



The 6th Annual International Conference (AIC 2016)

in conjunction with



The 12th International Conference on Mathematics, Statistics and Their Applications (ICMSA 2016)

PROCEEDING



AAC Dayan Dawood Darussalam - Banda Aceh. Indonesia
October 4-6, 2016

ISSN : 233 - 6606

COMMITTEES

Advisory Committees

Prof. Dr. Ir. Samsul Rizal, M.Eng, Syiah Kuala University - Indonesia
Dr. Hizir, Syiah Kuala University - Indonesia
Prof. Dr. Ir. Hasanuddin, M.S., Syiah Kuala University - Indonesia

Organizing Committees

Chairman:

Dr. Syaifullah Muhammad, M. Eng

Vice Chairman:

Prof. Dr. Samadi, M. Sc
Dr. Rini Oktavia, S.Si, M.Si

Secretary:

Dr. Nasrul Arahman, MT
drh. Triva Murtina Lubis, MP

Scientific Committees

Dr. drh. Al Azhar, M. Kes
Syiah Kuala University - Indonesia
Dr. Saiful, M.Si
Syiah Kuala University - Indonesia
Dr. Heru Fahlevi, SE., M.Sc
Syiah Kuala University - Indonesia
Dr. Taufik F. Abidin, M.Tech
Syiah Kuala University - Indonesia
Dr. Hasan Basri
Syiah Kuala University - Indonesia
Prof. Dr. Muchlisin Z.A., S.Pi, M.Sc.
Syiah Kuala University - Indonesia
Dr. Shabri A. Majid, SE., M.Ec
Syiah Kuala University – Indonesia

EDITOR

Prof. Dr. Samadi, M.Sc. (Syiah Kuala University – Indonesia)
Dr. Saiful, S.Si. (Syiah Kuala University – Indonesia)
Dr. Heru Fahlevi, S.E., M.Sc. (Syiah Kuala University – Indonesia)
Dr. Nasrul Arahman, ST, MT (Syiah Kuala University – Indonesia)
Dr. Yunisrina Qismullah Yusuf, S.Pd., M.Ling. (Syiah Kuala University – Indonesia)
Dr. Irsyadillah S.Pd., M.Sc. (Syiah Kuala University – Indonesia)
Dr. Hasan Basri M.Com. (Syiah Kuala University – Indonesia)
Dr. drh. Al Azhar, M. Kes. (Syiah Kuala University – Indonesia)
dr. Tristia Rinanda, M.Si. (Syiah Kuala University – Indonesia)

REVIEWER

Dr. M. Dani Supardan (Syiah Kuala University – Indonesia)
Dr. Taufik Fuadi Abidin (Syiah Kuala University – Indonesia)
Dr. Salmawati (Syiah Kuala University – Indonesia)
Dr. Mohd. Iqbal (Syiah Kuala University – Indonesia)
Dr. Ira Devi Sara (Syiah Kuala University – Indonesia)
Dr. Jane Teng Yan Fang (Sultan Idris Education University – Malaysia)
Prof. Dr. K. Ponnari Lakshmi (Narasaraopeta Engineering College – India)
Asst. Prof. Dr. Pairote Bennui (Thaksin University – Thailand)
Dr. Ahmed H. Ahmed (South Valley University – Egypt)
Dr. Alhashmi Aboubaker Lasyoud (Sharjah University - United Arab Emirates)
Dr. Rosaria Mita Amelia, M.Hum. (Universitas Padjajaran – Indonesia)
Dr. T. Zulfikar Akarim (Universitas Islam Negeri Ar Raniry - Indonesia)
Dr. Siti Sarah Fitriani, M.A. (Syiah Kuala University – Indonesia)
Wardah, S.H, MH, LL.M. (Syiah Kuala University – Indonesia)
Nellyana Rossa, S.H, LL.M. (Syiah Kuala University – Indonesia)

WELCOME SPEECH FROM THE RECTOR

Assalamualaikum Wa Rahmatullahi Wa Barakatuh,

In the Name of Allah, the Most Beneficent, the Most Merciful

May the peace, the mercy, and the blessings of Allah be upon you.

Distinguished Participants, Ladies and Gentlemen,

On behalf of Syiah Kuala University, I would like to welcome all of you to the The 6th Annual International Conference Syiah Kuala University in conjunction with The 12th International Conference on Mathematics, Statistics and Their Application (ICMSA), 2016.

I sincerely hope this conference is inspiring and also the one to be anticipated in the next years to come. The organizing committee is committed to make this conference a success with its ready applications not only to the university but also to the government. No matter how much we can accomplish by ourselves, whether it be research or development, it is never sufficient in this world of knowledge. Therefore, the focal drive of this conference is to exchange ideas, and by participating in this exchange, it is hoped that all parties who may benefit from the conference can apply it in managing activities in their areas. It is pleasing to note that the agenda of this conference covers a wide range of interesting topics related to life sciences, sciences and engineering, social sciences, and special topics on mathematics and statistics sciences.

Last but not the least, my deepest gratitude goes to the Organizing Committee, institutions, and companies who have directly and indirectly supported the well-running of this seminar. The committee has organized a vibrant scientific program and is working hard to present highly respected and internationally notorious speakers to lead it. Although we try our finest to be professional, on behalf of the Rector of Syiah Kuala University, please accept our sincere apologies should there be inconveniences that occur before, during, or after the event.

I wish you a very productive conference with exciting and encouraging discussions and exchange of knowledge so that together we can anticipate a future of groundbreaking sciences, technologies and education. May God bless us all with good health to make this event a successful and enjoyable one!

Thank you.

Prof. Dr. Ir. Samsul Rizal, M.Eng

Rector of Syiah Kuala University

MESSAGE FROM THE CHAIRMAN

Assalamualaikum Wr. Wb.

Honorable Guests, Presenters, and Participants,

As the Chairperson of the Organizing Committee, I take the privilege to warmly welcome our distinguished speakers and delegates who have come from all over Indonesia and overseas to our conference today. We are indeed honored to have you here with us.

The Annual International Conference (AIC) conference is a forum of information distribution, scientific discussion of literature, research, innovative and sustainable technology, industry product, etc. The AIC activity has been carried out regularly by Unsyiah since 2011. This year, the university will host The 6th Annual International Conference (AIC) in conjunction with The 12th International Conference on Mathematics, Statistics and Their Application (ICMSA). Furthermore, in this year The AIC program will also deliver an Innovation Expo and Industrial Forum event.

With many research activities that are conducted today on the global extent, it is important to share them to promote integrity in research at an international level. Accordingly, about 150 papers will be presented in this event, including those in the fields of Sciences and Engineering, Life Sciences, Social Sciences, and ICMSA topics. Therefore, to all participants, I would like to thank you for your valuable contributions to this conference.

I am also happy to inform that the committee is fortunate to have five keynote and invited speakers from Australia, Canada, Thailand, Malaysia and Indonesia, who have supported us from the very beginning with their capabilities to try and personally come and meet you all here at the conference.

At this juncture, I would like to take the opportunity to thank everyone who has made this event happen. It is a great pleasure for me to be a part of the organizing committee to coordinate such a remarkable conference. It does not only function as a platform to bring us who are academicians, researchers, students and others in sharing our research and experiences, but it also bridge us to further share ideas, concerns and constructive examples that we gain from this conference to build our society.

Finally, I hope that all participants will have memorable moments through this conference. The weather in Banda Aceh at the moment is at its best, so we hope that you enjoy your stay in Banda Aceh.

Thank you.

Sincerely,

Chairman of Committee

Dr. Syaifullah Muhammad, M. Eng

CONTENTS

		Pages
EDITORIAL BOARD		i
MESSAGE FROM THE RECTOR		ii
MESSAGE FROM THE CHAIRMAN		iii
No	Scientific Paper	
	Keynote and Invited Speaker	
1	Ministry of Agriculture Strategic Research Chair Program: Advanced Synchrotron Technology for Livestock and Feed Research Peiqiang Yu	2
2	The 3 Ps of Reproduction: Pheromones, Photons and Phood Graeme B. Martin	3
3		
	Theme : Chemistry-Chemical Engineering	
4	Biodiesel Production by Microwave Assisted Methanolysis of Refined Palm Oil in a Flow Reactor Marwan, Muhammad Furqan, Amzar Arfa and Cut Meurah Rosnelly (Indonesia)	6
5	In Situ Transesterification Of Screw Pine (Pandanus Tectorius) Seed To Biodiesel Using Mechanical Stirrer Mahlinda Mahlinda, M. Dani Supardan, Husni Husin and Medyan Riza (Indonesia)	11
6	The Adsorption Process of Nitrite and Nitrate Content from Fertilizer Plant Liquid Waste of PT. PIM by Using Activated Carbon from Coffee Waste Mariana, Mahidin and Farid Mulana (Indonesia)	18
7	Simultaneous Adsorption Of Trace Metal And So ₂ using Zeolite Adsorbent During Combustion Of Brown Coal Asri Gani (Indonesia)	23
8	Chitosan-rhodamine B probe as a simple colorimetric naked-eye sensor for Hg ²⁺ in aqueous solution Zarlaida Fitri, Della Kharisma and Muhammad Adlim (Indonesia)	30
9	PI Control of a Continuous Bio-Reactor Rudy Agustriyanto (Indonesia)	34
10	Activation of Palm Midrib by Using Mixed Citric Acid and Tartaric Acid and its Application for Adsorption of Zn (II) Heavy Metals from Wastewater Farid Mulana, Mariana, Pocut Nurul Alam and Abrar Muslim (Indonesia)	40
11	Synthesis And Characterization Of Bioplastic Based On Cassava Starch-PLA For Food Packaging Application Harunsyah, Ridwan, Salahuddin (Indonesia)	46
12	Utilization of Crude Extract Papain from Papaya Latex as A Coagulant in The Tofu Production Faridah, Fachraniah, Ariefin, Ayu Ardhia Rizqi and Cut Meutia Sari (Indonesia)	53
13	Synthesis of α -Mn ₂ O ₃ @ α -MnO ₂ Core/Shell Nanocomposite and Catalytic Oxidation of Phenolic Contaminants in Aqueous Solutions Edy Saputra (Indonesia), Jhon Armedi Pinem (Australia), Syaiful Bahri (Indonesia), Shaobin Wang (Australia)	58
14	Application of a water hyacinth (Eichhornia crassipes) for treatment of wastewater from a chicken farm Suhendrayatna, Marwan, Putri and Susanti Ria (Indonesia)	62
15	Identification of Mineral of Jades from Nagan Raya Aceh, Indonesia by using XRD and SEM-EDX Techniques Julinawati, Lubis, Irfan Mustafa (Indonesia)	66
	Theme : Architecture, Civil And Mechanical Engineering	
16	Development and Performance Test of Furrower Model Blade to Paddlewheel Aerator Samsul Bahri, Radite Praeko Agus Setiawan, Wawan Hermawan and Muhammad Zairin Junior (Indonesia)	73
17	The Priorities of Selection Suppliers Ikhsan Siregar (Indonesia)	77
18	Vehicles Potholes Detection Based Blob Detection Method and Neural Network Backpropagation Model	82

Biodiesel Production by Microwave Assisted Methanolysis of Refined Palm Oil in a Flow Reactor

Marwan*, Muhammad Furqan, Amzar Arfa, Cut Meurah Rosnelly

Department of Chemical Engineering, Faculty of Engineering, Syiah Kuala University, Darussalam, Banda Aceh 23111, Indonesia.

*Corresponding Author: marwan@unsyiah.ac.id

Abstract

Biodiesel is one of the most promising alternative fuels to reduce or even replace petroleum based diesel fuel. It offers many significant benefits, including being renewable, less greenhouse gas effect, low pollution, and non-toxic, while for the engine, biodiesel requires no modification and has excellent lubrication properties. Its production is potentially enhanced by combining the processes with microwave irradiation. Microwave does not only provide heating effect on the reactions, but also stimulate intermolecular interaction of involving materials such as reactants, solvent, and catalyst which is expected contributing on reaction rate enhancement. The purpose of this study is to produce palm oil biodiesel at a maximum yield in a short time by utilizing a flow reactor and microwave heating. The methanolysis was catalyzed by sodium hydroxide. The glass pipe reactor was installed inside a household type microwave. Flow rate of the reacting solution significantly determined the biodiesel yield. The yield was increased as the flow rate was reduced from 90 ml/min to 30 ml/min, and the yield was significantly dropped at lower flow rate due to soap formation in the feed tank. The results showed that the optimal condition of methanolysis was found at a methanol to oil molar ratio of 5:1 and a flow rate of 30 ml/min which resulted in maximum yield of 93%. This flow rate was corresponding to residence time of 1.33 min which is much faster than the reaction time needed in a batch reactor to achieve similar yield. FTIR analysis showed that the product formed is biodiesel. It is characterized by the formation of absorption at a wave number of 1435 cm^{-1} , which is evidence of the formation of methyl ester groups. The final biodiesel met EN 14214 and SNI standards. It shows a promising feature of flow type microwave reactor to produce biodiesel.

Key words: palm oil, methanolysis, biodiesel, microwave, flow reactor.

Introduction

Biodiesel offers many benefits as an alternative energy resource including being derived from a renewable domestic resource, thereby reducing the dependence on petro-diesel, and being biodegradable and non-toxic nature (Datta and Mandal, 2016). The total annual petroleum demand in the world increased from 90.3 in 2012 to 120.9 (million barrels per day) in 2040 with an average annual increase of 1.0% between 2012 and 2040 (USEI Administration, 2016). Further, petroleum fuel combustion has been known as the main reason for climate change and global warming. Annual production of CO₂ emissions has increased significantly in recent years. According to projected data, world energy-related CO₂ emissions rise from 32.2 billion metric tons in 2012 to 35.6 billion metric tons in 2020 and to 43.2 billion metric tons in 2040 (USEI Administration, 2016). Therefore, the demanding needs for a clean-burning and sustainable fuel such as biodiesel is constantly growing to avoid future problem of energy supply.

In a typical method of biodiesel preparation, reaction between a plant based oil with an alcohol in the presence of a homogeneous catalyst takes place under conventional heating; heat is transferred to the reaction molecules through convection, conduction, and radiation from the surface of the reactor. Microwave irradiation has become a prospective energy source for many organic syntheses, wherein chemical conversions are accelerated because of selective absorption of microwave energy by polar molecules, non-polar molecules being inert to the microwave dielectric loss (Varma, 2001). Many researches in the recent years show the microwave-assisted synthesis of biodiesel is faster, takes less than 5–6 min, gives higher yields, and produces fewer byproducts (Vyas *et al.*, 2010; Motasemi and Ani, 2012; Marwan and Indarti, 2016). Separation of the glycerol layer is easy and fast (Refaat *et al.*,

2008). Since the mixture of plant based oil, alcohol, and homogeneous base catalyst contains both polar and ionic components, fast heating is observed upon microwave irradiation, and because the energy interacts with the reacting compounds on a molecular level, a very efficient heating can be acquired (Barnard *et al.*, 2007). Microwave heating shows superior performance over conventional methods, where heating can be relatively slow and inefficient due to lack of energy transfer rate by convection currents and the thermal conductivity of the reaction mixture (Koopmans, 2006).

In the present work, preparation of palm oil biodiesel was studied by utilizing a flow reactor and microwave heating. Such flow system is much more suitable for large scale production. The methanolysis was catalyzed by sodium hydroxide and carried out at different flow rates and methanol to oil molar ratios. The resulted biodiesel was characterized for its functional groups, and some physical properties.

Materials and Methods

The refined palm oil was purchased from a local store. The palm oil, methanol 99.8% (Aldrich), sodium hydroxide, and deionized water were used as received. Experiments were performed in a modified Panasonic's NN-ST 342M model microwave unit, working at frequency of 2.45 GHz and maximum power output 800 W. A coiled glass tube (made of Pyrex, 126 cm in length x 0.635 cm in inside diameter) was installed inside the microwave chamber. The reaction fluid was circulated by a peristaltic pump (MasterFlex).

Transesterification was carried out at fixed parameters for the oil amount of 250 g and catalyst loading of 1% (w/w of the oil). Different flow rates (10, 30, 60, and 90 ml/min) and molar ratios of oil and methanol (1:3, 1:4, and 1:5) were selected for the transesterification reactions. Fig. 1 shows arrangement of microwave reactor for the present experiments. The oil, methanol, and the catalyst were charged into a 1.0 L feed flask and stirred during the experiments. The mixture was flowed to the reactor inlet by a peristaltic pump at selected flow rate until the mixture in the feed flask was empty. The reactor outlet was connected to a product flask. During the reaction, the microwave oven was run with heating set at low-micro power. Thereafter, the reaction mixture was cooled to room temperature. The reaction mixture was settled in a separatory funnel overnight, and the biodiesel phase (upper layer) was obtained. Finally, the biodiesel was washed with warm water three times, and dried by adding sodium sulphate. The yield of biodiesel was evaluated by gravimetric method. As a comparison, the palm biodiesel was also prepared by conventional technique in a stirred reactor by water bath heating at 60°C for 15, 30 and 60 min. The agitation speed was kept constant at 200 rpm.

The resulted biodiesel was characterized to determine its density, viscosity, water content, acid number, and refraction index. The chemical changes were identified by Fourier Transform Infrared (FTIR) Spectrophotometer (Model 8400S, Shimadzu) equipped with Interferometer to exclude the effect of moisture and carbon dioxide in the surrounding atmosphere.

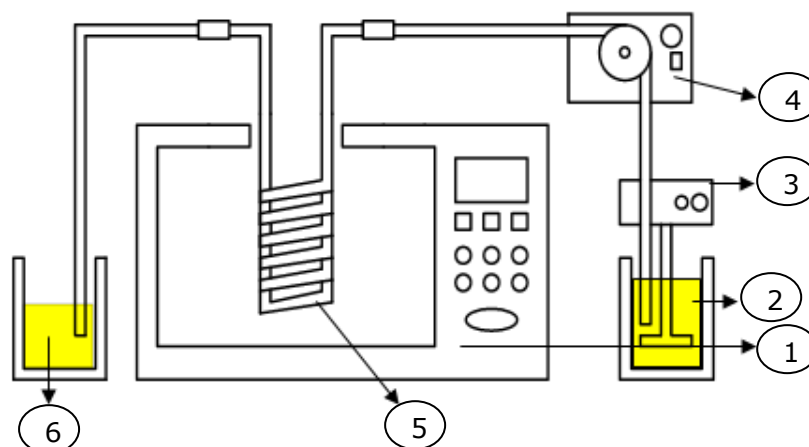


Figure 1. Schematic experimental setup (1. microwave oven, 2. feed flask, 3. stirring unit, 4. peristaltic pump, 5. coiled glass tube, 6. product flask)

Results and Discussion

The reaction mixture was pumped through the coiled glass tube in a single pass. It is essential to determine a precise transesterification time to ensure completion of the reaction. For a flow system, the reaction time corresponds to its residence time, which is determined by the flow rate. Analysis of the

outlet flow indicates that biodiesel was being formed. Fig. 2 shows the biodiesel yield with flow rate for NaOH 1% at different methanol to oil molar ratios. The yield was increased as the flow rate was reduced from 90 ml/min to 30 ml/min, and then the yield was significantly dropped. At flow rate of 10 ml/min, soap formation in the feed tank was observed. It shows that the optimal condition of methanolysis was found at a methanol to oil molar ratio of 5:1 and a flow rate of 30 ml/min which resulted in maximum yield of 93%.

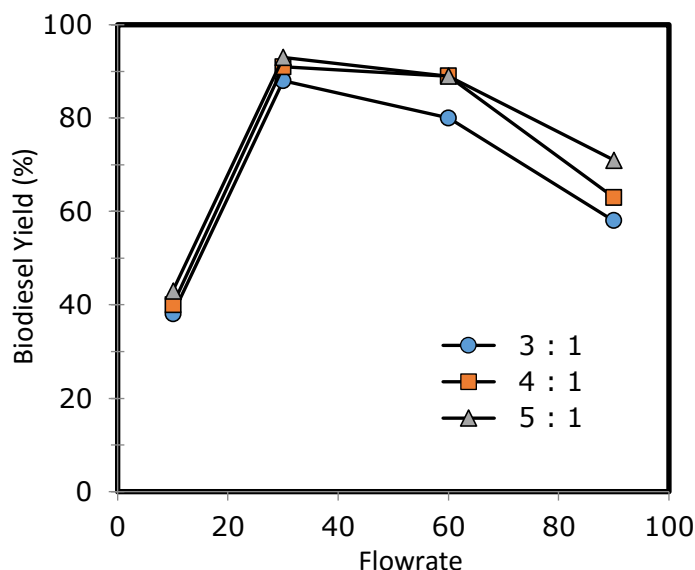


Figure 2. Biodiesel yield at different flow rates and methanol to oil molar ratios.

In the previous work (Marwan *et al.*, 2015), preparation of biodiesel in batch mode microwave reactor resulted in maximum yield of 94-96% for reaction time of 6-10 min, while the conventional heating method gave similar maximum biodiesel yield after 45 min. The maximum yield of 93% in the present work was observed at the flow rate of 30 ml/min. This flow rate was corresponding to residence time of 1.33 min which is much faster than reaction time needed in the batch mode to achieve similar yield. This result is comparable with the residence times of 1.75 min and 2 min found in Choedkiatsakul *et al.* (2015) and Encinar *et al.* (2012), respectively. Higher biodiesel yield at lower flow rate was due to long exposure time to microwave irradiation, and simultaneously causing an increase in thermal gradient during the reaction (Encinar *et al.*, 2012). Thermal microwave effects are revealed being dominant for homogenous-catalyzed reactions (Mazubert *et al.*, 2014).

Theoretical molar ratio of oil to methanol of 1:3 is required for the reaction, but higher than the stoichiometric value is necessary in practical production to enhance the degree of reaction completion. Moreover, effect of the molar ratio may be a key parameter due to high microwave absorption of methanol (Encinar *et al.*, 2012). Owing to its high dielectric constant ($\epsilon = 33$) as compared to palm oil ($\epsilon = 3$), methanol strongly absorbs microwave energy (Choedkiatsakul *et al.*, 2015). In this study, yield of biodiesel reached 88% for the reaction at stoichiometric composition and flow rate of 30 ml/min. Higher yields of 91% and 93% were obtained as the molar ratio was increased to 4:1 and 5:1, respectively. Effect of the molar ratio was more pronounced at higher flow rates or shorter residence times.

Fig. 3 shows FTIR spectra of the obtained biodiesel. Evidence of the formation of ester groups was characterized by a specific absorption band at 1435 cm^{-1} arising from (CO)-O-CH₃. The other strong peaks were related to carbonyl (C=O) at 1737 cm^{-1} and C-O (antisymmetric axial stretching and asymmetric axial stretching) at $1300\text{-}1000\text{ cm}^{-1}$. In addition, the stretching vibrations of CH₃, CH₂, and C-H of the fatty acid chains appear at frequency around 2916 , 2854 , and 2999 cm^{-1} , whereas the bending vibrations (ν_{CH_2}) of these groups appear at $1475\text{-}1350$, $1350\text{-}1150$, and 719 cm^{-1} respectively. These facts are in good agreement with biodiesel spectra reported elsewhere (Naureen *et al.*, 2015; Rabelo *et al.*, 2015; Marwan *et al.*, 2015).

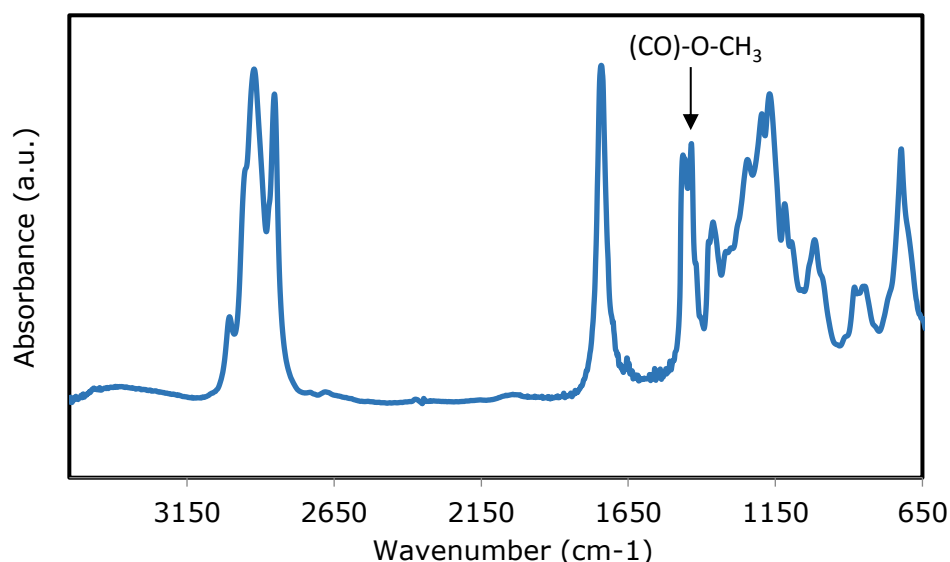


Figure 3. Infra-red spectra of the biodiesel produced in the microwave assisted flow reactor

Quality assessment was performed using physicochemical parameters such as density, viscosity, refraction index, acid number, and water content, and determined according to the EN14015 and ASTM D6751 standard methods. The results are listed in Table 1. The finally obtained biodiesel properties were within the mentioned range of biodiesel fuel standards.

Table 1. Quality assessment of biodiesel produced in the microwave assisted flow reactor

Properties	This Work	EN 14214	SNI
Density at 15°C	896 kg/m ³	860-900 kg/m ³	850-890 kg/m ³
Kinematic Viscosity at 40°C	5,2 mm ² /s	3,5-5,0 mm ² /s	2,3-6 mm ² /s
Refraction Index	1,44	-	1,45
Acid Number	0,07	max 0,5	max 0,8
Water Content	0,012%	-	max 0,05%

Conclusions

A flow reactor system with heating by microwave irradiation was adopted for preparation of biodiesel. Refined palm oil was reacted with methanol, using sodium hydroxide as homogenous catalyst. The most influential variable was flow rate, which corresponds to residence time and also temperature gradient of the reaction. The optimal condition of methanolysis was observed at a methanol to oil molar ratio of 5:1 and a flow rate of 30 ml/min which resulted in maximum yield of 93%. This flow rate was corresponding to residence time of 1.33 min which is much faster than reaction time needed in a batch reactor to achieve similar yield. The study also showed that the quality of the produced biodiesel satisfies the European and Indonesian standards; hence, it can provide an alternative. Moreover, microwave heating offers a fast and easy route to this important biofuel with advantages of enhancing the reaction rate, and lowering production cost that making the biodiesel more economically feasible and being attractive to the consumers.

Acknowledgements

Financial support from Ministry of Research, Technology, and Higher Education for Muhammad Furqan and Amzar Arfa through Student Creativity Program, Grant Year 2015 is gratefully acknowledged.

References

Barnard, T. M., Leadbeater, N. E., Boucher, M. B., Stencel, L. M., and Wilhite, B. A. (2007). Continuous-Flow Preparation of Biodiesel Using Microwave Heating, *Energy and Fuels*, 21: 1777-1781.

- Choedkiatsakul, I., Ngaosuwan, K., Assabumrungrat, S., Mantegna, S., Cravotto, G. (2015). Biodiesel Production in a Novel Continuous Flow Microwave Reactor. *Renewable Energy*, 83: 25-29.
- Datta, A., Mandal, B. K. (2016). A Comprehensive Review of Biodiesel as an Alternative Fuel for Compression Ignition Engine. *Renewable and Sustainable Energy Reviews*, 57: 799-821.
- Encinar, J. M., Gonzalez, J. F., Martinez, G., Sanchez, N., Parda, I. A. (2012). Soybean Oil Transesterification by the Use of a Microwave Flow System. *Fuel*, 95: 386-393.
- Koopmans, C., Iannelli, M., Kerep, P., Klink, M., Schmitz, S., Sinnwell, S. (2006). Microwave-Assisted Polymer Chemistry: Heck Reaction, Transesterification, Baeyer-Villiger Oxidation, Oxazoline Polymerization, Acrylamides and Porous Materials. *Tetrahedron*, 62: 4709-4714.
- Marwan, Indarti, E. (2016). Hydrated-Calcined *Cyrtopleura costata* Seashells as an Effective Solid Catalyst for Microwave Assisted Preparation of Palm Oil Biodiesel. *Energy Conversion and Management*, 117: 319-325.
- Marwan, Suhendrayatna, Indarti, E. (2015). Preparation of Biodiesel from Microalgae and Palm Oil by Direct Transesterification in a Batch Microwave Reactor. *Journal of Physics: Conference Series*, 622: DOI 10.1088/1742-6596/622/1/012040
- Mazubert, A., Taylor, C., Aubin, J., Poux, M. (2014). Key Role of Temperature Monitoring in Interpretation of Microwave Effect on Transesterification and Esterification Reactions for Biodiesel Production. *Bioresource Technology*, 161: 270-279.
- Motasemi, F., Ani, F. N. (2012) A Review on Microwave-Assisted Production of Biodiesel. *Renewable and Sustainable Energy Reviews*, 16: 4719-4733.
- Naureen, R., Tariq, M., Yusoff, I., Chowdhury, A. J. K., Ashraf, M. A. (2015). Synthesis, Spectroscopic and Chromatographic Studies of Sunflower Oil Biodiesel Using Optimized Base Catalyzed Methanolysis. *Saudi Journal of Biological Sciences*, 22: 332-339.
- Rabelo, S. N., Ferraz, V. P., Oliveira, L. S., Franca, A. S. (2015). FTIR Analysis for Quantification of Fatty Acid Methyl Esters in Biodiesel Produced by Microwave-Assisted Transesterification. ***International Journal of Environmental Science and Development***, 6: 964-969.
- Refaat, A. A., El-Sheltawy, S. T., Sadek, K. U. (2008). Optimum Reaction Time, Performance and Exhaust Emissions of Biodiesel Produced by Microwave Irradiation. *International Journal of Environmental Sciences and Technology*, 5: 315-322.
- USEI Administration (2016). *International Energy Outlook 2016 – With Projection to 2040*. [http://www.eia.gov/forecasts/ieo/pdf/0484\(2016\).pdf](http://www.eia.gov/forecasts/ieo/pdf/0484(2016).pdf)
- Varma, R. S. (2001). Solvent-free Accelerated Organic Syntheses Using Microwaves. *Pure and Applied Chemistry*, 73: 193-198.
- Vyas, A. P., Verma, J. L., Subrahmanyam, N. (2010). A Review on FAME Production Processes. *Fuel*, 89: 1-9.