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SYNTHESIS AND CHARACTERIZATION OF N-ACYL ALKANOLAMIDE SURFACTANT FROM FATTY ACIDS AND ALCOHOL AMINES USING SODIUM METHOXIDE CATALYST

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ABSTRACT

Surfactant is a substance added to the liquid that improves the spread's properties by weakening the liquid's surface voltage. Surfactants have a molecular structure consisting of hydrophilic groups and hydrophobic groups. Surfactant needs in Indonesia continue to increase along with the development of industries in Indonesia. This study will be synthesized by the N-acyl surfactant alkanolamide using one type of alcohol amine, namely diethanolamine, through a reaction of amidation between fatty acids and using organic solvents tert-amyl alcohol. The catalyst used is a chemical catalyst, namely sodium methoxide. Furthermore, the purpose of this research is to determine the effect of reaction variables and determine the characteristics of the N-acyl alkanolamide surfactant in the form of acidic numbers and spreading numbers. This study showed for lauric acid, palmitate acid, and the best stearate acid at 90 ^{o}C reaction temperatures and 2-hour reaction times, while the best succinic acid at 100 ^{o}C and the reaction time of 2 hours. The relationship between reaction rate and time is directly proportional; the longer the reaction time, the higher the rate. Conversion relationship with reaction time is directly proportional, where conversion will increase with the increase in reaction time. However, this does not happen to all fatty acids. Due to the increase in reaction time, it will not provide significant results on surfactant products. The relation between the reaction temperature and the conversion acquisition at the time obtained decreased along with the increase in reaction temperatures. The acid numbers in the best conditions in a row are 40.67 for N-palmitoyl diethanolamine, 47.41 for N-lauroyldiethanolamine, 63.11 for N-succinyl diethanolamine, and 22.44 for N-stearoyl diethanolamine. The saponification number in the best conditions in a row is 36.47 for N-palmitoyl diethanolamine, 23.84 for N-lauroyldiethanolamine, 57.50 for N-succinoyldiethanolamine, and 7.01 for N-stearoyl diethanolamine.

Keywords: surfactant, alkanolamide, diethanolamine, amidation reaction, tert-amyl alcohol.

INTRODUCTION

Surfactant (surface active agent) is a substance added to a liquid that is useful for increasing the spreading properties by weakening the surface tension of the liquid. The ability of surfactants to reduce stress is caused by surfactants having an amphipathic molecular structure, a molecular structure consisting of a hydrophilic group and a hydrophobic group. Surfactants have been widely applied in various industries, including emulsifiers, emuliency, defoaming, detergency, and so on. The need for surfactants in Indonesia is increasing along with the sector's development, while the production of surfactants is limited [1].

Amides are carboxylic acid derivatives where the -OH of the acid has been replaced by -NR2 where R=H, alkyl, aryl, etc. Various methods have been developed for the preparation of amides. Most involve the reaction of amines with activated carbonyl compounds (i.e., hydrochloric acid), very similar to the method used to make esters [2]. The construction of amide catalytic chains is one of the most critical reactions in environmentally friendly chemistry. The formation of amide chains is significant in many fields of chemistry. Many parties are interested in developing catalytic methods to form amide chains from various raw materials [3].

Types of Surfactants

Anionic surfactants

Anionic surfactants are commonly used as surfactants in cleaning applications. This type of surfactant can emulsify oil particulates from the surface. A suitable anionic surfactant can be seen from the critical micelle concentration (CMC) value, an important attribute.

Non-ionic surfactants

Non-ionic surfactants are primarily used in the textile, paper, food, plastic, glass, fiber, and health industries. Most non-ionic surfactants exist in liquid form; their solubility in water decreases with increasing temperature. Non-ionic surfactants have different physical chemistry from ionic surfactants. Non-ionic surfactants also have better ability than ionic surfactants [4].

Cationic surfactants

Surfactants in which the alkyl moiety is bonded to a cation. Examples include alkyl trimethyl ammonium salts, dialkyl-dimethyl ammonium salts, and alkyl dimethyl benzyl ammonium salts.

Amphoteric surfactants

It is a kind of Surfactant whose alkyl groups have a positive and negative charge. For example, surfactants containing amino acids, betaine, phosphobetain [5].

N-acyl alkanolamide is a non-ionic surfactant mainly used as lubricants, emulsifiers, detergents, and cosmetics. Non-ionic surfactants are widely used in food, pharmaceutical, and agricultural industries. For example, in the pharmaceutical industry, it is used to increase the solubility of drugs or enhance transepithelial drug transport and increase their bioavailability [6]. The physicochemical properties of surfactants can be distinguished based on the length of the hydrocarbon chain [7].

Chemical synthesis of N-acyl alkanolamides has been developed but is not very specific and requires high temperatures, above 100^{o}C and usually 180^{o}C. In the synthesis of N-acyl alkanolamide, lipase is commonly used because it has high stability in organic media, this enzyme's ability to accept a variety of substrates, and the nature of the reaction [8]. The use of N-acyl alkanolamides is extensive, for example, in shampoos, detergents, cosmetics, lubricants, foam control agents, and water emulsifiers. When reacted with amine alcohols at a temperature of 140-160 °C for 6-12 hours, fatty acids or fatty acid methyl esters will produce N-acyl ethanolamide [9].

MATERIALS AND METHODS

Fatty Acids and Amine

Palmitic acid ($C_{16}H_{32}O_2$) is a saturated fatty acid. At room temperature, palmitic acid is a white solid with a melting point of 64 ^{o}C [10]. Palmitic acid is a long-chain saturated fatty acid in triglycerides in vegetable or animal oils and other fatty acids. The palmitate content in PKO is 9% by weight and in CPO 46% by weight [11].

Lauric acid ($C_{12}H_{24}O_2$) was chosen as a source of fatty acids because the amides of lauric acid are widely used in various cosmetic and medicinal products [12]. Lauric acid is abundant in palm kernel oil, produced as a by-product of palm oil processing, and is present in significant and sustainable quantities in Indonesia. In addition, the by-product of the amidation reaction of amines with fatty acids is water which is safer than methanol [13].

Stearic acid ($C_{18}H_{36}O_2$) is white or slightly yellowish crystals, has a slight odor, and tastes like fat. Stearic acid is one type of saturated fatty acid, where saturated fatty acids tend to be more stable than unsaturated fatty acids [14]. Stearic acid with a molecular weight of 284.484 g/mol is found in animal and plant fats and oils. Stearic acid is widely used as a coating because it is non-toxic, easy to obtain, and hydrophilic. Although stearic acid has many benefits, it does not dissolve in dilute acid solutions. It can happen because surfactants can make insoluble molecules enter the micelles in the form to achieve solubility [15].

Succinic acid ($C_4H_6O_4$) is a commercial compound widely used in industry. Succinic acid is commonly used in the food sector, for example, in the soy sauce, fruit juice, and other dairy products industries. Not only that, but succinic acid is also used in the textile industry in the dyeing process, drug industry, varnish, paint, and photographic plates [16].

Diethanolamine (DEA) will be used as an amine source. The choice of diethanolamine (DEA) as an amine source in this study is because diethanolamine has been widely used as the liquid cutter, cosmetic field, as a dispersing agent for agricultural chemicals, and as an absorber for acid gas [17]. The presence of oily impurities such as sebum causes the stability of the foam of liquid soap or shampoo to be drastically reduced. To overcome this, a foam stabilizer is needed, which functions to stabilize and change the structure of the foam so that more foam is obtained, concentrated with less foam [5]. In addition, diethanolamine also functions as a stabilizer and foam developer.

Catalyst and Chemicals

This research will synthesize surfactant N-acyl alkanolamide through an amidation reaction using an organic solvent, tert-amyl alcohol. The catalyst used is a chemical catalyst, namely sodium methoxide, because it is more economical than biochemical catalysts and provides a shorter reaction time [18]. Analytical materials, namely KOH, Phenolphthalein, Acetone, Ethanol, citric acid, and HCl from E Merck.

Synthesis Amidation Reaction

Fifteen gram of fatty acid and diethanolamine was placed into a three-neck flask with a ratio (w/w) of2:1. Tert-amyl alcohol with a ratio (w/w) of 3:1 was added to the reaction mixture and stirred at 250 rpm until the reactants dissolved. Sodium methoxide was then added into the reaction vials with a ratio of 5% of fatty acids arranged in the experimental design in Table-1.

Five mL of 10% citric acid was added to the mixture to precipitate the catalyst. The precipitated catalyst is separated by filtration. The solvent tert-amyl alcohol was removed by evaporation. The product formed is taken and washed with acetone to clean it from amine residue. The product mixed with acetone was then evaporated again. Water is easily separated by dissolving the product mixture with acetone. In contrast, if the amide is obtained from the reaction between lauric acid methyl esters and amines, the methanol by-product obtained must be separated by evaporating methanol or working at pressures close to vacuum [19].

N-acyl Alkanolamide Analysis

The purified surfactants were analyzed for acid number and saponification number. Determination of acid number refers to the acid number test of SNI, 1998 by adding 10 ml of 95% ethanol to 2 g of product and then titrating with 0.1 N KOH until the sample turns soft pink. While the saponification number refers to the ASTM D5558 Standard Test Method, by adding 25 ml of 0.5 N KOH into 2 g of product, the mixture was homogenized and heated. The cooled mixture was titrated with 0.5 N HCl until the sample changed colour to transparent or whitish.

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FT-IR Analysis

FT-IR (Fourier Transform Infrared) spectroscopy is an excellent analytical technique for identifying the molecular structure. The main component of FT-IR spectroscopy is the Michelson interferometer, which disperses infrared radiation into frequency components. Its use gives the advantage of the FT-IR method compared to conventional infrared spectroscopy methods and other spectroscopic methods. FT-IR spectroscopy was used to analyze the absorption of functional groups of compounds contained in the reaction products in this study.

HLB Value Analysis

The HLB number for optimizing surfactants has been applied to almost all industries wherever surfactants are needed in product development, including pharmaceutical formulations, food, cosmetics, pesticides, and herbicides. However, less research has been done on the development of microbial pesticides [20]. Therefore, the formula for calculating the HLB value can base on analytical or compositional data.

Table-1. Experimental design of N-acyl diethanolamideamidation reaction and % conversion.

Fatty Acids	Temperature (°C)	Agitation Speed (rpm)	Time (hrs)	Fatty Acids : Amine (w/w)	Substrate : Solvent (w/w)	Catalyst (%)	Conversion (%)
Palmitic Acid	90	250	2	1:2	1:3	5	83.125
			3				81.250
			4				80.625
	100	250	2	1:2	1:3	5	81.563
			3				79.375
			4				80.938
Lauric Acid	90	250	2	1:2	1:3	5	94.444
			3				93.148
			4				92.315
	100	250	2	1:2	1:3	5	93.519
			3				92.778
			4				92.407
Succinic Acid	90	250	2	1:2	1:3	5	91.881
			3				91.556
			4				89.553
	100	250	2	1:2	1:3	5	97.700
			3				96.509
			4				95.399
Stearic Acid	90	250	2	1:2	1:3	5	60.800
			3				51.600
			4				47.200
	100	250	2	1:2	1:3	5	52.400
			3				47.200
			4				40.800

RESULTS AND DISCUSSIONS

This study aimed to obtain a high yield of fatty amides through the amidation reaction. The fatty amide yield is the independent variable's temperature and time reactions while the response is measured and optimized.

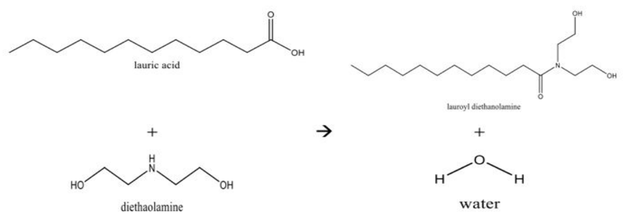

Figure-1. Reaction for the formation of N-lauroyldiethanolamide.

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Determination of Temperature and Reaction Time

This study aims to determine the best value of each process variable, where the observed process variables are temperature and reaction time. This research was conducted by reacting fatty acids and diethanolamine with tert-amyl alcohol as a solvent and sodium methoxide as a catalyst. The best reaction temperature and time can be determined based on the conversion. The conversion value can be done by sampling every hour at the 2nd, third and fourth. Where the equation can calculate the value of the conversion:

$$\% = \frac{\text{Initial acid number} - \text{Final acid number}}{\text{initial acid number}} \text{x} 100 \qquad (1)$$

So, by using Eq-1, the resulting surfactant conversion is obtained. In Table-1, it can be seen that the highest conversion obtained for each fatty acid occurred at 2 hours; the reaction temperature was 90 °C with a stirring rotation of 250 rpm. However, the best conversion results were obtained at 2 hours; the reaction temperature was 100 °C with a stirring rotation of 250 rpm. Based on these data results, the best conversion was obtained at a temperature of 90 °C and a reaction time of 2 hours with the conversion of lauric acid at 83.12%, palmitic acid 94.44%, and stearic acid at 60.8%. Meanwhile, succinic acid obtained the best conversion at 100 °C and a reaction time of 2 hours at 97.71%.

Relation of Reaction Time (t) to Reaction Rate (-rA)

In run I, the reaction rate increased at the 3rd hour and decreased at the 4th hour, and this also happened at runs II, III, IV, VI, VII, and VIII. The reaction rate of the run V is obtained, which constantly increases with increasing time. The interaction between surfactant molecules and the substrate can decrease and increase the reaction rate or change the product of the reaction, where sometimes the surfactant molecule acts as the reactant. The reaction rate of anionic surfactants decreases with an increasing chain length of the surfactant [21].

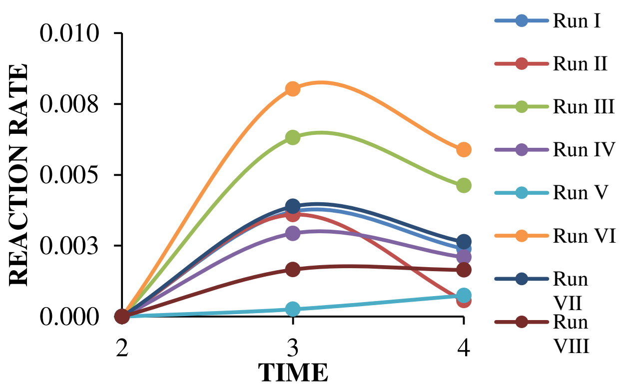

Figure-2. Relation of reaction time (t) to reaction rate (-rA).

The decrease in reaction rate is influenced by the decreasing concentration of reactants caused by increasing reaction time so that more reactants react to become products. It can be seen in the equation below:

$$-r_A = \frac{dC_A}{dt} = kC_A \qquad (2)$$

From Eq-4, the reaction rate is influenced by concentration, reaction time, and the rate constant of the reaction. The relationship between reaction rate and reaction time is directly proportional; the longer the reaction time, the more the reaction rate will increase.

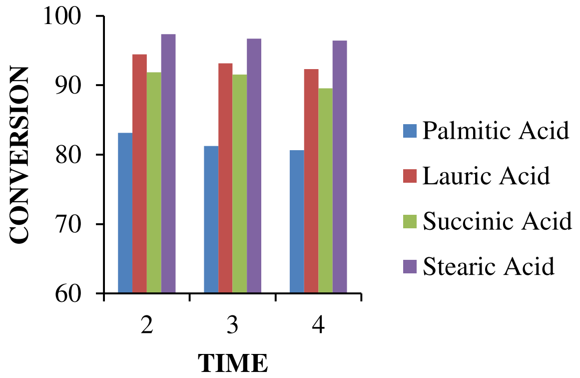

Figure-3. Relation of reaction time (t) to % conversion at 90 °C.

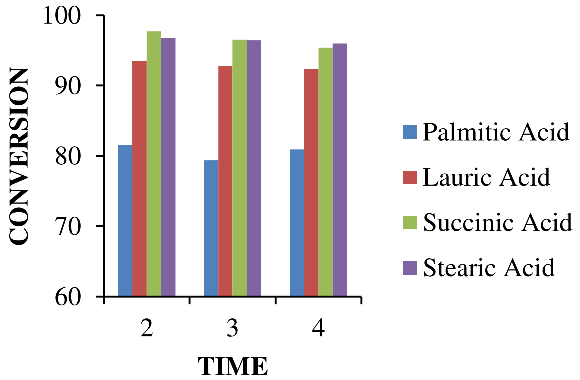

Figure-4. Relation of reaction time (t) to % conversion at 100 °C.

Relation of Reaction Time (t) to % Conversion

In Figure-3, it can be seen the relationship between reaction time and conversion gain at 90 °C, which can be seen in the figure that the conversion obtained for each fatty acid has decreased in conversion over time. For example, palmitic acid obtained a conversion of 83.13%, 81.25%, and 80.63%. Lauric acid obtained 94.44%, 93.15%, and 92.31%. Succinic acid obtained 91.88%, 91.56%, and 89.55%. Moreover, stearic acid obtained 60.8%, 51.6%, and 47.2%.

In Figure-4, it can be seen that the relationship between reaction time and conversion gained at 100 °C has decreased conversion over time. However, the conversion of palmitic acid obtained increased at the fourth reaction time, where palmitic acid obtained a conversion of 81.56%, 79.38%, and 80.94%. Lauric acid obtained 93.52%, 92.78%, and 92.41%. Succinic acid obtained 97.70%, 96.51%, and 95.40%. Moreover, stearic acid obtained 52.4%, 47.2%, and 40.8%.

Product conversion is influenced by reaction order, reaction constant, reaction rate, reactant concentration, and reaction time. Where this can be seen in the following equation:

$$X_A = \frac{C_{A0} - C_A}{C_{A0}} \tag{3}$$

So, based on the above equation, it can be known that the conversion relationship with reaction time is directly proportional, where the conversion will increase with increasing reaction time. However, this does not occur in all fatty acids at either 90°C or 100°C reaction temperatures. Increasing reaction time will not give significant results to surfactant products [7]. According to Masyithah et al., 2020, this happens because of the possibility of side reactions such as saponification that decrease conversion gain [22]. The optimum reaction time in this study is 2 hours; the optimal time is also caused by using a catalyst that acts like speeding up the reaction [23].

Relation of Reaction Temperature (T) to % Conversion

Figure-5 shows the relationship between reaction temperature and conversion gain at the optimum reaction time of 2 hours. It can be seen in the figure that the conversion obtained decreases with increasing reaction temperature, or the best conversion is obtained at a reaction temperature of 90°C. The conversion rates of palmitic, lauric, and stearic acid obtained are 83.13%, 94.44%, and 60.8%. Meanwhile, succinic acid's best conversion was obtained at 100 °C in 97.70%.

It is due to the melting and boiling points between the sample and the solvent. For example, the melting points of palmitic, lauric, succinic, and stearic acid are 62.9°C, 43.2°C, 184°C, and 69.3°C. In comparison, the boiling point of diethanolamine is 269°C. In addition, a decrease in conversion gain can also occur due to the possibility of side reactions such as saponification and transesterification reactions. Therefore, when producing surfactants, if the resulting temperature is higher than the solvent's boiling point, it will cause a decrease in conversion gain [7, 22]. Thus, based on the results of this study, 90°C was determined as the optimum reaction temperature.

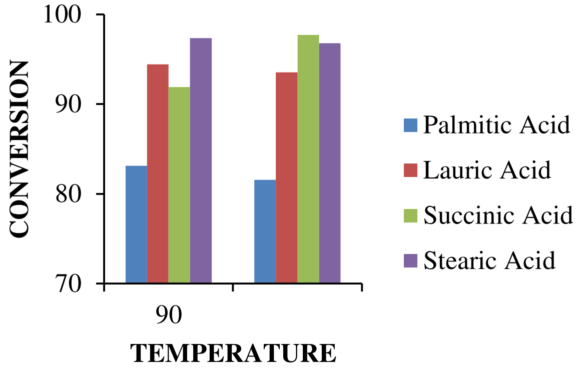

Figure-5. Relation of reaction temperature (T) to % conversion.

FT-IR Spectrum Analysis

In Figure-6, the FTIR test shows the absorption peak with a wavenumber of 3458 cm^{-1} with a 15% transmission indicating the presence of an O-H group as the final chain in the reaction for the formation of surfactant N-palmitoyl diethanolamine. The absorption peak at 2870 cm^{-1} with 17% transmission indicates the presence of a C-H group as a long chain in the reaction. It indicates that the product also comes from fatty acid raw materials. The absorption peak at a wavelength of 1603 cm^{-1} with 15% transmission indicated the presence of an N-H group which indicated that there were amines in the resulting surfactant product, where it is also indicated that the amine is derived from the diethanolamine (DEA). The absorption peak at a wavelength of 1092 cm^{-1} with a transmission of 15% indicates the presence of C-N compounds, which also indicates the product contains amine compounds.

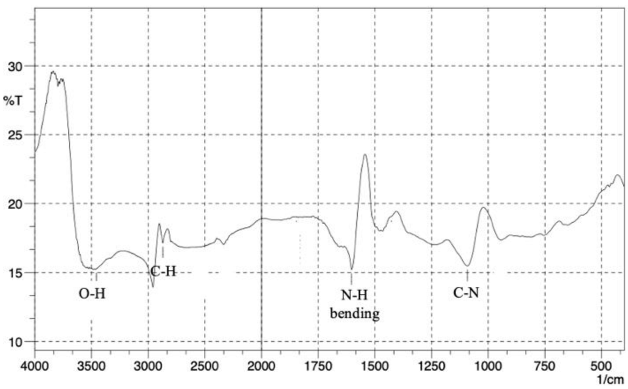

Figure-6. FTIR spectrum of N-palmitoyl diethanolamide.

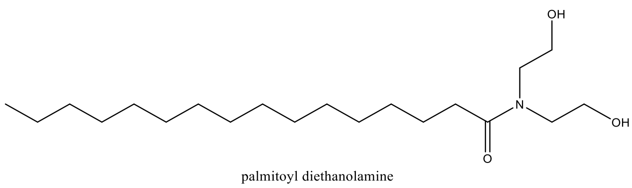

Figure-7. Surfactant structure of N-palmitoyl diethanolamide

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In Figure-8, it can be seen that the absorption peak at wavelength number of 3493 cm^{-1} with transmission at 46% indicates the presence of an N-H group which indicates that there are amine compounds in the surfactant.

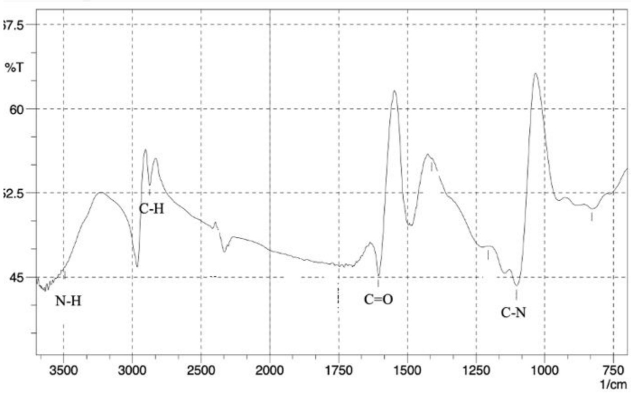
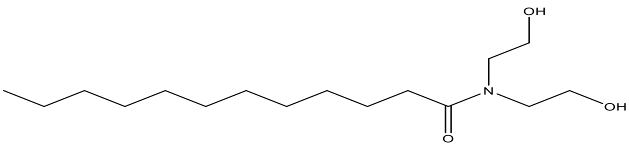


Figure-8. FTIR spectrum of N-lauroyl diethanolamide.

It is also indicated that the amine is derived from the amine diethanolamine. The absorption peak at wave number 2874 cm^{-1} at 53% transmission indicates the C-H group as a long chain in the reaction and indicates that the product also comes from fatty acid raw materials. The absorption peak at wave number 1605 cm^{-1} with transmission at 45% indicated the presence of a C=O double bond group which indicated an amide compound.
Finally, the absorption peak at a wavelength of 1103 cm^{-1} with transmission at 44% indicates the presence of C-N compounds, indicating that the product contains amine compounds.



lauroyl diethanolamine

Figure-9. Surfactant structure of N-lauroyl diethanolamide.

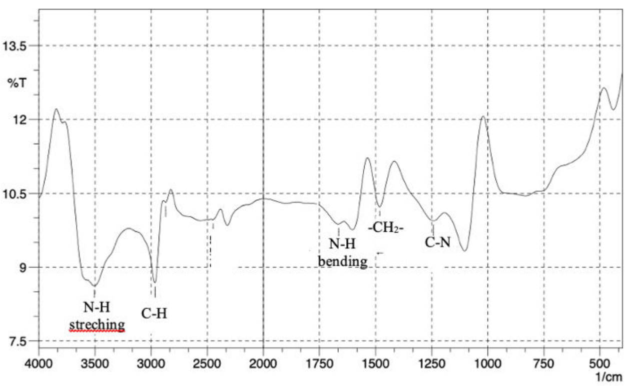
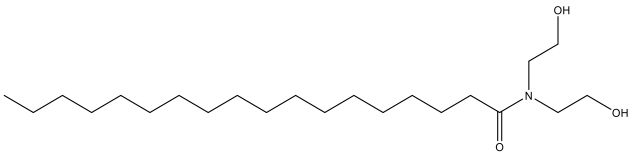


Figure-10. FTIR spectrum of N-stearoyl diethanolamide.

In Figure-10, the results of the FTIR test show the absorption peak with a wavenumber of 3507 cm^{-1} with a transmission of 8% indicates the presence of an N-H group which indicates the presence of an amine compound in the surfactant product N-stearoyl diethanolamide. The absorption peak at wavelength 2967 cm^{-1} with a transmission of 8% indicates the presence of C-H groups as a long chain in the reaction. It indicates that the product also comes from fatty acid raw materials. The absorption peak at a wavelength of 1481 cm^{-1} with 10% transmission indicates the presence of a -CH2- group. The absorption peak with a wavenumber of 1242 cm-1 with a transmission indicates the product contains amine compounds, where the amine compound is derived from the amine Diethanolamine (DEA).



stearoyl diethanolamine

Figure-11. Surfactant structure of N-stearoyl diethanolamide.

According to Pavia *et al.,* 2010, amide compounds are indicated by the intense peak of the C=O double bond that appears in the wave range of 1680-1630 cm-1. The N-H strain is seen in the wave range of 3475-3150 cm-1. The unsubstituted (primary) amide, R-CO-NH2, showed two absorptions in the N-H absorption region, while the single-substituted (secondary) amide, R-CO-NH-R, showed only one absorption. The presence of N-H bond absorption coupled with a low C-O absorption region will indicate the presence of an amide functional group. The substituted (tertiary) amide, R-CO-NR2, will show a C=O double bond group in the range of absorption peaks in the wavenumber 1680-1630 cm-1 but does not show any N-H group [24]. Lubis, 2018 also stated that alkanolamides were formed in the presence of solid absorption at C=O at 1630-1660 cm-1. The hydrogen and nitrogen bonds that will form on the absorption of N-H are around 3300 cm-1 [25].

Analysis Result of Surfactant Result Characteristics

Acid Number Analysis

According to the American Society for Testing and Materials (ASTM, Acid number), is the amount of base expressed by 1 milligram of KOH required to neutralize the acidic component in 1 g of the sample [26]. A high acid number will reduce the quality of the final product because it affects the polarity and foam [27]. So that mathematically the acid number can be obtained using the equation:

$$\text{Acid Number} = \frac{56{,}1 \text{ x N x V}}{\text{W}} x100\% \quad (4)$$

Based on the results of the study with operating conditions at a substrate ratio of 1:2, solvent ratio 1:3, and catalyst weight of 5%, the acid number at the best conditions was 40.67 for n-palmitoyl diethanolamine, 47.41 for n -lauroyl diethanolamine, 63.11 for n-succinyl diethanolamine and 22.44 for n-stearoyl diethanolamine. Meanwhile, the initial acid numbers obtained were 89.76 for palmitic acid, 302.94 for lauric acid, 1036.45 for succinic acid, and 70.13 for stearic acid.

The length of the carbon chain strongly influences the acid number; the longer the carbon chain, the greater the value of the acid number and the lower its role as an emulsifier of oil in water [28]. According to research conducted by Faridah *et al*., 2018, with the same value and characteristics of the saponification number, the greater the acid number, the higher the HLB value will be. Therefore, it can be concluded that the value of the acid number is directly proportional to the HLB value [29].

Saponification Number Analysis

The saponification number is a measure of the content of the ester linkage. The saponification number was determined from the back titration of the hydroxide in the presence of phenolphthalein and 0.5 N sulfuric acids as an indicator [30]. The saponification number obtained has a sensitive response to fatty acid chain length and surfactant substitution level changes. The shorter the fatty acid chain and the higher the substitution level, the saponification number will increase and vice versa [31]. So that mathematically the saponification number can be obtained using the equation:

$$\text{Saponification Number} = \frac{56{,}1 \text{ x N x (b}-\text{s)}}{\text{W}} x100\% \quad (5)$$

From the results of the study with operating conditions at a substrate ratio of 1:2, solvent ratio 1:3, and catalyst weight of 5%, the resulting saponification number under the best conditions was 36.47 for n-palmitoyl diethanolamine, 23.84 for n-lauroyl diethanolamine, 57.50 for n-succinyl diethanolamine and 7.01 for n-stearoyl diethanolamine.

According to research conducted by Tadros, 2013, with the same value and characteristics of the acid number, the greater the value of the saponification number, the smaller the HLB value will be. Therefore, it can be concluded that the saponification number is inversely proportional to the HLB value [29].

HLB Value Analysis

The HLB value is a system used to determine the characteristics of surfactant products that work most optimally with the oil phase of the emulsified product. For example, surfactants that are soluble in fat will be given a low HLB value, while emulsifiers that are water-soluble (hydro) will be given a high HLB value. So that mathematically determining the HLB value can be used the equation:

$$\text{HLB Value} = 20(1 - \frac{S}{A}) \quad (6)$$

Based on the research carried out to determine the HLB value, the surfactant n-palmitoyl diethanolamine is 2.07. It can be used in the pulp and paper industry and has complex characteristics dissolved in water. The surfactant n-lauroyl diethanolamine obtained an HLB value of 9.94. It can be used in the cosmetic industry and has the characteristic of causing a milky white color after being dissolved in water. The surfactant n-succinyl diethanolamine obtained an HLB value of 1.78. It can be used in the pulp and paper industry and has complex characteristics to dissolve in water. The surfactant n-stearoyl diethanolamine obtained an HLB value of 13.75. It can be used in the detergent industry and has the characteristics of light to clear color when dissolved in water.

The higher the addition of alcohol, the higher the HLB value. It is because alcohol has a hydroxy group, so its addition causes the resulting product to be more hydrophilic (polar) [29]. In order to obtain the best surfactant characteristics, n-lauroyl diethanolamine obtained an HLB value of 9.94, which, based on theory for the range 8-18 [30], is a suitable surfactant for dissolving oil with water. Therefore, the surfactant product n-lauroyl diethanolamine can be used in the cosmetic industry.

Table-2. HLB value range**.**

HLB Range	Purpose
3-6	Emulsifier W/O
7-9	Wetting Agent
8-18	Emulsifier O/W
13-15	Detergent
15-18	Solvent

CONCLUSIONS

Temperature and time are crucial factors in a reaction. In general, the resulting conversion will increase with increasing time and temperature reactions. However, the amount of product conversion is also strongly influenced by the alkali concentration. Where the higher the concentration of alkali, the faster the reaction rate. Fatty acid obtained the best conversion at 90 ^{o}C and 2 hours. However, the best conversion results obtained by succinic acid were at a temperature of 100 ^{o}C and 2 hours. The choice of diethanolamine in the synthesis of fatty amides will produce a surfactant with a better degree of polarity because diethanolamine has two hydroxyl groups in its molecule. The HLB value is used to determine the surfactant product's characteristics that work most optimally for the emulsified product. The HLB value is directly proportional to the acid number and inversely proportional to the saponification number.

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