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OPTIMIZATION OF EPOXIDATION REACTION OF PALM OIL METHYL ESTER USING RESPONSE SURFACE METHODOLOGY

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Abstract

The utilization of vegetable oils modification as a renewable raw material has attracted many researchers. In particular, epoxidized fatty acid methyl ester derived from plant oils such as palm oil can be used as stabilizers and plasticisers in polymer, as lubricant additives and as intermediate product for synthesis of polyurethane foam. Palm oil methyl ester (POME) is a potential raw material for synthesis of epoxidized palm oil methyl ester (EPOME) as palm oil contains high amount of unsaturated fatty acid and excess amount of palm oil production in Indonesia. Palm oil is converted to palm oil methyl ester and then followed by epoxidation reaction to produce EPOME. A response surface methodology was utilized to determine the influence of molar ratio of POME/H_2O_2 and reaction time on reaction conversion and oxirane content. In addition, the optimal operating conditions are determined and indicated by high oxirane content. The epoxidation reaction was performed in a batch reactor using acetic acid as an oxygen carrier. A central composite design, with two independent variables and two response functions was performed to determine the influence of the input variables. The conversion of reaction increased with increasing reaction time and molar ratio of POME/H_2O_2. The optimal operating condition indicated by maximum oxirane value was achieved with a reaction time of 4.13 hours and at a molar ratio POME/H_2O_2 of 1:1.83.

Keywords: *Palm oil, epoxidation, reaction conversion, oxirane content*

I. INTRODUCTION

The existence of double bonds in vegetable oils and fats has attracted many researchers to study their derivatives for numerous applications particularly as supplies of petroleum cannot be guaranteed. Therefore, attention has been paid to the application of derivative vegetable oils in the chemical industry as vegetable oils are renewable resources (Goud et al., 2007). Double bonds in the vegetable oils can be converted chemically or enzymatically to produce epoxidized oil that has several applications such as stabilizers of polymer materials and plasticizers (Du et al., 2004). Hence, the world's demand for epoxidized oil is projected to increase each year.

Indonesia is the largest palm oil production in the world. Palm oil provides an attractive alternative raw material to produce epoxidized palm oil methyl ester (EPOME) as it contains unsaturated bonds that may be converted into epoxide groups. To date, palm oil used primarily as cooking oil and in the future the amount of palm oil in Indonesia will be overstock. Typically, the unsaturated content of palm oil indicated by iodine value ranges from 52.9-60 (Bailey, 1951). Clearly, palm oil has enormous potential as a renewable resource to produce EPOME and research is required to develop its added value by converting the double bond content in palm oil. Epoxidized vegetable oils are one of the largest applications of vegetable oil with annual product of about 200,000 tons mainly for use as a plasticizer but the largest potential application of vegetable oil is for polyols for polyurethane.

The unsaturated fatty acid content in vegetable oils is measured by the iodine value which may vary from zero to about 200. One criterion to ensure high yields of epoxidized oil is the use of vegetable oils with high iodine value to provide a high content of oxirane groups. The common method for production of EPOME in industry is with conversion of palm oil to palm oil methyl ester (POME) through transesterification reaction followed by epoxidation reaction of unsaturated bonds with percarboxylic acids and acids or enzymes as catalysts (Cai et al., 2008).

1. Literature Review

It opportune to clarify exactly what is meant by epoxide. The term normally is defined as cyclic ether which consists of three elements in the epoxide ring. The term oxirane usually is used to refer to epoxide (according to IUPAC). The chemical structure of epoxide is illustrated in Figure 1 (Solomons, 1992):

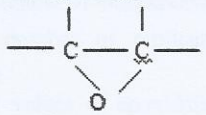

Figure 1 Epoxide Group

The general process for production of EPOME is transesterification reaction to produce methyl ester/POME then followed by epoxidation reaction wherein an alkene is reacted with an organic peroxy acid. The term peracid is frequently used and refers to a