International Journal of ChemTech Research
CODEN (USA): IJCRGG, ISSN: 0974-4290, ISSN(Online):2455-9555
Vol.10 No.9, pp 905-908, 2017

Effect of Gas Flow Rate and Time of Electrolysis on Converting Carbon Dioxide to Ethanol Using Cu-Zn as Cathode

Septian Ramadan*[1], Sholah Fariduddin[1], Afianti Rizki Aminudin[2], Antisa Kurnia Hayatri[3], Riyanto[1,2]

[1]Department of Chemistry, Faculty of Mathematic and Natural Science, Islamic University of Indonesia
[2]Department of Chemistry Education, Faculty of Mathematic and Natural Science, Islamic University of Indonesia
[3]Department of Statistic, Faculty of Mathematic and Natural Science, Islamic University of Indonesia

Abstract : A research on conversion of carbon dioxide to ethanol by electrochemical synthesis method has been done. The conversion process is carried out using a $NaHCO_3$ electrolyte solution at an electrochemical reactor equipped with a cathode and anode. As the cathode is used Cu-Zn, while as anode is used carbon. The effect of CO_2gas flow rate and time of electrolysis were investigated to determine the optimum conditions of process. The result was analyzed by gas chromatography to determine the content of the compounds produced qualitatively and quantitatively. The optimum conditions are gas flow rate and time of electrolysis are 0.5 L/min and 90 min with ethanol concentration yielded 1.57%.
Keywords : carbon dioxide, electrochemical synthesis, ethanol, Cu-Zn electrode, optimum condition.

Introduction

Energy is one of the major problems faced by almost all countries in the world. Given that energy is one of the main factors of economic growth of a country. Energy problems are becoming increasingly complex as energy demand from all countries in the world continues to increase in order to sustain economic growth that makes the inventory of conventional energy reserves less and less. The increasing need for energy is in fact also in conflict with the needs of mankind to create a clean environment and free from carbon dioxide (CO_2) pollution.

Global issues about CO_2 are also increasingly widespread talked about and studied along with the increasing number and impact on the world climate. This increase is triggered by the accelerated growth in CO_2-producing energy consumption worldwide, carbon-based energy resource crisis and low energy efficiency in existing technology. According to the Intergovernmental Panel on Climate Change (IPCC), three-quarters of the increase in CO_2 in the air is related to the use of fossil[1].

Concerns over world climate change are contained in the Kyoto Protocol document and the United Nations Framework Convention on Climate Change (UNFCCC) which emphasizes the importance of reducing CO_2 emissions and their absorption from the atmosphere. Similarly, the United Nations Conference on

Environment and Development (UNCED) in 1992 in Rio Janeiro, Brazil, which produced two general declarations, one of which also emphasized efforts to reduce global climate change[2].

Due to the high potential of CO_2 hazards, research is needed that can convert CO_2 into other safer forms of compounds, moreover compounds that can be utilized for the welfare of mankind. Currently there are many studies that try to produce a compound by using CO_2 as its base material. This is one of many ways to overcome CO_2 hazard aside from minimizing its source of production.

The synthesis of other more useful compounds is a great solution for CO_2 processing, as it will provide great and sustainable benefits. In addition, it will also provide a dual solution, ie reducing the amount of CO_2 as well as the production of a more useful compound. Some of the methods that have been done in the synthesis of CO_2-based compounds are chemistry, radiochemistry, thermochemistry, photochemistry, biochemistry and electrochemistry[3].

The synthesis of alcohol by using CO_2 is also a hot topic. From various studies that have been done, it is known that CO_2 is very potential for the synthesis of renewable energy. The products of the most potent CO_2-based synthesis of the compounds are carbon monoxide (CO), formic acid (HCOOH), formaldehyde (CH_2O), methanol (CH_3OH), oxalic acid ($H_2C_2O_4$), methane (CH_4), ethylene (CH_2CH_2) or ethanol C_2H_6O)[4,5].

Ways can be done to synthesis alcohol from CO_2 is by electrochemistry. The synthesis of alcohol from CO_2 electrochemically has two major advantages over the other way. The first advantage is the selectivity of the product produced on each electrode. Second, the tools and materials used are simple and economical because they do not require high vacuum or temperature conditions[6].

Until now, the optimization process of CO_2-based alcohol synthesis is still very necessary to do. Efficiency in the process and the intended product should still be improved, so that a more effective and selective method is obtained. In this study, it is proposed the use of Cu-Zn as cathode and carbon as anode in electrolysis process to get target product, that is ethanol.

Materials and Methods

Apparatus

The apparatus used in this study are a set of electrolysis reactors, a set of glassware, oven Memmert, desiccator, power supply Sanfix SP-303E, magnetic heated stirrer HMS-79 and gas chromatography BUCK Scientific Model 901.

Materials

The materials used in this study are pure CO_2 gas, Cu-Zn electrode, carbon electrode from Panasonic used battery stone, sandpaper, deionized water, $NaHCO_3$ Merck and ethanol.

Methods

Electrode Preparation

The Cu-Zn electrode plate is cut to the size of 1.5 × 4 cm. Rubbed using sandpaper until the dirt on the surface of the missing electrode. Washed by using deionized water clean and dried. While the carbon electrode used in this study is a carbon electrode derived from a battery stone. Carbon electrode is first washed using deionized water until clean. In the oven for 3 hours at 110 °C to remove the water content, then cooled in the desiccator.

Carbon Dioxide Conversion Process to Ethanol

Conversion of CO_2 into ethanol in an electrochemical reactor is done by varying the CO_2 gas flow rate and time of electrolysis to obtain the most optimum conditions for converting CO_2 to ethanol.

In CO_2 gas flow rate variation, 50 mL of a 0.1 M sodium bicarbonate electrolyte solution was obtained and fed into the electrolysis reactor. The Cu-Zn electrode plate (cathode) and the carbon electrode (anode) rod are fed into the electrolysis reactor. Drain the CO_2 gas into the electrolysis reactor with flow rate of 0.5; 1; 1.5

and 2 L/min. Circulated potential of 3 volts for 90 min. Analyzing the electrolysis solution by using gas chromatography.

At a times variation, 50 mL of a 0.1 M sodium bicarbonate electrolyte solution was obtained and fed into the electrolysis reactor. The Cu-Zn electrode plate (cathode) and the carbon electrode (anode) rod are fed into the electrolysis reactor. Drain the CO_2 gas into the electrolysis reactor with optimum flow rate. Circulated potential of 3 volts for 150 min and taken electrolysis solution every 30 min starting from 60 min. Analyzing the electrolysis solution by using gas chromatography.

Results and Discussion

Theoretically, if the more quantity of CO_2 is flowing, the more CO_2 will be converted to ethanol so that the ethanol product that will be formed will also be more numerous. The flow rate of CO_2 given should be noted as it will affect the outcome of electrochemical synthesis products. In this study, CO_2 flow rate varied to 0,5; 1; 1.5 and 2 L/min. Then we studied the most optimum CO_2 flow rate to produce ethanol.

Table 1.Concentration of Ethanol (%) at CO_2Flow Rate of 0.5-2 L/Min

CO_2Gas Flow Rate (L/Min)	Concentration of Ethanol (%)
0.5	1.32
1.0	1.01
1.5	0
2.0	0

Table 1 shows the concentration of ethanol (%) obtained at a CO_2 0.5-2 L/min flow rate. It is known that ethanol is formed at a flow rate of CO_2 0.5 L/min and then decreases when CO_2 flow rate is increased to 1 L/min. No ethanol was detected when the CO_2 flow rate was increased to 1.5 and 2 L/min. Table 1 shows that the optimum CO_2 flow rate is 0.5 L/min with an ethanol concentration of 1.32%.

The solubility of CO_2 in water is only 0.033 mM. In water CO_2 forms equilibrium to H_2CO_3, but only 1% of CO_2 dissolves in the form of H_2CO_3[7]. This allows the cause of ethanol not to form when CO_2 flow rate is increased. As the CO_2 boost rate is increased it will cause CO_2 bubbles in more and more electrolysis reactors. Excessive CO_2 gas bubbles will affect the stirring factor thus affecting the results of electrochemical synthesis.

Although the quantity of CO_2 that flows more and more, but in fact not all CO_2 dissolves in sodium bicarbonate electrolyte solution to be converted to ethanol. In addition, the sodium bicarbonate electrolyte solution is also a water-soluble compound and reacts with other compounds to produce CO_2. The reaction of sodium bicarbonate in producing CO_2 gas is as follows[8].

$NaHCO_3 + H^+ \rightarrow Na^+ + CO_2 + H_2O$

Ethanol will be formed after the electrochemical synthesis process is done until the optimum time is reached. If the electrochemical synthesis process continues with a longer time, it will be able to cause the already formed ethanol is lost or turned into another compound. In addition, some researchers claim that metal electrodes can be deactivated which can poison their electrocatalytic activity after being used for a period of time[9]. In this research, the time variation of electrochemical synthesis process to find out the most optimum time to convert CO_2 to ethanol.

Table 2.Concentration of Ethanol (%) on Electrolysis Time 60-150 Min

Time (Min)	Concentration of Ethanol (%)
60	0.95
90	1.57
120	1.56
150	0.50

Table 1 shows the concentration of ethanol (%) obtained at electrolysis 60-150 min. It is known that the ethanol concentration in the sample continues to increase until the electrolysis time of 90 min, then continues to decrease until the electrolysis time of 150 min when the electrochemical synthesis process is continued. The most optimum electrolysis time is the electrolysis time that produces ethanol with the highest concentration. Table 1 shows that the optimum electrolysis time is 90 min with the ethanol concentration produced is 1.57%.

Conclusion

Carbon dioxide can be converted to ethanol by electrochemical synthesis using Cu-Zn electrode. The optimum electrochemical synthesis condition to convert carbon dioxide to ethanol are CO_2 gas flow rate and time of electrolysis are 0.5 L/min and 90 minutes. The result show conversion of carbon dioxide to ethanol using electrochemical synthesis technique is 1.57%.

References

1. Metz B, Davidson O.R., Bosch P.R., Dave R, Meyer L.A.,*Climate change 2007: Mitigation Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge UK and New York, USA: Cambridge University Press, 2007.
2. Hakim S., Study of Conversion Carbon Dioxide (CO_2) to Methanol Using Copper Electrode by Electrochemical Reduction Method. *Thesis.* Yogyakarta: Islamic University of Indonesia, 2015.
3. Kaneco S., Iiba K., Hiei N.H., Ohta K., Mizuno T. and Suzuki T.,Electrochemical Reduction of Carbon Dioxide to Ethylene with High Faradaic Efficiency at a Cu Electrode in CsOH/Methanol, *ElectrochimicaActa*. 2002, (44):26, 4701-4706.
4. Jones C., RobertsonE., AroraV., Friedlingstein P., Shevliakova E., Bopp L.,BrovkinV., Hajima T., Kato E., Kawamiya M., Liddicoat S., Lindsay K., Reick C.H., Roelandt C., Segschneider J. and TjiputraJ.,Twenty-First-Century Compatible CO_2 Emissions and Airborne Fraction Simulated by CMIP5 Earth System Models under Four Representative Concentration Pathways. *DOI*, 2013, 10.1175/JCLI-D-12 00554.
5. Kuhl K.P., Hatsukade T., Cave E.R., Abram D.N., Kibsgaard J. and Jaramillo T.F.,Electrocatalytic Conversion of Carbon Dioxide to Methane and Methanol on Transition Metal Surfaces. *J. Am. Chem. Soc.*, 2014, 136(40), pp 14107–14113.
6. Lee J.A. and Tak T., Electrocatalytic Activity of Cu Electrode in Electroreduction of CO_2*Electrochimica*, 2001, 46: 3015 3022.
7. Fitriani, S., Study of CO_2 Reduction Reaction by Electrochemical Methode Using Cu Electrode, Depok: Indonesia University, 2012.
8. Ratna, The Effect of The Developer Material on The Wafer. *Report of Practical Work,* Surabaya: Widya Mandala Catholic University, 2008.
9. Lee, J.A. and Tak, T., Electrocatalytic Activity of Cu Electrode in Electroreduction of CO_2, *Electrochimica*, 2001,46: 3015 3022.

*****