

An experimental study of the production of biofuel from *Lyngbyasp* algae

Abbas Mohsin Abbas^{1a}, Roaa Jafar Elkheralla^{2b}, Abbas Talib Abd Ali^{3c}, Assala salam Jebur^{3d},^{3e}Iman H Shwayel and ^{4f}M.R.Jayp^{6f}¹College of Dentistry, University of Thi-Qar, Thi-Qar, Iraq .²Biology Department, College of Science, University of Thi-Qar, Thi-Qar, Iraq.³Chemistry Department, College of Science, University of Thi-Qar, Thi-Qar, Iraq.⁴Primoda Chemical and Pharmaceutical, Research and Development Center, Hyderabad, India.^aE-mail abbasmohsin_chem@sci.utq.edu.iq, ^bE-mail roa.kh-bio@utq.edu.iq, ^dE-mail ass.sa_ch@utq.edu.iq^eE-mail iman.hussain@sci.utq.edu.iq, ^fdrmrjayapal@gmail.com, ^{c*}Corresponding author: abbas.tal.ch@utq.edu.iq

Received: 2024-03-13, Revised:2024-03-26, Accepted: 2024-03-30, Published: 2024-06-18

Abstract— Global energy consumption is steadily rising, and fossil fuels are nonrenewable energy sources which provide the majority of this energy. Researchers are seeking and supporting renewable energy sources in order to balance supply and increasing demand. Microalgae is seen as an emerging and dependable feedstock that has the potential to displace fossil fuel-based sources of renewable energy among other options. In the present investigation, none dible hazardous oils from *lyngbya* sp. algae have been selected for the use as a feedstock for the biofuel production. The microalgal isolates were identified based on their surface morphology under microscope. The biofuel was produced by the transesterification reaction. Using Fourier-transform infrared spectroscopy (FTIR) analysis, the generated biofuel was characterized and the conversion was calculated. The findings imply that *lyngbya* sp. algal biomasses are suitable for the generation of biofuel. More experimental investigations are required in this field.

Keywords — IR , biofuel , *Lyngbyasp* algae, Ultrasound

I. INTRODUCTION

Scientists and investors in the field of energy have real concerns about the dramatic increase in demand on energy which requires a parallel sharp increase in the consumption of conventional fuels (coal, oil and gas). The uncontrolled increase in that consumption is directly correlated with the increase in the ecology pollution and climate change since more energy generation means more greenhouse gases (GHG) emissions. The dependence on the renewables could change the direct correlation between the energy generation in one hand and ecology pollution and global warming in the other hand. This is because renewables can generate energy with no or low gas emissions and consequently low or no impact on the environment [1-5]. Many targets are persuaded and this can include: (i) the unlimited support to the implementation of renewables such as solar energy, wind energy and bioenergy; (ii) a reduction in the GHG emissions by urging manufacturers to produce new products or machines depend on renewables as a fuel [1]. Common biofuels represented by biodiesel and bioethanol extracted

from food crops rich with starch such as barley, corn, sugarcane, are produced globally on an industrial scale [6-7]. Recently, algal biomass received increasing interest as potential and promising source for the production of biofuels. This interest might be due to algae being able to offer several benefits compared to land-based biomass crops. These benefits can include: better photosynthetic efficiency; higher oil yield; growth on non-fertile land and this means that there is no need to use chemical fertilizers; moreover, there is no need to fresh water since algae growth can be with a variety of water sources such as fresh, saline and brackish water; finally and most importantly that most types of algae has the potential of CO₂ re-using. Some new ideas claimed that integration is possible and beneficial between algae cultivation and wastewater treatment projects [8-14]. Another importance to the growth in the interest in the algae field is many types of algae are the source of extraction of some useful chemical such as pharmaceuticals and nutritional materials [15-18]. The production of biodiesel from algal species depends mainly on the extraction of lipids from these species and the conversion of lipids into biodiesel. The conversion process occurs by the reaction of transesterification [3]. *Lyngbya* is a toxic cyanobacteria algae, filamentous form, long and unbranched. The cells are shorter than their width and the filaments are surrounded by a sheath or a covering called Sheath consisting of a gelatinous substance-mucilage and a small amount of cellulose [19], which is either uni-layer or bilayer. Studies have shown that this cover is used by algae as an adaptive means to resist environmental conditions appropriateness [20]. Most of the species of this genus are attached to bottom materials or floating on the surface or wandering.

II. EXPERIMENTAL WORK

The experiment was conducted in the Phycological Laboratory at Dept. of biology, College University of Thi-Qar. Alga (*Lyngbya* sp.) was collected from the Al-Gharaf river in Al-Refaay city Thi-Qar, Iraq. It was ground with



grinding machine, and dried for 20 min. at 80°C in an incubator for releasing water. The aim of extraction was to obtain the oil contained in the samples.

A. The method

1) The following extractions:

Soxhlet, chemical extraction with conventional solvents and the help of ultrasound, Acoustic analysis, Folch extraction and Bligh & Dyer extraction (for the purpose of determining the method that gives highest oil production from the samples under study. Below are the extraction steps followed for each method: Extraction by Soxhlet For the purpose of the extraction procedure, 1 g of dry biomass was weighed and placed in a rolled filter paper completely on the sample. The extraction solvent mixture was prepared from (by mixing 100 ml ethanol+ 100ml hexane) -Extraction was carried out in the following steps (making 3 replicates): The dried biomass was placed inside a filter paper and fixed in the designated place of the Soxhlet device. Add 200 ml of extraction solvent to a 500 ml round bottom flask on a hot plate heater. The temperature was set at 65°C to prevent solvent evaporation and begin extraction.

The extraction process continued for 5 hours. After completing the specified time, the resulting extract was transferred in the circular flask to the evaporator distillation device the rotor is for the purpose of disposing of the collected solvents for reuse again. The extracted oil collected on the walls of the round flask was collected after the evaporation process using 3ml of n-hexane solvent, and keep it in a sealed container for the purpose of performing the esterification reaction later.

2) Ultrasound extraction:

For the purpose of obtaining the extract, the following steps were performed: Weight of 1 g of dry biomass. (Make 3 replicates), prepare 100 ml of extraction solvent (chloroform: methanol). The solvent was added to the dry biomass and distributed evenly into three 45 ml tubes with 7 10-15 g glass balls added to each tube. Shake the biomass with the extraction solvent and glass balls with a Vortex device for 5 minutes per tube. Prepare a cold water bath for ultrasound, which operates at a frequency of 50/60 Hz at 25 - 10°C for 110 minutes. Filter the solution using whatman No.1 filter paper to get rid of the solid and separate it from the extract. Evaporate the solvent with a rotary evaporator. Collect the extracted oil with 3 ml of n-hexane solvent and keep it in an airtight container.

III. RESULTS AND DISCUSSION

The technique of FTIR spectrometry was used to ensure the presence of fatty acids in the selected algae. Figure 1 shows the FTIR spectrum of the dry powder of the selected algae (Lyngbya sp. algae).



Figure 1: The FTIR spectrum of extract

For the spectrum shown in Figure 1, it can be seen the appearance of a weak peak at 1669 cm⁻¹. This is belonging to the carbonyl group (C=O) of the fatty acid, as well as a wide peak at 1139 cm⁻¹ belonging to the hydroxyl group in the carboxylic acid of the fatty acid.

To perform the transesterification reaction, the extracted fatty acids were reacted with sodium methoxide to synthesise the required fatty acids esters. Figure 2 and Figure 3 show respectively the FTIR spectrum of the upper and lower layers of the reactants after the termination of transesterification reaction and then the separation process.

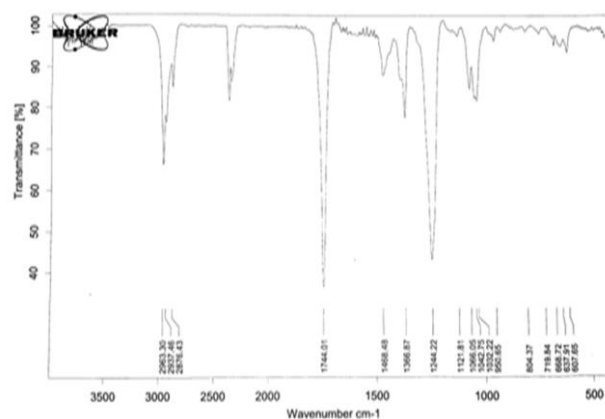


Figure 2: The FTIR of the upper layer after the esterification reaction

The spectrum shown in Figure 2 which represents the upper layer of the reaction refers to the formation of esters of fatty acids. This can be confirmed by the appearance of a very strong and sharp peak of the carbonyl ester group at 1744 cm⁻¹. Moreover, there is another evidence which support the claim of ester formation which is the disappearance of the broad peak belonging to the hydroxyl group of fatty acids. Furthermore, the figure shows bands appearing at 2937 cm⁻¹, 2963 cm⁻¹ and 2876 cm⁻¹ belong to aliphatic C-H. Lastly, the peak appears at 1244 cm⁻¹ belonging to C-O group. The availability of the above peaks in the spectrum of the upper layer introduces an indication to the formation of the esters of the reacted fatty acids. The FTIR of the lower layer is shown in Figure 3

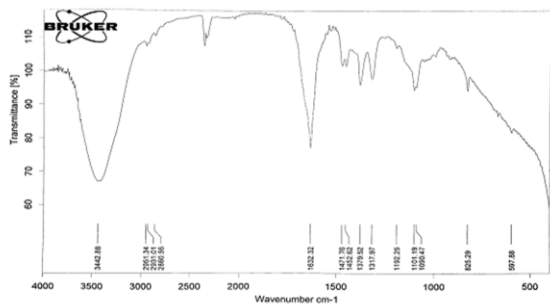


Figure 3: The FTIR of the lower layer of the esterification reaction.

It is clear from Figure 3 the formation of glycerol which is the side product of the esterification reaction. The formation of glycerol can be confirmed by the presence and appearance of a very strong peak of the hydroxyl-alcohol group at 3444 cm^{-1} . Moreover, peaks appear at 2951 cm^{-1} , 2938 cm^{-1} indicate the formation of C-H aliphatic peak.

IV. CONCLUSION

Researchers are now paying closer attention to microalgae because of its unique characteristics, which include photosynthetic transposition, fast growth, and the ability to produce a variety of biofuel sources. Microalgae are used in the food and pharmaceutical industries, but they have also recently gained attention as viable solutions for energy-related issues due to their potential for use in the production of renewable energy. Certain microalgae species can respond to varying stressors by generating different fatty acids or altering the makeup of these fatty acids. In this study, it was concluded that *Lyngbya* sp. Algae can be a worthy source of biofuel as a result of its production of fatty acids, which is a recent trend in obtaining alternative energy to fossil fuels. Axenic culture isolation, genetic comparison, wastewater resource cultures, open raceway pond cultivation, and other techniques could be explored in future research.

CONFLICT OF INTEREST

Authors declare that they have no conflict of interest.

REFERENCES

- [1] R. Stefania, A. Alessandro, G. Jacopo, and M. Luisa, "Biofuels from algae: technology options, energy balance and GHG emissions: Insights from a literature review," 2015.
- [2] P. Gerbens-Leenes, L. Xu, G. De Vries, and A. Y. Hoekstra, "The blue water footprint and land use of biofuels from algae," *Water resources research*, vol. 50, pp. 8549-8563, 2014.
- [3] A. H. Sayer, H. Al-Hussaini, and A. N. Campbell, "The utilisation of statistics to estimate evaporation from the surface of solar ponds," *University of Thi-Qar Journal of Science*, vol. 8, pp. 161-169, 2021.
- [4] A. H. Sayer and H. B. Mahood, "Improved thermal efficiency of salinity gradient solar pond by suppressing surface evaporation using an air layer," *Energy Engineering*, vol. 117, pp. 367-379, 2020.
- [5] A. Galetović, G. Peña, N. Fernández, M. Urrutia, N. Flores, B. Gómez-Silva, *et al.*, "Cellulose Synthase in Atacama Cyanobacteria and Bioethanol Production from Their Exopolysaccharides," *Microorganisms*, vol. 11, p. 2668, 2023.
- [6] L. Marelli, M. Padella, R. Edwards, A. Moro, M. Kousoulidou, J. Giuntoli, *et al.*, "The impact of biofuels on transport and the environment, and their connection with agricultural development in Europe," 2015.
- [7] V. Patil, K.-Q. Tran, and H. R. Giselrød, "Towards sustainable production of biofuels from microalgae," *International journal of molecular sciences*, vol. 9, pp. 1188-1195, 2008.
- [8] J. A. Alic, "Biofuel battles: Politics, policy, and the pentagon," *Energy Research & Social Science*, vol. 10, pp. 10-18, 2015.
- [9] Y. Chisti, "Biodiesel from microalgae," *Biotechnology advances*, vol. 25, pp. 294-306, 2007.
- [10] L. Brennan and P. Owende, "Biofuels from microalgae—a review of technologies for production, processing, and extractions of biofuels and co-products," *Renewable and sustainable energy reviews*, vol. 14, pp. 557-577, 2010.
- [11] A. Darzins, P. Pienkos, and L. Edey, "Current status and potential for algal biofuels production," *A report to IEA Bioenergy Task*, vol. 39, pp. 403-412, 2010.
- [12] B. Zhao, J. Ma, Q. Zhao, L. Laurens, E. Jarvis, S. Chen, *et al.*, "Efficient anaerobic digestion of whole microalgae and lipid-extracted microalgae residues for methane energy production," *Bioresource technology*, vol. 161, pp. 423-430, 2014.
- [13] I. C. Woertz, J. R. Benemann, N. Du, S. Unnasch, D. Mendola, B. G. Mitchell, *et al.*, "Life cycle GHG emissions from microalgal biodiesel—a CA-GREET model," *Environmental science & technology*, vol. 48, pp. 6060-6068, 2014.
- [14] S. Hena, S. Fatimah, and S. Tabassum, "Cultivation of algae consortium in a dairy farm wastewater for biodiesel production," *Water Resources and Industry*, vol. 10, pp. 1-14, 2015.
- [15] L. Zhu, "Biorefinery as a promising approach to promote microalgae industry: An innovative framework," *Renewable and sustainable energy reviews*, vol. 41, pp. 1376-1384, 2015.
- [16] M. Rizwan, J. H. Lee, and R. Gani, "Optimal design of microalgae-based biorefinery: Economics, opportunities and challenges," *Applied Energy*, vol. 150, pp. 69-79, 2015.
- [17] J. Trivedi, M. Aila, D. Bangwal, S. Kaul, and M. Garg, "Algae based biorefinery—how to make sense?," *Renewable and Sustainable Energy Reviews*, vol. 47, pp. 295-307, 2015.
- [18] M. Hannon, J. Gimpel, M. Tran, B. Rasala, and S. Mayfield, "Biofuels from algae: challenges and potential," *Biofuels*, vol. 1, pp. 763-784, 2010.
- [19] B. S. Sturm and S. L. Lamer, "An energy evaluation of coupling nutrient removal from wastewater with algal biomass production," *Applied energy*, vol. 88, pp. 3499-3506, 2011.
- [20] E. Fialkowska and A. Pajdak-Stós, "Dependence of cyanobacteria defense mode on grazer pressure," *Aquatic Microbial Ecology*, vol. 27, pp. 149-157, 2002.