental data. Using MATLAB software, the model was iterated 100 times to obtain the reaction rate constants. The optimized ESOLA reaction rate constants were: k_{11} =1.662 $mol{\cdot}L^{-1}{\cdot}min^{-1}$, k_{12} = 10.421 $mol{\cdot}L^{-1}{\cdot}min^{-1}$, k_2 = 0.052 $mol{\cdot}L^{-1}{\cdot}min^{-1}$, and k_3 = 0.011 $mol{\cdot}L^{-1}{\cdot}min^{-1}$. Overall, the results of this study will be useful for the development of environmentally friendly methods for ESOLA.

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CHAPTER ONE
INTRODUCTION

1.1 Background of the Study

In recent years, vegetable oil has the highest demand especially in the manufacturing field as the raw material contribute to the lower pollution of the environment [1]. Vegetable oil as a renewable source that can undergo the chemical process to replace the used of petroleum based [2]. Moreover, the composition of fatty acid contains oleic acid and linoleic acid that being used to produce epoxide product [8]. Though most are made from petroleum-derived oils, epoxides can be produced from various feedstocks. However, the gradual depletion of fossil fuels and the high price of petroleum-derived oils leads to the search for renewable feedstocks to have epoxides. Using petroleum-derived oils also harms the environment and human health during spillage, leading to global warming, smog, and eutrophication [1]. Hence, much attention has been given to the epoxidation of vegetable oils such as palm oil as an alternative to petroleum-derived oils.

In general, fatty acids have different levels of saturation. Fatty acids such as linoleic acid and oleic acid contain three double bonds and one double bond respectively, and therefore they are categorized as unsaturated fatty acids. Oleic and linoleic acids have the highest lipid content among all fatty acids and therefore, these fatty acids can be harnessed to produce good skincare products. Despite the benefits of oleic and linoleic acids, these fatty acids are often neglected and regarded as low-value products. The composition of fatty acids in sunflower oil is shown in Figure 1.1. It can be observed from the pie chart that linoleic acid constitutes the largest percentage of fatty acid composition, followed by oleic acid with a value of 63.42% and 23.64%, respectively for consideration unsaturated fatty acid. Owing to the high percentage of double-bond fatty acids in sunflower oil, the modifications of these fatty acids play a key role in the production of marketable products in the manufacturing industry.