

UPGRADING BIO-METHANE STORAGE BY ADSORPTION

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Thesis submitted in partial fulfillment of the requirements for the degree Master of Science

Department of Chemical and Process Engineering

University of Moratuwa

Sri Lanka

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DECLARATION OF THE CANDIDATE AND SUPERVISOR

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ABSTRACT

There is a growing global interest on bio-methane as a vehicular fuel and Europe Union (EU) has stated that this as a best well-to-wheel fuel. Commercialization of bio-methane under atmospheric conditions is limited due to its requirement on higher storage capacity. Compressed bio-methane systems have been currently commercialized in order to increase its low energy density however the process requires higher capital and maintenance costs. Thus, adsorbed bio-methane is suggested as a better alternative to store methane under low pressure conditions.

This study is based on upgrading bio-methane storage by gas adsorption technique. Activated Carbon (AC) is selected considering its potential and suitability as commercial scale adsorbent for Sri Lanka. This study focuses on identifying adsorption potential of bio-methane on Sri Lankan commercial AC. Two types of commercial AC samples as granular & pellet forms have been used from supplier HAYCARB for the analysis. The potential on supplied AC is discussed by characterization data of the samples. Further, the pilot scale experiment set up was developed and biogas adsorption experiments were carried out for granular and pellet samples. The experiment data was analysed by Langmuir and Toth models. Extended Langmuir model was used to understand the bio-methane adsorption behaviour from biogas adsorption. Storage capacity of 71.5V/V and 82.8 V/V values were obtained from granular and pellet AC respectively proving better methane adsorption potential on commercial AC available in Sri Lanka.

Keywords: Biogas, bio-methane, Activated Carbon, Adsorption, Toth equation, Extended Langmuir equation



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DEDICATION

I dedicate this thesis to my parents who have devoted their life for making me an educated and a successful person. I would like to express my love and appreciation for the encouragement and the sacrifices made by them.



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LIST OF ABBREVIATIONS

Abbreviation Description

| | |
|-----|---------------------------------|
| AC | Activated Carbon |
| STP | Standard Temperature & Pressure |
| CNG | Compressed Natural Gas |
| LNG | Liquefied Natural Gas |
| ABM | Adsorbed Bio-Methane |
| ANG | Adsorbed Natural Gas |
| BET | Brunauer-Emmett-Teller |
| DR | Dubinin-Redushkevich |
| PSD | Pore Size Distribution |
| GAC | Granular Activated Carbon |

GCMC Grand Canonical Monte Carlo

MOF Metal-Organic Framework



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Notation Description

| | |
|------------|--|
| n | Adsorbed moles per unit mass (mmol/g) |
| P | System Pressure (barg) |
| n_{max} | Maximum adsorption per unit mass (mmol/g) |
| k_L | Affinity parameter -Langmuir model (bar^{-1}) |
| α_T | Affinity parameter -Toth model (bar^{-1}) |

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