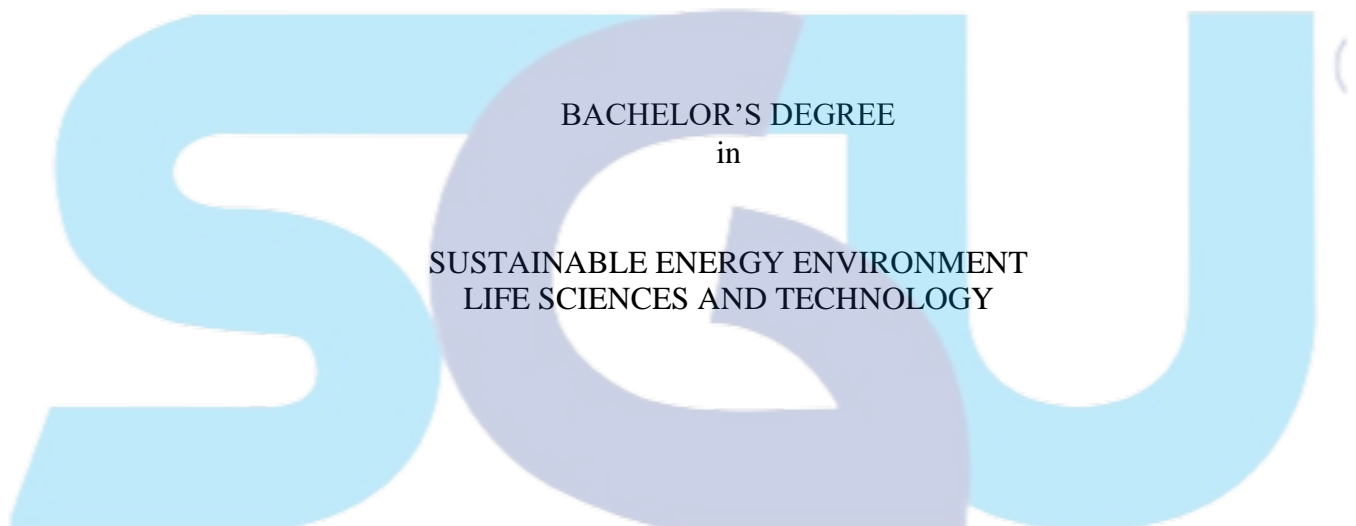


**BINARY EFFECT OF TERTIARY BUTYLHYDROQUINONE AND  
BUTYLATED HYDROXYTOLUENE ADDITIVES WITH THE ADDITION  
OF GLYCEROL MONOSTEARATE TO IMPROVE OXIDATIVE  
STABILITY OF PALM OIL-BASED BIODIESEL**

By

Chelselyn Charissa Chuaca  
11918001



BACHELOR'S DEGREE  
in

SUSTAINABLE ENERGY ENVIRONMENT  
LIFE SCIENCES AND TECHNOLOGY



SWISS GERMAN UNIVERSITY  
The Prominence Tower  
Jalan Jalur Sutera Barat No. 15, Alam Sutera  
Tangerang, Banten 15143 - Indonesia

Revised after the Thesis Defense on 18 July 2023

### STATEMENT BY THE AUTHOR

I hereby declare that this submission is my work and to the best of my knowledge, it contains no material previously published or written by another person, nor material which to a substantial extent has been accepted for the award of any other degree or diploma at any educational institution, except where due acknowledgment is made in the thesis.



Chelselyn Charissa Chuaca

Student

25 July 2023

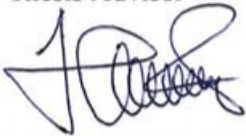
Date

Approved by:



Silvy Yusri M.Si

Thesis Advisor



Dr. Hery Sutanto M.Si

Thesis Co-Advisor



Dr. Hery Sutanto M.Si

Dean of Life Sciences Technology

25 July 2023

Date

25 July 2023

Date

25 July 2023

Date

## ABSTRACT

### BINARY EFFECT OF TERTIARY BUTYLHYDROQUINONE AND BUTYLATED HYDROXYTOLUENE ADDITIVES WITH THE ADDITION OF GLYCEROL MONOSTEARATE TO IMPROVE OXIDATIVE STABILITY OF PALM OIL-BASED BIODIESEL

By

Chelselyn Charissa Chuaca  
Silvya Yusri M.Si, Advisor  
Dr. Hery Sutanto M.Si, Co-Advisor

SWISS GERMAN UNIVERSITY

Biodiesel is a renewable and environmentally friendly alternative to conventional diesel fuel. However, like any fuel, biodiesel is subject to oxidation, which can negatively impact its quality and performance when kept for long-term. The addition of binary antioxidants such as TBHQ:BHT had been proven to improve oxidation stability of biodiesel. Combining surfactant such as GMS into single antioxidant had been proven to solve its insolubility issue. However, the implementation of mixing binary antioxidants and surfactant has not been done yet. Therefore, this research analyzed the effect of single antioxidant, binary antioxidants, and binary antioxidants with GMS (100 ppm) addition into biodiesel and biodiesel blend B35. The effect was observed within 8 weeks storage period. The result showed that B35 did not have any significant impact. While in pure biodiesel samples, B100-bi and B100-bi+GMS had a slight difference in the results of oxidative parameters. B100-bi showed the best result in induction period and kinematic viscosity. Rancimat test showed 170 hours for B100-bi and 168 hours for B100-bi+GMS. While B100-bi+GMS indicated as the best additives in term of acid number, iodine value, and dispersion test. For that reason, the addition of surfactant into binary antioxidants showed similar performance with B100-bi but with slightly better solubility.

*Keywords: Antioxidant, Binary effect, Biodiesel, Oxidative stability, Surfactant*



## DEDICATION

I dedicate this study to support the development of science in Indonesia.  
Also, to Swiss German University which provides valuable knowledge.  
Lastly, to my beloved parents and friends for their endless love and support.



## ACKNOWLEDGEMENTS

With the humblest heart, I would like to express my sincere appreciation and thankfulness for those who has helped and support me during my study.

First and foremost, I want to thank God for providing me the strength, peace, and courage to complete my thesis.

I want to share my gratitude to my advisor Silvy Yusri, M. Si. for her kind assistance, patience, and valuable knowledge that makes me able to do this research. Thank you for your availability to help me by giving wise direction.

Also, I would like to thank my co-advisor Dr. Hery Sutanto M.Si. for providing me the opportunity to do this topic. Furthermore, for sharing your deep knowledge and keen advice.

Moreover, I am grateful to Dr. -Ing Evita H. Legowo for providing me a more than enough reliable biodiesel samples so that I can research properly with the given samples.

As well to SGU's lab assistants, especially Kak Rizal who helped me so much on how to deal with my analysis.

To Chemical Engineering 2019 for being warm and supportive friends all along. Thanks to your companion all along, I was able to get through this college period well.

Last but not least, to my parents and friends for giving me never-ending support.

## TABLE OF CONTENTS

	Page
STATEMENT BY THE AUTHOR.....	2
ABSTRACT.....	3
DEDICATION.....	5
ACKNOWLEDGEMENTS.....	6
TABLE OF CONTENTS.....	7
LIST OF FIGURES.....	9
LIST OF TABLES.....	10
CHAPTER 1 - INTRODUCTION.....	11
1.1 Background.....	11
1.2 Research Problems.....	14
1.3 Objectives.....	14
1.4 Hypothesis.....	14
CHAPTER 2 - LITERATURE REVIEW.....	15
2.1 Oxidative stability of biodiesel standard.....	15
2.2 Effect of Long-Term Storage on the Quality of Palm Oil Biodiesel.....	17
2.3 Oxidation mechanism.....	19
2.4 Antioxidant mechanism.....	19
2.5 Antioxidant addition to biodiesel.....	20
2.6 Synergistic effect from binary antioxidants.....	21
2.7 Surfactant addition to solve insolubility.....	23
CHAPTER 3 - RESEARCH METHODS.....	25
3.1 Materials and Equipment.....	25
3.2 Design of Experiment.....	25
3.3 Experimental Procedure.....	27
CHAPTER 4 - RESULTS AND DISCUSSIONS.....	30
4.1 Effect of various additive addition to acid number during storage.....	30
4.2 Effect of various additive addition to iodine value during storage.....	36
4.3 Effect of various additive addition to kinetic viscosity at 40 °C during storage.....	42
4.4 Effect of various additive addition to induction period during storage.....	43
4.5 Dispersion Test.....	44
CHAPTER 5 - CONCLUSIONS AND RECOMMENDATIONS.....	47
5.1 Conclusions.....	47

5.2 Recommendations .....	47
GLOSSARY.....	48
REFERENCES.....	49
APPENDIX.....	54
CURRICULUM VITAE.....	67





## LIST OF FIGURES

Figure 2.1 a) kinematic viscosity at 40 °C b) acid number and c) density at 40 °C d) total glycerol e) Peroxide number and f) FAMES content of POB and COB during 18 weeks of storage.....	19
Figure 3.1 Design of experiment.....	26
Figure 3.2 B100 and B35 samples .....	27
Figure 4.1 oleic acid, linoleic acid, and palmitic acid chemical structure .....	31
Figure 4.2 The oxidative degradation of linoleic acid leads to the creation of hydroperoxides.....	31
Figure 4.3 Acid number of pure biodiesel for 8 weeks.....	32
Figure 4.4 Acid number slope difference of pure biodiesel with four different kinds of additive(s).....	33
Figure 4.5 Acid number of pure biodiesel and biodiesel with binary antioxidants and surfactant for 8 weeks .....	33
Figure 4.6 Biodiesel B35 acid number for 8 weeks .....	34
Figure 4.7 Chemical structure of petroleum diesel and biodiesel.....	35
Figure 4.8 Acid number slope difference of biodiesel B35 with four different kinds of additive(s).....	35
Figure 4.9 Biodiesel B35 with additive(s) acid number trend for 8 weeks .....	36
Figure 4.10 Pure biodiesel iodine value for 8 weeks .....	38
Figure 4.11 Iodine value slope difference of pure biodiesel with four different kinds of additive(s).....	38
Figure 4.12 Iodine value of pure biodiesel and biodiesel with binary antioxidants and surfactant for 8 weeks .....	39
Figure 4.13 Biodiesel B35 iodine value for 8 weeks .....	40
Figure 4.14 Iodine value slope difference of biodiesel B35 with four different kinds of additive(s).....	40
Figure 4.15 Iodine value of biodiesel B35 and biodiesel B35 with binary antioxidants and surfactant for 8 weeks .....	41
Figure 4.16 Kinematic viscosity at 40 °C during 8 weeks storage .....	42
Figure 4.17 Kinematic viscosity at 40 °C difference .....	43

Figure 4.18 Induction period in hours of pure biodiesel with none, binary  
antioxidants, and binary antioxidants & GMS .....44

### LIST OF TABLES

Table 2.1 The American Standard ASTM D6751 (Sakthivel et al., 2018)..... 15  
Table 2.2 The European Standard EN 14214 (Sakthivel et al., 2018)..... 16  
Table 2.3 The Indonesian Standard SNI 7182 (Layanan BBN, n.d.) ..... 16  
Table 2.4 Induction period of palm oil-based biodiesel, biodiesel with single and  
binary antioxidants at 500 ppm .....22  
Table 4.1 The average of absorbance of each sample at 290nm and 278nm wavelength  
in the initial week .....45  
Table 4.2 Delta absorbance of B100 at 290nm wavelength between four weeks .....46  
Table 4.3 Delta absorbance at 278 nm wavelength between four weeks .....46