CHEMICAL ENGINEERING TRANSACTIONS Volume 21, 2010
Editor J. J. Klemeš, H. L. Lam, P. S. Varbanov
 ISBN 978-88-95608-05-1 ISSN 1974-9791
DOI: 10.3303/CET1021067

CO_2 Reduction and Production of Algal Oil Using Microalgae Nannochloropsis oculata and Tetraselmis chuii

Elida Purba*, Taharuddin
Department of Chemical Engineering, The University of Lampung, Bandar Lampung, 35145 Indonesia,
elida_purba@unila.ac.id

This research concerns about reduction of CO_2 and production of algal oil using microalgae *Nannochloropsis oculata* and *Tetraselmis chuii*. The objectives are to determine the ability of the microalgae in reducing CO_2 during photosynthesis and also to produce biomass for algal oil. The CO_2 in air was fed into photobioreactor with concentration of 3, 6, and 9 % and light intensity of 360 and 1250 lumen. The CO_2 concentration output was analysed to determine the reduction of CO_2 during photosynthesis. The microalgae was harvested in 5 days and then it was extracted to obtain algal oil. The results show that both CO_2 concentration and light intensity affect the CO_2 reduction significantly. The higher the CO_2 input and light intensity the higher the reduction of CO_2 for both algae. Therefore, the best condition within the range of this research is at the CO_2 concentration of 9% and light intensity 1250 lumen which gives reduction of CO_2 49.5 %. The extraction gives yield of algal oil 11.37 % and 9.50 % for both *Nannochloropsis oculata* and *Tetraselmis chuii*, respectively.

1. Introduction

Global warming is one of the hottest global issues because the big impact on our universe and environment. By definition, global warming is an increase in the average temperature of the earth's atmosphere, especially a sustained increase sufficient to cause climatic change. One the cause is Carbon Dioxide (CO_2) as much as 75 % contribute to Green House Gases (GHGs). Other gases methane (CH_4) 18 %, Ozone (O_3) 12 % and *chlorofluorocarbon* (CFC) 14 %. The CO_2 is actually not toxic, but because of the increase of the quantity it becomes dangerous to the GHGs and environment. This is due to the development of industries and transportation, as the increae of energy demand. A research in Jakarta showed that vehicle contribute to air pollution of CO_2 98.80 % , NO_x 73.40 % , and HC 88.90 %. As the energy demand increased, the nations look for alternative energy such as biogas, bioethanol, biodiesel which lessen the CO_2 emission. One of ways to produce biofuel is utilising green alga which in the same time reducing CO_2 by consuming it during photosynthesis. fotosintesis. For example, *Nannochloropsis oculata* and *Tetraselmis chuii*. These are microalgae which can be

Please cite this article as: Purba E. and Taharuddin T., (2010), CO_2 reduction using microalgae nanochloropsis oculata and production of oil algae, Chemical Engineering Transactions, 21, 397-402 DOI: 10.3303/CET1021067

easily found in Indonesian marine. Algae contains organic substance such as pollysacharides, lipid, vitamins, minerals, and othe bioactive substances. Based on the above information, CO_2 reduction using microalgae can be used as an efficient solution. Beside using for reduction of CO_2, these algae also produce algal oil which can be converted into biodiesel. This work was carried out to investigate the ability of microalgae in reducing CO_2 and producing algal oil.

2. Experimental Work

Apparatus for algal growth and CO_2 reduction was assembled from photobioreactor, aerator, piping flowmeters, and fluorescent lamps 360 dan 1250 lumen as shown in Figure 1. Some chemical materials were used for analysis and extraction of algal oil. Other materials were broth of *Nannochloropsis oculata* and *Tetraselmis chuii*, brine water, air, CO_2, nutrition, $Ca(OH)_2$ 1 M, and hexane. Other assecories are *centrifuge*, decanter, and evaporator. Algae was placed in photobioreactor with addition of some nutrition. The ratio of alga to brine water was 1:4. The CO_2 – air mixture with known concentration was fed into the photobioreactor at 1 L/min. The growth of algae took place 5 days and then it was harvested by centrifugation. Concentration of CO_2 output was analyzed twice a day to observe CO_2 reduction by algae. After centrifugation, algal paste was obtanained and then it was dried in an oven. Dried algae and etanol were prepared with ratio of 1:20. Extraction was carried out several stages by immersion until no more algal oil obtained. The filtrate was evaporated at 60 ^oC until all the ethanol evaporates.

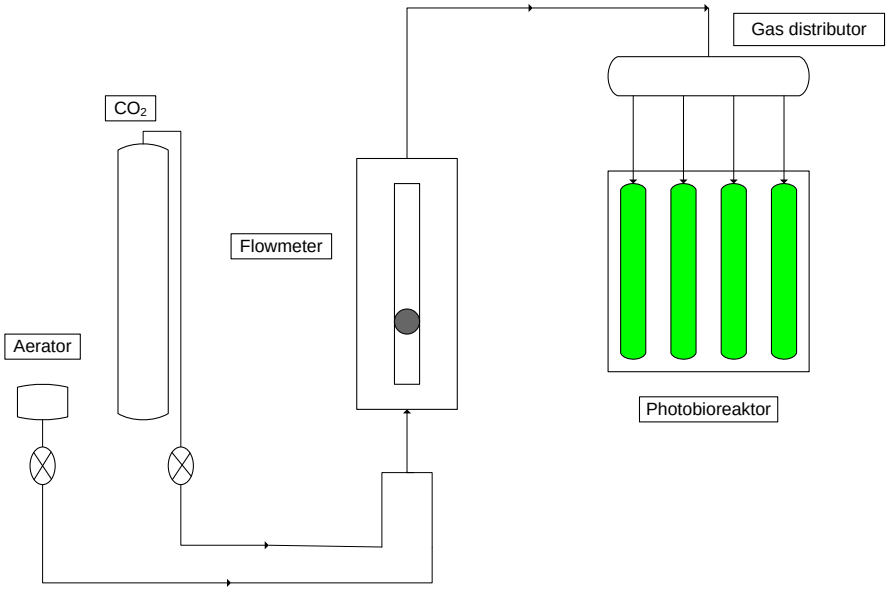

Figure 1: Skematic diagram of ekperimental rig

3. Results and discussions

Reduction of CO_2 was observed daily for 5 days during the growth of lagae in the photobioreactor. The persentage of reduction is calculated from the concentration of inlet and outlet gas. The concentration profile is shown in Figure 2.

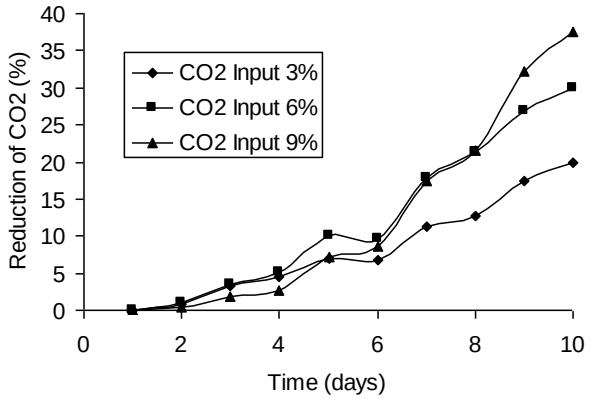

Figure 2:. Reduction of CO_2 at various CO_2 input concentration constant light intensity of 360 lumen

The figure shows the reduction of CO_2 daily with inlet concentration of 3, 6, and 9 % of CO_2-air mixture. Light intensity was constant at 360 lumens. As shown in the figure, the reduction is increased up to 36.547 %. A similar trend is shown in Figure 3 for the same inlet concentration of CO_2 at contrant light intensity of 1250 lumens. The reduction is increased up to 49.5 %. From the figures it can be seen that the input concentration of CO_2 have significant effect on the reduction of CO_2. The higher the input of CO_2 concentration, the higher the reduction of CO_2. The reduction of CO_2 are 18.2 % and 36.55 % for 3 % and 9 % inlet concentration, respectively.

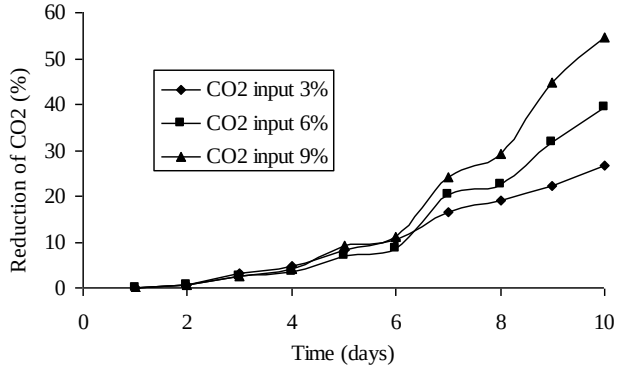

Figure 3: Reduction of CO_2 at various CO_2 input concentration with constant light intensity of 1250 lumen

A similar trend is observed in Figure 3 where the reduction of CO_2 is increased with increased of CO_2 concentration. The reductions are 25.01 % and 49.45 % for 3 % and 9 % inlet concentration of CO_2, respectively. *Nannochloropsis oculata* and *Tetraselmis chuii* grow by splitting cells. When enough CO_2 is available, the split of algal cells occur faster. As a result, the algae consumes more CO_2. Beside the CO_2 inlet concentration, light intensity also affect the CO_2 reduction. Two light intensities of 360 and 1250 lumens were applied. Figure 3 shows the CO_2 reduction at fixed input CO_2 concentration of 9 %. As can be seen, higher light intensity gives more reduction of the CO_2. Light intensity of 1250 lumens can be reduced the CO_2 up to 49.49 % in comparison to only 36.55 % for light intensity of 360 lumens. Similar trend is shown for fixed CO_2 input of 3 and 6 %.

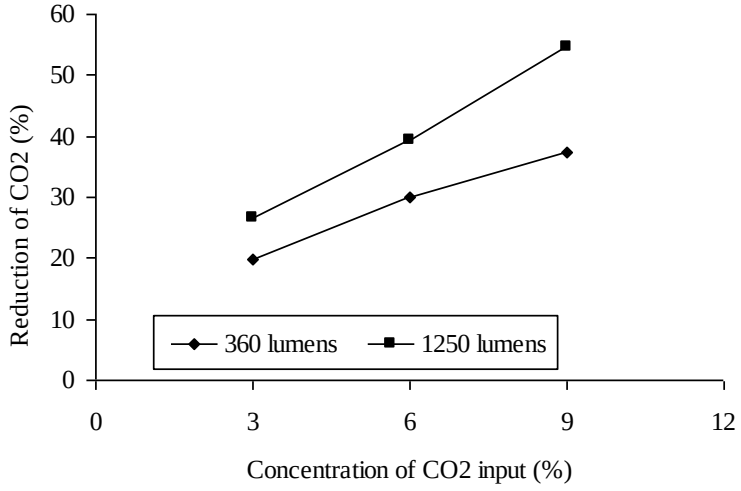

Figure 4. The effect of CO_2 input on CO_2 reduction

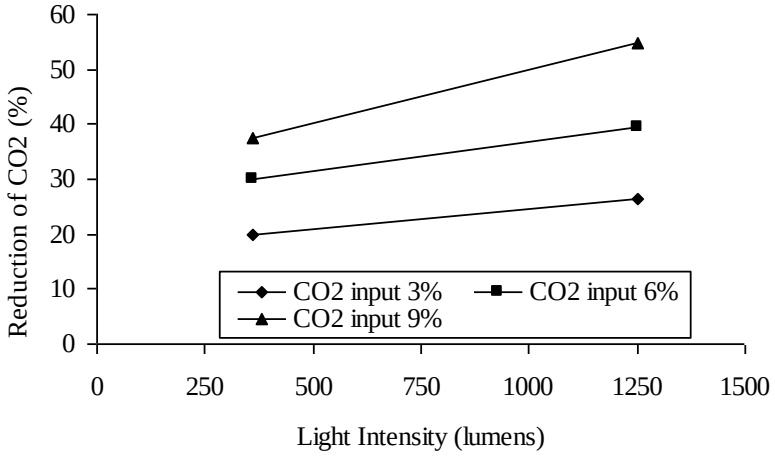

Figure 5: The effect of light intensity on CO_2 reduction

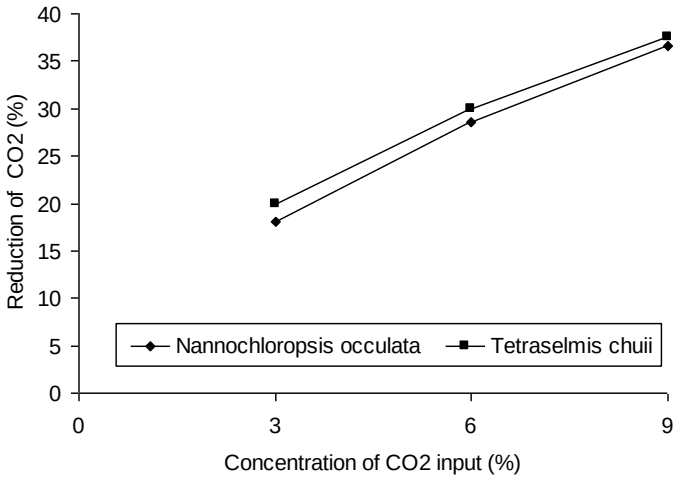

Figure 6: Comparison of CO_2 reduction by Nannochloropsis oculata and Tetraselmis chuii at light intensity 360 lumens

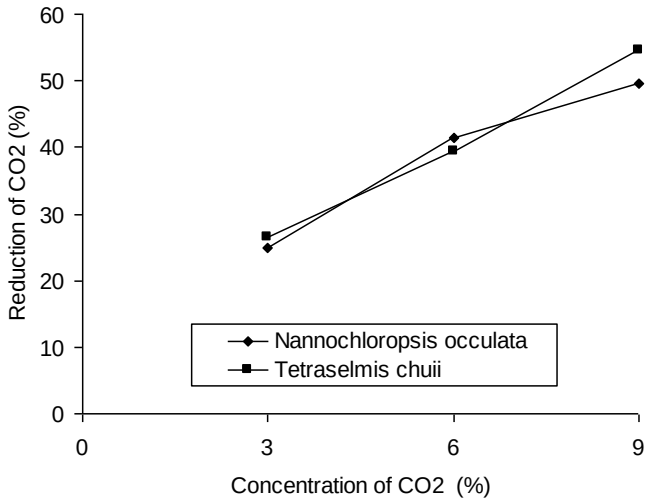

Figure 7 Comparison of CO_2 reduction by Nannochloropsis oculata and Tetraselmis chuii at light intensity 1250 lumens

4. Extraction of Algal Oil

After growing the algae, it then harvested and extracted to obtain algal oil. Extraction was carried out using hexane with immersion method. The results show that algal oil extracted was only 0.83 mL from 7.3 mL algal paste. This means that extracted algal oil is only 11.73%. The extraction need to be improved by using different solvent such as ethanol or by changing algal phase that is dried alga instead of algal paste.

5. Conclusions

Reduction of CO_2 is affected by both input CO_2 concentration and light intensity. Increasing of both input CO_2 concentration and light intensity also increases reduction of CO_2 at the range of variable in this research. Extracted algal oil is only 11.37 %.

Acknowledgments

The financial support from The Higher Education of Ministry of The National Education of The Indonesian Government s gratefully acknowledged. The experimental data provided by Eko Hernadi and Pirdaus Purwanto are also gratefully acknowledged.

References

Adanez, J., et. al, 2003, Characterization Of Oxygen Carriers for Chemical-Looping Combustion, Instituto De Carboquímica (Csic), Department of Energy And Environment. Miguel Luesma Castán 4, 50015 Zaragoza, Spain

Becker, E.W., 1994, Microalga: biotechnology and microbiology, 178, Cambridge Univ. Press, Cambridge, New York, USA.

Christi, Y., 2007. Biodiesel from Microalgae. Biotechnology Advances, 25 294–306.

Oilgae, 2010, </www.oilgae.com> (last accessed 26.05.10)

Litvansky, K,1996. Effect of O_2, CO_2, and Temperature on The Light Saturated Growth of Scenedesmus obliquus. Academy of Sciences of The Czech Republic. Prague, Czech Republic.

Purba, E., Mahmud, T., Javed, K.H., 2001, An Experimental Study of Hydrodynamics and Mass Transfer in a Spray TowerProceeding AIChE, Volume 1, pp.l 208-214

Purba, E., 2001, Enhancement of Mass Transfer Process Using Tangential Gas Entry in Spray Columns, Proceeding 6^{th} Indonesian Scientific Meeting (ISSM) Manchester, UK. No. A028,

Purba, E., Mahmud, T., Javed, K.H , 2005, Enhancement of Mass Transfer In Spray Towers Using Swirling Gas Flow: Part A Absorption Of NH_3 From Air- NH_3/H_2O, Transactions IChemE, Part A, Chem Eng Res Des.

Sheehan, J., Dunahay, T., Benemann, J., Roessler, P.,1998. A look Back at The U.S. Department of Energy's Aquatic Species Program : Biodiesel from Alga. Colorado, USA