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Conversion of 1-Octadenaol into Short Chain Alkenes and Alkanes Using Zsia Catalyst and Fluidized Bed Reactor at a Temperature of 400°C

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ABSTRACT

Research has been carried out on the catalytic conversion of 1-octadecanol compounds into 1-octadecene alkanes at high temperatures (400°C) in a fluidized bed reactor. The research results obtained are as follows; Hydrogenation of 1-octadecanol was carried out in a fluidized bed reactor. The hydrogenation of 1-octadecanol was carried out in a fluidized bed reactor at a temperature of 400°C with 10 g of ZSiA catalyst and 10 g of pure 1-octadecanol reactant.The results of the study showed the following results: catalytic hydrogenation of 1-octadecanol with ZSiA catalyst at 400°C produced alkanes and alkenes in the chain length range up to C18 reaching 49.60% and the dominant compound produced was 1-octadecene with a relative concentration of up to 20 ,21 %.

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Konversi 1-Octadenaol Menjadi Alkena Rantai Pendek dan Alkana Menggunakan Katalis Zsia dan Reaktor Fluidized Bedpada Suhu 400^{O}c

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ABSTRACT

Telah dilakukan penelitian tentang konversi katalitik senyawa 1-oktadekanol menjadi alkana 1-oktadesen pada suhu tinggi (400 oC) dalam reaktor fluidized bed. Hasil penelitian yang diperoleh adalah sebagai berikut; Hidrogenasi 1-oktadekanol dilakukan dalam reaktor unggun terfluidisasi. Hidrogenasi 1-oktadekanol dilakukan dalam reaktor fluidized bed pada suhu 400 oC dengan 10 g katalis ZSiA dan 10 g reaktan 1-oktadekanol murni. Hasil penelitian menunjukkan hasil sebagai berikut: hidrogenasi katalitik 1 -oktadekanol dengan katalis ZSiA pada suhu 400 oC menghasilkan alkana dan alkena dengan rentang panjang rantai hingga C18 mencapai 49,60% dan senyawa dominan yang dihasilkan adalah 1-oktadesen dengan konsentrasi relatif hingga 20 ,21 %.

INTRODUCTION

The pure 1-octadecanol compound has the following physical properties: in the form of a solid, it has the molecular formula $C_{18}H_{38}O$, content 95%, boiling point 336 ^{o}C, density 0.81 g/mL and melting point 58 oC. Prior to the catalytic hydrogenation process using the ZSiA catalyst, the standard 1-octadecanol compound was subjected to GC-MS analysis first. The results of the analysis were carried out using GC-MS equipment and showed that the compound 1-octadecanol was detected at a retention time of 23.33 minutes and is shown in Figure 1.

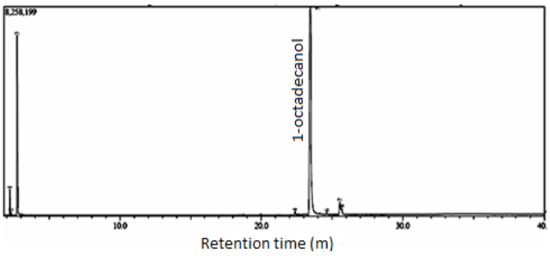

Figure 1. GCMS Chromatogram of 1-Octadecanol Compound

The GC-MS chromatogram in Figure 1. shows the result that the detected 1-octadecanol shows a yield of 70.65%. This result is due to the percentage of solvent equal to 1.75% of diethyl ether and 23.11% of chloroform that is counted, thereby reducing the amount of 1-octadecanol that is counted, if the solvent is not counted or not displayed in the analysis using GCMS then the percentage of 1-octadecanol can reach 95%.

The thermal product of 1-octadecanol at 400 ^{o}C produces many compounds with chains shorter than C:18. The percentage of compounds with a chain length shorter than C:18 is relatively large or the conversion of 1-octadecanol compounds is relatively large, which is greater than 50%.

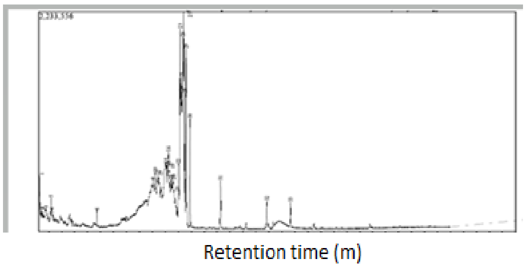

Figure 2. GCMS Chromatogram of Thermal Process From 1-Octadecanol

The GC-MS chromatogram of the thermally cracked 1-octadecanol compound is shown in Figure 2. The product of the thermally cracked 1-octadecanol compound is presented in Table 1 with the dominant product being 1-octadecene (12.60%).

Table 1. Products of Alkanes and Alkenes with Chain Lengths < C18 from the Thermal Cracking Reaction of 1-Octadecanol at 400 ^{o}C (estimated Data Library GCMS QP2010 Shimadzu)

Name of Compound	**SI t_R (minutes)**	**Amount**	**(%)**
4-dodecene	96	3,28	1,50
5-tetradecene	95	4,18	0,83
Pentene	96	7,72	0,62
Hexadecane	95	12,23	0,51
7-hexadecene	95	14,01	3,88
1-octadecene	97	14,14	12,60
3-octadecene	96	14,34	9,45
5-octadecene	97	14,67	8,68
Octadecan	96	22,65	1,13
Amount			**39,20**

The GC-MS chromatogram of the product analysis of the catalytic hydrogenation reaction of 1-octadecanol thermally showed a number of product compounds as shown in the chromatograms of Figure 2 and table 1. The product of the catalytic hydrogenation reaction of 1-octadecanol thermally at a temperature of 400^{o}C produced alkanes and Alkenes in the chain length range up to C18 reach 39.20% as shown in Table 1 and the dominant compound produced is 1-octadecene with a relative concentration of 12.60%.

METHODOLOGY

The materials used are: 1-octadecanol, ZSiA catalyst, glass wool, hydrogen gas.Tools needed: Fluidized bed reactor, automatic voltage regulator (AVR), thermocouple, Erlenmeyer, glass beaker. Method: weigh 10 g of 1-octadecanol and put it into the evaporator, set the reactor, heat the evaporator so that the temperature reaches 400 ^{o}C, place 3 grams of catalyst into the reactor column. Then the flow of hydrogen gas is flowed so that it passes through the evaporator column and the reactor with a flow rate of 5 mL/second. After the evaporator temperature reaches almost 400 ^{o}C the reactor column is heated so that the temperature reaches 400 ^{o}C then with hydrogen gas flowing so that the feed flows into the reactor and the product is accommodated after the feed passes through the reactor. After the process lasts for 30 minutes then the process is turned off or stopped, then the product is analyzed with GCMS.

RESULTS AND DISCUSSION

Based on Table 1 it can be shown that the catalytic hydrogenation of 1-octadecanol compounds produces quite a lot of alkenes and several types of alkane compounds. Relatively less yield of alkanes than alkenes is probably due to imperfect hydrogenation processes, such as the insufficient amount of hydrogen flowing quantitatively or the possibility of increasing the hydrogen pressure so that the amount of hydrogen is sufficiently abundant and the physisorption process between hydrogen and the 1-octadecanol functional group is expected. effective enough. In the experiment, researchers were unable to increase the pressure due to leaks in the reactor and relatively high operating conditions, so it was very dangerous.

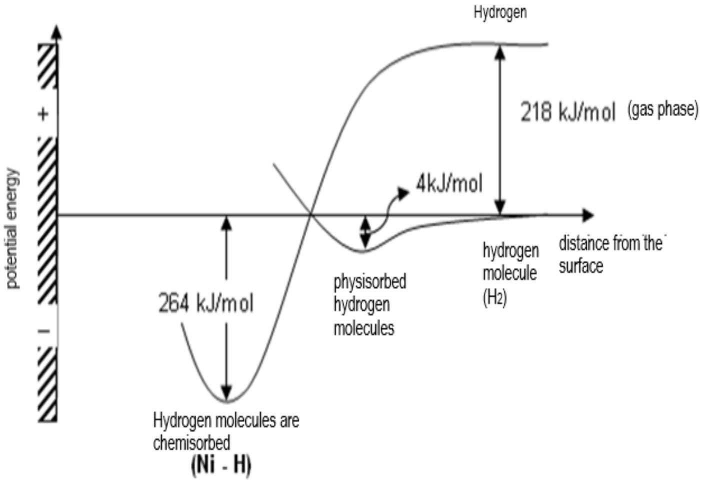

Figure 3. Potential Energy Diagram (Campbell, 1988)

The less optimum adsorption of hydrogen on the catalyst surface due to insufficient pressure also causes the quantity of hydrogen on the catalyst surface to quantitatively decrease, so that the probability of a collision between the adsorbed hydrogen and the 1-octadecanol functional group also decreases, thus the resulting alkanes and alkenes are 49. 60%. The process of collisions can take place more easily if it starts with a physisorption process, then continues with a chemisorption process.

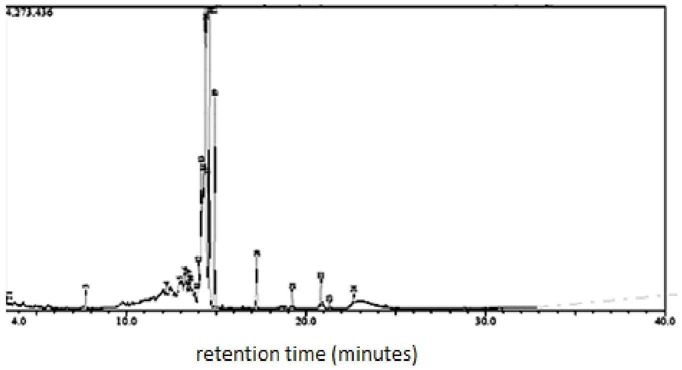

Figure 4. GC-MS Chromatogram of The Hydrogenation Reaction of 1-Octadecanol With Zsia Catalyst At 400ºc

The catalytic hydrogenation of 1-octadecanol with ZSiA catalyst in a fluidized-bed reactor at a temperature of 400 ^{o}C produced alkanes and alkenes with a chain length < C18 of 49.60%. The mechanism of the catalytic hydrogenation of 1-octadecanol is thought to follow two main steps, namely reduction of the alcohol group to an alkene and breaking of alkene bonds to form alkanes and shorter chain alkenes.

Table 2. The Product of the Catalytic Hydrogenation Reaction of 1-Octadecanol Compounds into Alkanes and Alkenes with Chain Lengths < C18 At 400 ^{O}c (Estimated From Shimadzu GC-MS QP2010 Data Library)

Compound Name	**t_R (m)**	**Amount (%)**
5-dodecane	3,28	0,23
Heptadecane	7,73	0,80
Pentene	12,23	0,30
7-hexadecene	14,01	3,29
9-octadecene	14,15	10,40
1-octadecene	14,38	20,21
5-octadecene	14,63	14,37
Amount	**49,60**	

The catalytic reaction of alcohol compounds at relatively high temperatures generally produces alkenes. According to Campbell (1988), the catalytic hydrogenation of alkenes according to the "Horiuti–Polanyi" mechanism produces alkanes. In the catalytic hydrogenation reaction of 1-octadecanol with ZSiA catalyst at 400 oC many alkenes and alkanes are produced.

The higher the reaction temperature with 1-octadecanol, the more active the interaction between the surface of the catalyst and 1-octadecanol was, resulting in the main product N-octadekene (N = 1,3,5 or 9). This situation indicates a match between the type of catalyst used and the type of reactants used. The higher the flow rate of hydrogen given to the reaction system indicates the greater the adsorption of hydrogen on the surface of the catalyst so that the probability of interaction between 1-octadecanol as a reactant and hydrogen on the surface of the catalyst can take place. According to the van't Hoff equation,

$$d(\ln K) = \frac{\Delta H}{R\,T^2}\,dT \quad \text{(Gasser, 1987)}$$

where K = equilibrium constant
R = general gas constant
R = 0.082 L.atm/mol.K

The adsorption of hydrogen on the surface of the catalyst is not optimal because the pressure also causes the amount of hydrogen on the surface of the catalyst to be quantitatively reduced, so that the probability of a collision between the adsorbed hydrogen and the functional group 1-octadecanol also decreases, thus the resulting alkanes and alkenes are 49.60 %. The process of collisions can take place more easily if it starts with a physisorption process, then continues with a chemisorption process.

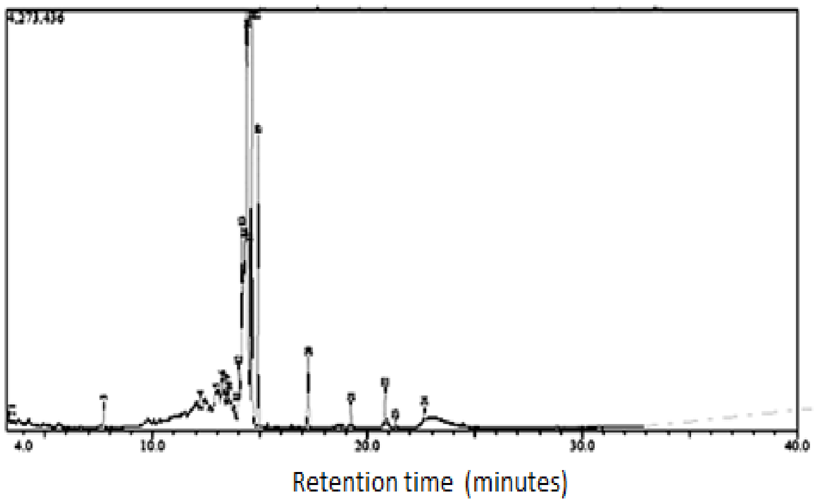

Figure 5. GC-MS Chromatogram of the Hydrogenation Reaction Of 1-Octadecanol With Zsia Catalyst At 400^{o}c

The catalytic hydrogenation of 1-octadecanol with ZSiA catalyst in a fluidized-bed reactor at a temperature of 400 oC produced alkanes and alkenes with a chain length < C18 of 49.60%. The mechanism of the catalytic hydrogenation of 1-octadecanol is thought to follow two main steps, namely reduction of the alcohol group to an alkene and breaking of alkene bonds to form alkanes and shorter chain alkenes.

Table 3. The Product of the Catalytic Hydrogenation Reaction of 1-Octadecanol Compounds into Alkanes and Alkenes With Chain Lengths < C18 At 400^{o}c (Estimated From Shimadzu Gc-Ms Qp2010 Data Library)

Compound name	**t_R (minute)**	**Amount(%)**
5-dodecane	3,28	0,23
Heptadecane	7,73	0,80
Pentene	12,23	0,30
7-hexadecene	14,01	3,29
9-octadecene	14,15	10,40
1-octadecene	14,38	20,21
5-octadecene	14,63	14,37
Amount		**49,60**

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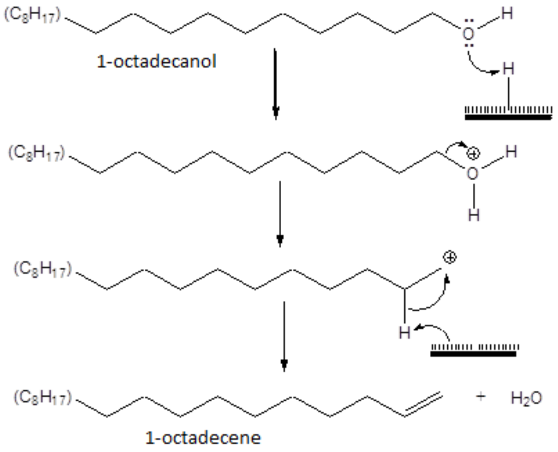

Figure 6. Hydrogenation Of 1-Octadecanol to 1-Octadecene

According to Campbell (1988), the 1-octadekene compound then formed its isomers, namely 5-octadekene and 9-octadekene with relative concentrations of 14.37 and 10.40%.

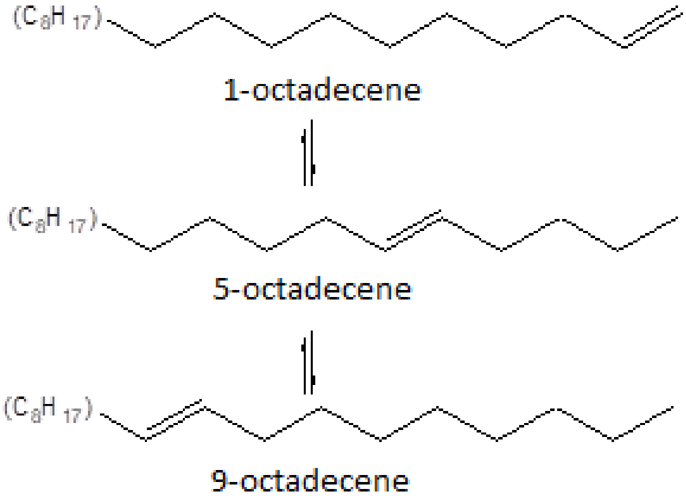

Figure 7. Isomerization of I-Octadekene

Furthermore, the 1-octadecenes, 5-octadekenes and 9-octadecenes undergo further cracking into shorter alkanes and alkenes.

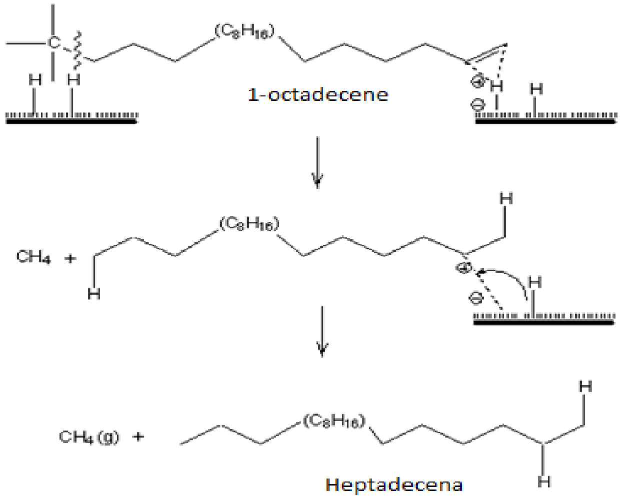

Figure 8. The Event of Breaking The I-Octadekene Compound Into A Shorter Compound

The mechanism of the 1-octadecanol compound to 5-dodecene is thought to follow the following steps: alcohol dehydration, double bond shift, bond breaking to 5-dodecene and hexane, hexane hydrogenation to smaller compounds (ethane and butane) in the gas.

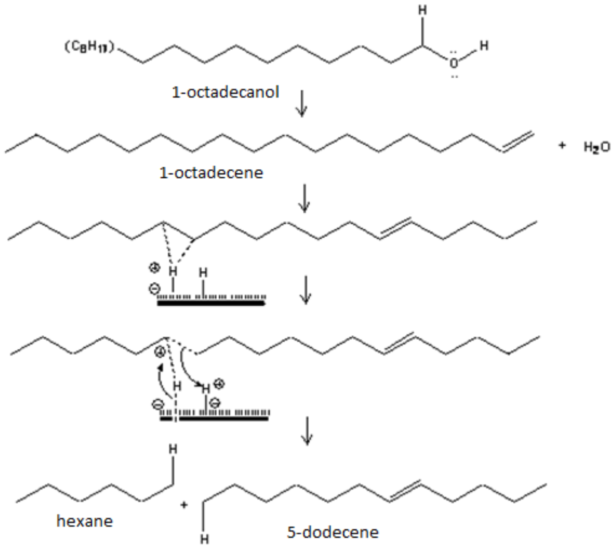

Figure 9. The Cleavage Event of the 1-Octadecanol Compound to Hexane and 5-Dodecene

Then hexane decomposes into gaseous compounds or volatile compounds as follows,

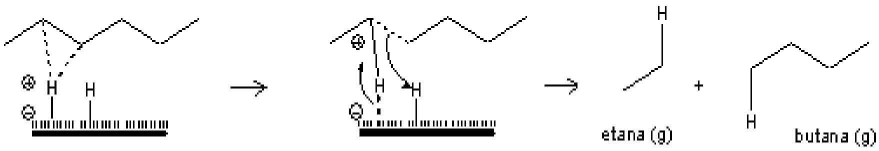

Figure 10. The Events of The Formation of Ethane and Butane Compounds

Effect of Hydrogen Gas Flow Rate

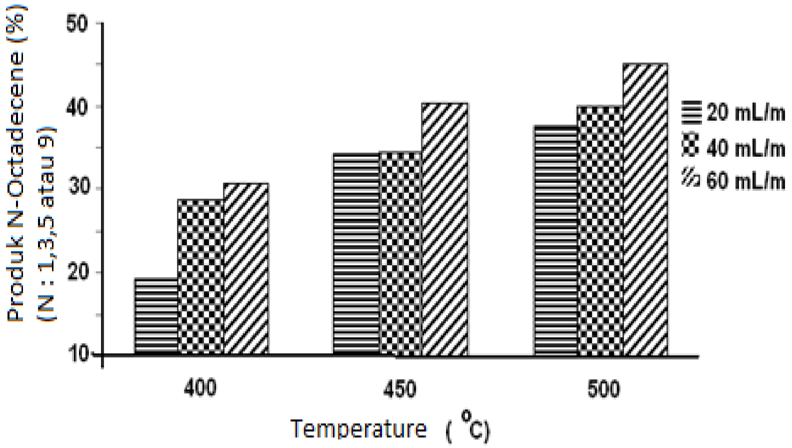

Figure 11. Effect of Temperature and Flow Rate of Hydrogen on N-Octadecene Products (N = 1,3,5 And 9)

The higher the reaction temperature with 1-octadecanol, the more active the interaction between the surface of the catalyst and 1-octadecanol, resulting in the main product N-octadekene (N = 1,3,5 or 9). This situation indicates a match between the type of catalyst used and the type of reactants used. The higher the flow rate of hydrogen given to the reaction system indicates the greater the adsorption of hydrogen on the surface of the catalyst so that the probability of interaction between 1-octadecanol as a reactant and hydrogen on the surface of the catalyst can take place. According to the van't Hoff equation,

$d(\ln K) = \frac{\Delta H}{R\,T^2}\,dT$ (Gasser, 1987)

where K = equilibrium constant
R = general gas constant
R = 0.082 L.atm/mol.K

CONCLUSION

The acid treatment of natural zeolite resulted in the release of Ca and Fe metals contained in natural zeolite so that the zeolite experienced an increase in acidity. Besides that, the acid treatment of natural zeolite also resulted in a dealumination event that increased the ratio of Si/Al zeolite.

The catalytic hydrogenation of 1-octadecanol to 1-octadecene with ZSiA catalyst tends to increase with increasing hydrogen flow rate from 20, 40 to 60 mL/min and increasing reaction system temperature from 400, 450 and 500 oC. The main products of catalytic hydrogenation of 1-octadecanol to 1-octadecene is 20.21%, 5-octadecene is 14.37% and 9-octadecene is 10.40%.

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