RESEARCH PROJECT

METAL-PHENOLIC NETWORK-COATED RGO FOR MALACHITE GREEN ADSORPTION

Submitted by

Clarissa Sucitro	NRP. 5203018001
Veronika Priliana	NRP. 5203018004

DEPARTMENT OF CHEMICAL ENGINEERING

FACULTY OF ENGINEERING

WIDYA MANDALA CATHOLIC UNIVERSITY SURABAYA

2022

LETTER OF APPROVAL

Seminar of **RESEARCH PROJECT** for student with identity below:

Name : Clarissa Sucitro
NRP : 5203018001

has been conducted on 23rd March 2022, therefore the student has fulfilled one of several requirements to obtain **Bachelor of Engineering** degree in **Chemical Engineering** Department, Faculty of Engineering, Widya Mandala Catholic University Surabaya.

Surabaya, 23rd March 2022

Principal Supervisor	Co-Supervisor
Ir. Wenny Irawaty, Ph.D., IPM., ASEAN Eng.	Ir. Shella P. Santoso, Ph.D., IPM.
NIK. 521.97.0284	NIK. 521.17.0971

Committees

Chairman	Secretary
Ir. Maria Yuliana, Ph.D., IPM.	Ir. Wenny Irawaty, Ph.D., IPM., ASEAN Eng.
NIK. 521.18.1010	NIK. 521.97.0284
Member	**Member**
Ir. Aning A., M.Eng.Sc., Ph.D., IPM., ASEAN Eng.	Ir. Shella P. Santoso, Ph.D., IPM.
NIK. 521.03.0563	NIK. 521.17.0971

Authorized by

Dean of Engineering Faculty	Head of Chemical Engineering Department
Prof. Ir. Suparsi Ismadji, Ph.D., IPM., ASEAN Eng.	Ir. Sandy Budi Hartono, M.Phil., Ph.D., IPM.
NIK. 521.93.0198	NIK. 521.99.0401

LETTER OF APPROVAL

Seminar of **RESEARCH PROJECT** for student with identity below:

Name : Veronika Priliana
NRP : 5203018004

has been conducted on 23rd March 2022, therefore the student has fulfilled one of several requirements to obtain **Bachelor of Engineering** degree in **Chemical Engineering** Department, Faculty of Engineering, Widya Mandala Catholic University Surabaya.

Surabaya, 23rd March 2022

Principal Supervisor	Co-Supervisor
Ir. Wenny Irawaty, Ph.D., IPM., ASEAN Eng.	Ir. Shella P. Santoso, Ph.D., IPM.
NIK. 521.97.0284	NIK. 521.17.0971

Committees

Chairman	Secretary
Ir. Maria Yuliana, Ph.D., IPM.	Ir. Wenny Irawaty, Ph.D., IPM., ASEAN Eng.
NIK. 521.18.1010	NIK. 521.97.0284

Member	Member
Ir. Aning A., M.Eng.Sc., Ph.D., IPM., ASEAN Eng.	Ir. Shella P. Santoso, Ph.D., IPM.
NIK. 521.03.0563	NIK. 521.17.0971

Authorized by

Dean of Engineering Faculty	Head of Chemical Engineering Department
Dr. Ir. Suryadi Ismadji, Ph.D., IPM., ASEAN Eng.	Ir. Sandy Budi Hartono, M.Phil., Ph.D., IPM.
NIK. 521.93.0198	NIK. 521.99.0401

COPY RIGHT AGREEMENT

In order to support the development of science and technology, I am as the student of Widya Mandala Catholic University Surabaya:

Name : Clarissa Sucitro
NRP : 5203018001

agree to transfer the copyright of my research project:

Title:
Metal-Phenolic Network-Coated RGO for Malachite Green Adsorption

to be published in internet or other media (Digital Library of Widya Mandala Catholic University Surabaya) for academic purposes according to copyright law in Indonesia.

Surabaya, 23rd March 2022

Author,

(Clarissa Sucitro)
NRP. 5203018001

COPY RIGHT AGREEMENT

In order to support the development of science and technology, I am as the student of Widya Mandala Catholic University Surabaya:

Name : Veronika Priliana
NRP : 5203018004

agree to transfer the copyright of my research project:

Title:
Metal-Phenolic Network-Coated RGO for Malachite Green Adsorption

to be published in internet or other media (Digital Library of Widya Mandala Catholic University Surabaya) for academic purposes according to copyright law in Indonesia.

Surabaya, 23rd March 2022
Author,

(Veronika Priliana)
NRP. 5203018004

LETTER OF DECLARATION

I declare that this research was my own work and does not contain any material that belongs to the others, unless it was stated in the references. Should it is known that this research belongs to others. I aware and accept the consequences that this research cannot be used as a requirement to obtain **Bachelor of Engineering** degree.

Surabaya, 23rd March 2022

Student,

Clarissa Sucitro

NRP. 5203018001

LETTER OF DECLARATION

I declare that this research was my own work and does not contain any material that belongs to the others, unless it was stated in the references. Should it is known that this research belongs to others. I aware and accept the consequences that this research cannot be used as a requirement to obtain **Bachelor of Engineering** degree.

Surabaya, 23rd March 2022

Student,

Veronika Priliana

NRP. 5203018004

CONTENTS

LETTER OF APPROVAL ii
COPY RIGHT AGREEMENT iv
LETTER OF DECLARATION vi
CONTENTS viii
LIST OF FIGURES ix
LIST OF TABLES x
PREFACE xi
ABSTRACT xii
I. INTRODUCTION 1
I.1. Background 1
I.2. Objectives 3
I.3. Problem Limitations 4
II. LITERATURE REVIEW 5
III. MATERIALS AND METHODS 14
IV. RESULTS AND DISCUSSION 21
V. CONCLUSIONS AND SUGGESTIONS 41
REFERENCES 43
APPENDIX A 53
APPENDIX B 57
APPENDIX C 62

LIST OF FIGURES

Figure II.1. Structural Changes of GO to RGO 6
Figure II.2. The mechanism of green reduction of GO 7
Figure II.3. Scheme TA-Fe Films Covered GO Sheet 12
Figure IV.1. Mechanism of MPN/RGO Preparation by (a) Method I and (b) Method II 22
Figure IV.2. The Color Change during MPN/RGO Preparation 23
Figure IV.3. Adsorption Performances of GO, MPN/GO, RGO, and MPN/RGO 24
Figure IV.4. % Removal of Malachite Green Adsorbed on MPN/RGO Prepared from Different Ratio of GO:Extract ($^{v}/_{v}$) 25
Figure IV.5. The Color Change of MG Solution Before and After Adsorption using MPN/RGO 26
Figure IV.6. % Removal of Malachite Green Adsorbed on MPN/RGO Prepared from Different pH 27
Figure IV.7. The Interaction between The MPN/RGO Surface is Positively and Negatively Charged with The Positively Charged Adsorbate at The pH Value Below and Above The pH_{pzc}. 28
Figure IV.8. Value of pH_{pzc} MPN/RGO 1:0.125 28
Figure IV.9. SEM for MPN/RGO Method I (a) and Method II (b) 29
Figure IV.10. FTIR Spectra for GO, MPN/RGO Method I, and MPN/RGO Method II 31
Figure IV.11. Adsorption Mechanism of MG by MPN/RGO (a) Method I and (b) Method II 32
Figure IV.12. Adsorption Kinetics of MPN/RGO 1:0.125 Method I Pseudo-first Order (a), Method I Pseudo-second Order (b), Method II Pseudo-first Order (c), Method II Pseudo-second Order (d), Method I Intraparticle Diffusion (e), and Method II Intraparticle Diffusion (f), ... 34
Figure IV.13. Isotherm Adsorption of MPN/RGO 1:0.125 Method I Langmuir Model (a), Method I Freundlich Model (b), Method II Langmuir Model (c), and Method II Freundlich Model (d) 37
Figure B.1. Raw Curve of Gallic Acid Standard Solution 59
Figure C.1. Raw Curve of Malachite Green Standard Solution 63
Figure C.2. Adsorption Thermodynamics of MPN/RGO Method I onto MG 75
Figure C.3. Adsorption Thermodynamics of MPN/RGO Method II onto MG 77

LIST OF TABLES

Table II.1. The adsorption capacity of RGO prepared from GO reduction using plant extracts 8
Table II.2. Research related to the application of GO-MPN 11
Table IV.1. EDX Analysis for MPN/RGO 30
Table IV.2. Parameters of The Kinetic Model for MG Adsorption onto MPN/RGO 1:0.125 35
Table IV.3. Parameters of The Langmuir and Freundlich Isotherm Model for MG Adsorption onto MPN/RGO 1:0.125 38
Table IV.4. Thermodynamics Parameter for MG adsorption onto MPN/RGO 40
Table A.1. Preparation of Gallic Acid Standard Solution 54
Table A.2. Preparation of Malachite Green Standard Solution 55
Table B.1. Data Calculation of TPC 61
Table C.1. Adsorption Performance of GO, MPN/GO, RGO, and MPN/RGO 65
Table C.2. Relations between Adsorption Performance and Variation in Ratio of MPN/(RGO) for Method I 66
Table C.3. Relations between Adsorption Performance and Variation in Ratio of MPN/RGO for Method II 67
Table C.4. Relations between Adsorption Performance and Variation in pH 68
Table C.5. Adsorption Kinetic of MPN/RGO 1:0.125 (Method I) 69
Table C.6. Adsorption Kinetic of MPN/RGO 1:0.125 (Method II) 70
Table C.7. Isotherm Adsorption of MPN/RGO 1:0.125 (Method I) 72
Table C.8. Isotherm Adsorption of MPN/RGO 1:0.125 (Method II) 73
Table C.9. Adsorption Thermodynamic of MPN/RGO Method I 75
Table C.10. Adsorption Thermodynamic of MPN/RGO Method II 76

PREFACE

Thank God almighty because for His grace and grace, the author was able to complete the Research Project and prepare his report well. The purpose of this thesis is to meet the requirements in obtaining a Bachelor of Engineering degree in Chemical Engineering Department, Faculty of Engineering, Widya Mandala Catholic University Surabaya.

The preparation of this Thesis Report can be completed due to support from many parties so that the author expresses his deepest gratitude to:

1. Ir. Wenny Irawaty, Ph.D., IPM., ASEAN Eng. and Ir. Shella Permatasari Santoso, Ph.D., IPM. as a principal supervisor and co-supervisor who has taken time, energy, and thoughts in providing direction, guidance, and suggestion.
2. Ir. Maria Yuliana, Ph.D., IPM. and Ir. Aning Ayucitra, M.Eng.Sc., Ph.D., IPM., ASEAN Eng. as committees who have given suggestion and direction during the final thesis report.
3. All lecturers and staff of the Department of Chemical Engineering, Faculty of Engineering, Widya Mandala Catholic University Surabaya who have indirectly assisted us in completing the final thesis report.
4. All parties who have provided assistance either directly or indirectly to the author until the completion of this final thesis report.

Finally, the author expects criticism and suggestions for the refinement of this practical work report. The author also hopes that this final thesis report can be useful for readers.

Surabaya, 23rd March 2022

Author

ABSTRACT

Malachite green (MG) is one of dyes commonly found in wastewater of textile industries. Since the presence of MG is harmful for living organisms. Adsorption is considered as the most method widely investigated since the process is simple and brings advantageous in term of its applicability. Composite of MPN (metal-phenolic network)/RGO (reduced graphene oxide) has been selected as adsorbent to adsorb MG. The aims of the study were to study the preparation of MPN/RGO, to determine the adsorption capacity of MPN/RGO toward MG dye as the selected adsorbate, and to investigate the kinetic, isotherm, and thermodynamic study for MG adsorption over MPN/RGO. Kaffir lime peels extract was used as the reducing agent of GO. MPN/RGO itself was prepared by two different methods by changing the alter of chemicals added during the preparation. In method I, RGO was prepared first, followed by coating it with MPN. In method II, MPN was firstly coated on GO, then MPN-coated GO was reduced by kaffir lime peels extract. SEM-EDX analysis showed that the % atomic weight of O and Fe in MPN/RGO method I was lower than in MPN/RGO method II. FTIR analysis shows that MPN/RGO method I losses hydroxyl, alkoxy, and epoxy functional groups, indicating the successful of reduction process. Whilst on the surface of MPN/RGO indicates part of these groups are still bound which means the GO reduction process is occurred partially. However, the adsorption study shows both adsorbent performed similar achievement by removing around 95% of dye for the same adsorption conditions. The adsorption kinetic were also studied and pseudo-second order adsorption phenomena was confirmed. The intraparticle diffusion model shows that the adsorption process is controlled by surface adsorption. The adsorption capacity based on the Langmuir isotherm for MPN/RGO method I and II are 349 and 360 mg/g, respectively. Thermodynamics approach for MG adsorption over MPN/RGO suggests that MG adsorption occurs spontaneously and endothermic. The recyclability of MPN/RGO sample is interesting to be further investigated to seek a candidate adsorbent applied in textile-based industries.