# $CO_2$ CAPTURE FROM A POST-COMBUSTION PROCESS INVOLVING A NOVEL HYBRID ADSORBENT-ABSORBENT SYSTEM

**VERSHIMA, DENEN ASHIEKAA**
**(12CF013587)**

**JULY, 2022**

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**BY**

**VERSHIMA, DENEN ASHIEKAA**
**(12CF013587)**
**B.Eng. Chemical Engineering, Covenant University, Ogun State**

**A DISSERTATION SUBMITTED TO SCHOOL OF POSTGRADUATE STUDIES, IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF ENGINEERING (M.Eng.) DEGREE IN CHEMICAL ENGINEERING IN THE DEPARTMENT OF CHEMICAL ENGINEERING, COLLEGE OF ENGINERRING, COVENANT UNIVERSITY**

**JULY, 2022**

# ACCEPTANCE

This is to attest that this dissertation is accepted in partial fulfilment of the requirements for the award of the degree of Masters of Engineering in Chemical Engineering in the Department of Chemical Engineering, College of Engineering, Covenant University, Ota, Ogun State.

**Mr.Taiwo B. Erewunmi**
**(Secretary, School of Postgraduate Studies)** **Signature and Date**

**Prof. Akan B. Williams**
**(Dean, School of Postgraduate Studies)** **Signature and Date**

# DECLARATION

I, **VERSHIMA, DENEN ASHIEKAA (12CF013587),** declares that this research was carried out by me under the supervision of Dr. Samuel E. Sanni of the Department of Chemical Engineering, College of Engineering, Covenant University, Ota, Nigeria. I attest that this dissertation has not been presented either wholly or partially for the award of any degree elsewhere. All sources of data, and scholarly information used in this dissertation are duly acknowledged.

**VERSHIMA, DENEN ASHIEKAA**

**Signature and Date**

## CERTIFICATION

We certify that this dissertation titled "**$CO_2$ CAPTURE FROM A POST-COMBUSTION PROCESS INVOLVING A NOVEL HYBRID ADSORBENT-ABSORBENT SYSTEM**" is the original research work carried out by **VERSHIMA, DENEN ASHIEKAA (12CF013587)** in the Department of Chemical Engineering, Covenant University, Ota, Ogun State, Nigeria under the supervision of Dr. Samuel E. Sanni of the Department of Chemical Engineering. We have examined and found this research work acceptable as part of the requirements for the award of the degree of Master of Engineering in Chemical Engineering.

**Dr. Samuel E. Sanni**
**(Supervisor)** **Signature and Date**

**Prof. Vincent E. Efeovbokhan**
**(Head of Department)** **Signature and Date**

**Prof. Kayode G. Latinwo**
**(External Examiner)** **Signature and Date**

**Prof. Akan B. Williams**
**(Dean, School of Postgraduate Studies)** **Signature and Date**

# DEDICATION

This dissertation is dedicated to God Almighty.

# ACKNOWLEDGEMENTS

All the praise and adoration belong to GOD Almighty for my existence and for his mercy over me.

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| ANG | Associated Natural Gas |
| CCS | Carbon capture and storage |
| CNG | Natural gas vehicles |
| COP21 | 21st Conference of Parties |
| CI | Climate impact |
| CST | Concentrated solar thermal energy |
| DEA | Diethanolamine |
| DIPA | Diisopropylamine |
| GDP | Gross domestic product |
| GHG | Greenhouse gasses |
| Gt | Gigatonne |
| GO | Graphene oxide |
| IL | Ionic liquids |
| $KMnO_4$ | Potassium permanganate |
| MEA | Monoethanolamine |
| MN | Methylammonium nitrate |
| MOF | Metal-organic framework |
| Mt | Megatonne |
| PN | Propylammonium nitrate |
| PVA | poly(vinyl alcohol) |
| PCC | Post-combustion capture |
| PAMAM | Poly(amidoamine) |
| SFSI | Strategic Fuel Substitution Initiatives in Nigeria |
| UNFCCC | United Nations Framework Convention on Climate Change |

# ABSTRACT

Due to the global menace caused by carbon emissions there have been concerted efforts by researchers to search alternative ways of curbing issues arising (environmental pollution, health related diseases, risks to aquatic life etc.) from such emissions. In today's world, $CO_2$ has become one of the major gaseous pollutants that has attracted significant interest as a result of man's consistent use of energy from fossils and other human activities. The traditional ways of controlling carbon emissions are not very efficient and somewhat expensive, hence the need to search alternative solutions. The research is aimed at capturing carbon from a post-combustion using an adsorbent- absorbent system. Graphene oxide was synthesized using a modified hummers method. Ionic liquids (methylammonium nitrate and propylammonium nitrate) were synthesized by dissolving ammonium chloride in methanal and propanal. Cellulose acetate membrane was then synthesized using the casting method. The cellulose acetate membrane was doped with the ionic liquids and graphene oxide for carbon capture. $Ca(OH)_2$ solution was prepared to test for the presence of $CO_2$ in the experimental process. A combustor- adsorber -desorber system was fabricated to capture $CO_2$ in a post-combustion process. The combustible material used was Napier grass. 600 g of Napier grass was fed into the system and heated at 400 $^0$C. At the exhaust pipe of the adsorber, the bottle containing the $Ca(OH)_2$ solution was fitted in order to confirm if the flue gas leaving the system contains $CO_2$ and the amount of $CO_2$ leaving the process. This helped to determine the amount of $CO_2$ captured by the system. The experiment was monitored for 50 minutes and at 10-minute intervals, a syringe was used to draw out 25 $cm^3$ samples for analysis. The maximum adsorption capacity recorded for the 30 wt.% GO - 20 wt.% PN - membrane was 1.32753 ($\frac{mol.CO_2}{dm^3.membrane}$) which was considerably high compared to that in literature. The results showed carbon capture efficiency of 80 % for the membrane doped with ionic liquids/graphene oxide. These results confirmed the possibility of using the membrane doped with ionic liquids/graphene oxide for efficient and effective carbon capture.



**Keywords:** ***Adsorption; Biogas; Biomass; Carbon capture; Membrane-Ionic liquid system; Post-combustion***