SORPTION ENHANCED CATALYTIC PYROLYSIS OF RICE HUSK USING HIERARCHICAL ZSM-5 CATALYST

BY
ADAMU, SULAIMAN YAHAYA
(P16EGCE8014)

PRESENTED
TO

CHEMICAL ENGINEERING DEPARTMENT

FACULTY OF ENGINEERING

AHMADU BELLO UNIVERSITY

ZARIA, NIGERIA

APRIL, 2021

SORPTION ENHANCED CATALYTIC PYROLYSIS OF RICE HUSK USING HIERARCHICAL ZSM-5 CATALYST.

BY

ADAMU, SULAIMAN YAHAYA
(P16EGCE8014)

A DISSERTATION SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES

AHMADU BELLO UNIVERSITY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR

THE AWARD OF MASTER OF SCIENCE DEGREE IN CHEMICAL ENGINEERING

DEPARTMENT OF CHEMICAL ENGINEERING,

FACULTY OF ENGINEERING,

AHMADU BELLO UNIVERSITY,

ZARIA, NIGERIA

APRIL, 2021

Declaration

I, Sulaiman Yahaya ADAMU, hereby declare that this thesis entitled "SORPTION ENHANCED CATALYTIC RICE HUSK PYROLYSIS USING HIERARCHICAL ZSM-5 CATALYST" was carried out by me in the Department of Chemical Engineering. The report presented in the literature was duly acknowledged in the text and no part of this thesis was previously presented for the award of degree or diploma at any establishment.

Sulaiman Yahaya ADAMU	_____	_____
Name of Student	Signature	Date

Certification

This is to certify that this dissertation entitled "SORPTION ENHANCED CATALYTIC RICE HUSK PYROLYSIS USING HIERARCHICAL ZSM-5 CATALYST" by Sulaiman Yahaya ADAMU, registration number P16EGCE8014, meets the regulations governing the award of Master of Science (M.Sc.) degree in Chemical Engineering of the Ahmadu Bello University, and is approved for its contribution to knowledge and literally presentation.

Dr. F.N. Dabai	_____	_____
Chairman,Supervisory Committee	Signature	Date
Prof. B. J. El-Yakubu	_____	_____
Member, Supervisory Committee	Signature	Date
Dr. A. Y. Atta	_____	_____
Member, Supervisory Committee	Signature	Date
Prof. M. S. Galadima	_____	_____
Head of Department	Signature	Date
Prof. S. A. Abdullahi	_____	_____
Dean, School of Postgraduate Studies	Signature	Date

Dedication

To my Parents.

Acknowledgement

In the name of Allah, the entirely Merciful, the especially Merciful. All praise is due to Allah (SWT), may peace and blessings of Allah (SWT) be upon His final prophet, Muhammad (SAW), his companions and those that follow the right path to the last day. I give thanks to Almighty Allah who Has given me the strength, will and opportunities for making this work successful.

I want to use this medium to show my appreciation and gratitudeto members of my supervisory team, Dr. F.N. Dabai, Dr. A.Y. Atta, and Prof. B. J. El-Yakubu. I am very grateful for their priceless efforts and contributionsto my academic and non-academic issues.

I also want to extend my sincere gratitude to the entire staff of Chemical Engineering Department, Ahmadu Bello University, Zaria, for their kind contributions to the success of this work.

Abstract

The necessity to source clean energy and contain CO_2 emissions has brought about a global interest in the use of biomass as an environmental friendly renewable energy route. One of the drawbacks in the conversion of biomass to energy via pyrolysis/gasification is the liberation of CO_2 from the syngas.This study was carried out in a two- stage catalytic process using rice husk as feed, ZSM-5 catalysts for cracking and reforming of the pyrolysis volatiles and calcineddolomite as CO_2 capture material (sorbent).The catalyst include commercial ZSM-5, hierarchical ZSM-5 which was prepared by desilication method using 0.2 mol/dm^3 NaOH, and 2 wt.% Zn-wt.%and hierarchical ZSM-5 which was prepared by doping metal on the hierarchical ZSM-5 through wetness impregnation.Calcineddolomite was prepared by size reduction and calcination of the dolomite precursor.Sorbent and catalysts were characterized using XRD, FTIR, BET and TGA techniques. The XRD results of the catalysts indicatedthat the crystalline zeolite structure of HZSM-5 was maintained after alkali treatment and metal modification with slight reduction in intensities of some noticeable peaks as a result of desilication. The structure stability confirmed with XRD was supported with the FTIR resultswhich showed no loss in major functional groups of the HZSM-5 such as the Bands observed at 450 cm^{-1} represents the T-O-T bending vibration (T=Si or Al) and 550 cm^{-1} which represents the five membered ring pentasil unit of ZSM-5. At 790 and 1225 cm^{-1} which represents the external symmetric and asymmetric stretching of the Si-O-Si bond Although on critical examination of the band at 1100 cm^{-1} which signifies internal tetrahedral bridged Si-OH-Al vibrations in the asymmetric regionit appears that the peak has broadened on alkaline treatment of the catalyst, as compared to the shaper peak of the parent HZSM-5, while the band at 1100 cm^{-1} signifies internal tetrahedral bridged Si-OH-Al vibrations in the asymmetric region.TGA affirmed the thermal stability of the catalyst with a total percentage weight loss of less than 6% and a notable thermal change at 400^0C for parent, hierarchical and Zn-Ni/

hierarchical catalyst. The BETresults showed an increase in surface mesopores from 111 m^2 /g in the parent ZSM-5 catalyst to

141 m^2 /g and 136 m^2 /g in the hierarchical and metal treated hierarchal catalyst respectively.There was also an increase in the volume mesopores and average pore width. These increase was observed after desilication, this is to say there was successful introduction of mesopores into the system hence converting the catalyst to a hierarchical catalyst.Introduction of calcineddolomite into the reformer displayed a reduction of CO_2 andCO with a surge in H_2 liberated. Upon loading of fractions of hierarchical catalyst to calcineddolomite, it was observed that there was an increase in the generation of non-condensable volatiles with the highest amount of gases produced at 3.0 g hierarchical ZSM-5 catalyst in ratio to 7.0 g calcineddolomite. However, the best in terms of CO_2 capture and H_2 was noted at 1.5g hierarchical ZSM-5 catalyst in ratio to 8.5g calcineddolomite which gave a high amount of H_2 and traces of CO_2 with an average of 72 wt. % (vol) and 4wt. %(vol) respectively. Hierarchical catalyst incorporated with metal promoter (2 wt. %Zn- 2 wt. %Ni hierarchical ZSM-5) displayed improved H_2yields at the expense of other syngas produced as compared to the hierarchical ZSM-5 and commercial ZSM-5 at similar catalyst to calcineddolomite ratios (1.5g: 8.5g).Increase in loading of hierarchical ZSM5 also led to changes in the composition of the condensates. The FTIR as well as the GC-MS results showed an increase in the aromatic compounds and a decrease in the aliphatic and oxygenated compounds for the catalytic pyrolysis. The GC-MS results confirmed that, hierarchical catalyst showed selectivity towards aconversion of condensates to mostly BTX compounds. Aromatic hydrocarbons composition increased to about 71% of the reformed condensates when Zn/Ni-hierarchical ZSM-5 was used as compared to 61% for hierarchical ZSM-5 and 58% for the parent ZSM-5.

Table of Contents

Declaration iii

Certification iv

Dedication v

Acknowledgement vi

Abstract vii

List of Tables xii

List of Figures xiii

List of Appendices xv

List of Symbols and Abbreviations xvi

1.0 INTRODUCTION 1

1.1 Background 1
1.2 Problem Statement 3
1.3 Aim and Objectives 3
1.4 Scope 4
1.5Justification 4
2.0 LITERATURE REVIEW 5

2.1 Introduction 5
2.2 Biomass as a Source of Fuel 6
2.3 Biomass Composition 6
2.3.1 Proximate and ultimate analysis 9

2.3.2 Heating Value 10

2.4 Pyrolysis 10
2.4.1 Pyrolysis Classification 12

2.4.2 Pyrolysis Products 13

2.4.3 Pyrolysis Reactor 15

2.5 Catalytic Pyrolysis 16
2.6 Hierarchical ZSM-5 Catalyst 18
2.7 CO_2 Capture 20
2.8 Reaction Mechanism 21
2.8.1 Thermal Conversion of Lignocellulose Components 21

3.0 MATERIALS AND METHODS 24

3.1 Materials and Equipment 24
3.2 Feed Preparation 24
3.3 Dolomite Preparation 25
3.4 Catalyst Preparation 25
3.4.1 Calcination of NH_4 – ZSM-5 25

3.4.2 Desilication of ZSM-5 using NaOH 25

3.4.3 Metal oxide impregnation on hierarchical ZSM-5 catalysts 26

3.5 Catalysts and Dolomite Characterization 27
3.6 Experimental Setup and Conditions 27
3.6.1 Experimental Setup 27

3.6.2 Experimental conditions 29

4.0 RESULTS AND DISCUSSION 32

4.1 Structural and Textural Properties of Catalyst and Sorbent 32
4.1.1 X-ray diffraction. 32

4.1.2 Fourier transformed infrared (FTIR) analysis. 34

4.1.3 Nitrogen sorption studies 36

4.1.2 Thermo gravimetric analysis. 39

4.2 Effects of Catalyst and Sorbent on Pyrolysis Product Distribution **40**
4.3 Effect of Catalyst and Sorbent on Non-Condensable Reformed Products **43**
4.3 Effect of Catalyst and Sorbent On Non-Condensable Reformed Products **51**
5.0 CONCLUSIONS AND RECOMMENDATIONS **62**

5.1 Conclusions **62**
5.2 Recommendations **63**
REFERENCES **65**

APPENDICES. **69**

List of Tables

Page

Table 2. 1. Lignin, Cellulose and Hemicellulose Content of Selected Biomass Materials 8

Table 2. 2. Proximate Analysis of Selected Biomass Materials. 9

Table 2. 3. Proximate Analysis of Selected Biomass Materials. 10

Table 2. 4. Typical Operating Parameters and Products for Pyrolysis Process. 12

Table 2. 5. Pyrolysis Reactions at Different Temperatures. 15

Table 3. 1. Materials and Equipment Used in This Study. 24

Table 4. 1. Physiochemical Properties of Sorbent and Catalyst. 37

Table 4. 2. Summary of The Most Abundant Components from GC/MS of The Condensates. 54

List of Figures

Page

Figure 2. 1. Decomposition of Individual Biomass Components with Pyrolysis Temperature. 11

Figure 2. 2.Representation of The Reaction Paths for Wood Pyrolysis 12

Figure 2. 3. Relative Proportions of end Products in Pyrolysis of Biomass. 14

Figure 2. 4. Catalytic Pyrolysis of Biomass.. 17

Figure 2. 5. Effect of NaOH on Si/Al; ratio During Desilication of ZSM-5 19

Figure 2. 7. Lignin Pyrolysis Scheme 23

Figure 3. 1. Catalyst Preparation. 26

Figure 3. 2. Catalyst and Sorbent Performance Test. 29

Figure 3. 3. Process Flow Diagram of Catalytic Pyrolysis of Rice husk Volatiles with In-Situ CO_2 Capture 30

Figure 4. 1. XRD Patterns of the Parent ZSM-5, Hierarchical ZSM-5 and Zn-Ni Hierarchical ZSM-5. 33

Figure 4. 2. XRD Pattern of Calcined Dolomite. 34

Figure 4. 3. FTIR Spectra of Parent ZSM-5, Hierarchical ZSM-5 and Zn-Ni Hierarchical ZSM-5. 35

Figure 4. 4. FTIR Spectra of Calcined Dolomite 36

Figure 4. 5. Nitrogen Adsorption and Desorption Isotherms of Parent ZSM-5, Hierarchical ZSM-5 and Zn-Ni Hierarchical ZSM-5. 38

Figure 4. 6. Nitrogen Adsorption and Desorption Isotherms of Calcined Dolomite 39

Figure 4. 7. TGA of Parent ZSM-5, Hierarchical ZSM-5 and Zn-Ni Hierarchical ZSM-5. 40

Figure 4. 8. Product Yield of Liquids and Gas Using Various Ratio of Bed Material. 42

Figure 4. 9. Product Yield of Liquids and Gas Using Different Catalyst as Bed Material. 43

Figure 4. 10. Gas Composition for Blank Run. 44

Figure 4. 11. Gas Composition Using 10.0 g Dolomite (N_2 flow rate 100 ml/min). 44

Figure 4. 12. Gas Composition Using 10.0 g Dolomite (N_2 flow rate 50 ml/min). 46

Figure 4. 13. Gas Composition Using 0.5g Hierarchical ZSM-5 and 9.5g Dolomite. 46

Figure 4. 14. Gas Composition Using 1.0 g Hierarchical ZSM-5 and 9.0 g Dolomite. 47

Figure 4. 15. Gas Composition Using 1.5g Hierarchical ZSM-5 and 8.5g Dolomite. 48

Figure 4. 16. Gas Composition Using 2.0 g Hierarchical ZSM-5 and 8.0 g Dolomite. 49

Figure 4. 17. Gas Composition Using 3.0 g Hierarchical ZSM-5 and 7.0 g Dolomite. 49

Figure 4. 18. Gas Composition Using 1.5g Parent ZSM-5 and 9.5g Dolomite. 50

Figure 4. 19. Gas Composition Using 1.5g (2wt % Zn- 2wt% Hierarchical ZSM-5) and 8.5g Dolomite. 50

Figure 4. 20. FTIR Analysis of bio oils; Blank run, 0.5g Hierarchical ZSM-5 and 9.5g Dolomite, 1.0g Hierarchical ZSM-5 and 9.0 g Dolomite, 1.5g Hierarchical ZSM-5 and 8.5g Dolomite, 2.0 g Hierarchical ZSM-5 and 8.0 g Dolomite, 3.0 g Hierarchical ZSM-5 and 7.0 g Dolomite. 51

Figure 4. 21. FTIR Analysis of Bio oils; Blank run, 1.5g Parent ZSM-5and 9.5g Dolomite, 1.5g Hierarchical ZSM-5 and 8.5g Dolomite, 1.5g Zn-Ni/ Hierarchical ZSM-5 and 8.5g Dolomite. 52

Figure 4. 22. Chemical Compositions of the Condensates from GC-MS Analysis of Blank run, 1.5g Hierarchical ZSM-5and 8.5g Dolomite run, 1.5g 2wt % Zn- 2wt% Ni - Hierarchical ZSM-5and 8.5g Dolomite run at 450^{o}C. 59

Figure 4. 23. Chemical Compositions of the Condensates from GC-MS Analysis of , 1.5g 2wt % Zn- 2wt% Ni - Hierarchical ZSM-5and 8.5g Dolomite run, 1.5g Hierarchical ZSM-5and 8.5g Dolomite run, 1.5g Parent ZSM-5 and 8.5g Dolomite run at 450^{0}C. 60

Figure 4. 24. Chemical Compositions of the Condensates from GC-MS Analysis of Dolomite run. 61

Appendices

Appendix A: Calculations on NaOH Concentration and Metal Impregnation on Reference and Hierarchical ZnO/ZSM-5 Catalysts 69

Appendix A (I): Calculations on NaOH Concentration. 70

Appendix A (II):Calculations on Zinc and Nickel Metals Impregnation on Hierarchical ZSM-5 b n Catalyst. 70

Appendix B: BET Report. 72

Appendix C: GC-MS. 80

List of Symbols and Abbreviations

Theta	θ
Armstrong unit	A
Benzene, Toluene, Xylene	BTX
Brunauer-Emmett-Teller	BET
Barrette Joyner Halenda	BJH
Conical spouted bed reactor	CSBR
Fourier transform infrared	FTIR
Fluid catalytic cracking	FCC
Gas chromatography/mass spectrometry	GC/MS
High-density polyethylene	HDPE
Low Density Polyethylene	LDPE
Mobil Composition of Matter Number 41	MCM-41
Nanometer unit	nm
Relative pressure	P/P^0
Scanning Electron Microscopy	SEM
External surface area/mesopores surface area	Smeso
Micropore surface area	Smicro
Total surface area	VTotal
Thermo Gravimetric Analysis	TGA
Mesopores volume	Vmeso
Micropore volume	Vmicro
Total pore volume	Vtotal
X-ray diffraction	XRD

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

Energy is one of the basic indices for evaluating the progress and development of nations and societies. It is also considered the foundation block of economic and social development. The growing world population, industrialization, technological advancement and transportation has brought energy demand under an increased pressure. Furthermore, the global energy demand is expected to grow by about 50% by 2025, with the major part of this increase coming from rapidly emerging countries (Kumar *et al*., 2009). Limited availability of fossil fuel and growing awareness of its detrimental consequences to the environment cannot be overemphasized. These factors have reinforced the importance of identifying and harnessing alternative sources of energy.

Sustainable energy resources, which include wind, solar, biomass etc., have become areas of high interest in developed and developing countries alike. In this regard, agricultural residues in form of biomass can play a significant role in biomass energy generation and hence help the society meet its ever growing energy demand (Alhinai *et al.*, 2018).

Rice husk is a popular source of biomass and is the major by-product from rice production. The prevalence and year-round production of rice crops on both industrial and small scale means that rice husks are an attractive biomass fuel because they are not only readily available in large quantities but are also easy to collect. Although there is an alternative use as livestock feed, rice husk as a source of bio-fuel is quite promising and has the potential to be economically viable. Rice farming in Nigeria has improved greatly in recent years with reports claiming the average production has risen to about 3.7 million metric in 2017 (PwC Nigeria., 2018).

Rice husk as a typical source of biomass can be converted through various thermochemical processes into syngas, liquids (bio-oil), and solid (char). These thermochemical processes are combustion,

gasification and pyrolysis.

Pyrolysis is a process of thermal decomposition of biomass fuels in the absence of oxygen and/or air. Its occurrence releases solid charcoal, liquid tar, and permanent gases whose proportion depends on the nature of biomass fuel used and the operating conditions of the process (Kumar *et al*., 2009).

The permanent gas consists of a mixture of various gases such as carbon monoxide (CO), hydrogen (H_2), carbon dioxide (CO_2), methane (CH_4), nitrogen (N_2), water vapors (H_2O) etc. and other undesirable impurities such as tar, solid particulates, ammonia, hydrochloric acid, sulfur compounds and alkali metal species. The gas must be cleaned properly for smooth and efficient end use applications. They have wide range of applications, especially as gaseous fuel for internal combustion engines, turbines, fuel cells, etc.

Tar present in the producer gases constitutes the biggest problem to this technology. These tars can cause several problems, such as cracking in the pores of filters, condensing in the cold spots, coke forming and plugging resulting in serious operational interruptions and equipment break down (Zwart, 2009). Heavy tars are broken down by thermal cracking into lighter components and species such as methane, hydrogen, and carbon dioxide at a higher temperature around 1000 ℃ (Singh *et al*., 2014). Downstream applications such as internal combustion engine and turbines require so little tar which cannot be achieved using thermal cracking of tars. In such cases catalytic cracking of tars using suitable catalyst is suitable. Various types of materials such as zeolites and calcites have been investigated to find solutions (Shun *et al*.,2013).

In anticipation of requirements to limit CO_2 emissions, plant designs have been developed to remove the CO_2 from the syngas stream prior to the combustion of the hydrogen rich gas in the gas turbine.In a sorption enhanced reaction process (SERP), the CO_2containing stream is passed through a bed of adsorbent and the CO_2 is adsorbed. The CO_2can be recovered during the regeneration process of the sorbent. This technology can use a variety of adsorbents such as activated carbons, zeolites or other

materials (Ifeanyi, 2013).

In energy and fuel production applications, the use of high temperature sorbents is an interesting option since it is not necessary to spend energy to cool down the gas stream. Materials that have been investigated for capacity, stability and good reaction kinetics include calcium oxide (limestone and dolomite), lithium oxides, hydrotalcites and double salts. (Dou *et al.*, 2016).

1.2 Problem Statement

Various catalysts have been reported to improve the quality and quantity of biomass pyrolysis products such as gas and bio-oil without integrating a sorption process to capture CO_2 and enhance the syngas (H_2 ,CO, CH_4)produced.

1.3Aim and Objectives

The aim of this research work is to enhanced catalytic pyrolysis of rice husk via sorption using hierarchical ZSM-5 catalyst.

The objectives of this research work are to:

- Prepare CO_2 adsorbent using dolomite as precursor and characterize the adsorbent, using XRD, FTIR and BET techniques.
- Prepare hierarchical catalyst from parent ZSM-5 catalyst and characterize the catalyst using XRD, FTIR and BET techniques.
- Prepare hierarchical catalyst from parent ZSM-5 impregnated with 2wt%ZnO-2wt. %NiO and characterize the catalyst using XRD, FTIR and BET techniques.
- Carryout performance test of rice husk pyrolysis using dolomite(sorbent), hierarchical ZSM-5 catalysts and 2wt.%ZnO-2wt. %NiOhierarchical ZSM-5 on CO_2 capture and reforming of pyrolysis products.

1.4Scope

This research work was limited to carrying out catalytic reforming in a Fixed Bed Reactor FBR at 650 ^{0}C and 1atm of volatile products from pyrolysis of rice husk in a pyrolyser at 450 ^{0}C and 1atm.Hierarchical zeolite catalyst (ZSM-5) was used for the purpose of catalytic reforming while dolomite for CO_2 capture at various loading ratios (catalyst: dolomite); (0.5:9.5, 1:9, 1.5:8.5, 2:8, 3:7)g in the bed. The best in terms of syngas production was tested using conventional HZSM-5 and hierarchical HZSM-5 with 2wt. %ZnO-2wt. %NiO.

1.5 **Justification**

The justifications for carrying out this research work are;

- The application of dolomite will capture the CO_2 produced from the gas stream of the rice husk pyrolysis.
- Hierarchical ZSM-5 will provide mesoporous active sites that will enhance the conversion of large molecules (tar) into value fine chemicals such as benzene, toluene and xylene (BTX).

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Introduction

Developing new energy sources to produce reliable, affordable energy while respecting the environment is one of today's most compelling needs. Biomass is a promising eco-friendly alternative source of renewable energy in the context of current energy scenarios. Biomass for the most part of history has been the major source of energy for human development. This has taken various forms from wood and dung for cooking and heating, charcoal for metallurgy and animal feeds for food and transportation. With increasing concerns regarding negative impacts and dwindling petroleum reserves, humanity looks again towards biomass resources to provide significant portions of our energy needs(Jahirul *et al.*,2012). Currently 85% of the world's energy demand is met by combustion fossil fuels, which are depleting. Furthermore, the global energy demand is expected to grow up to 50% by 2025, with rapidly emerging countries contributing to this increase. (Agboro and Ogie, 2012).

The term biomass is used to describe any material of recent biological origin and includes plant materials such as trees, grasses, and agricultural crops(Matin and Sedak, 2016). It is a biological material that stores energy through photosynthesis in the presence of sunlight. It contains carbon, hydrogen, nitrogen, and little amounts of sulphur. Biomass resources include various natural and derived materials, such as woody and herbaceous species, wood wastes, bagasse, agricultural and industrial residues (Agbro and Ogie, 2012). Others are waste paper, municipal solid waste, sawdust, bio-solids, grass, waste from food processing, animal wastes, aquatic plants and algae (Dhyani and Bhaskar, 2017)

Rice husk is a locally accessible biomass available in large portions across Nigeria. Rice husk is the

membranous outer covering of the rice. It is an exceptional biomass normally available with 10-12% moisture while the ash contains small amount of alkaline minerals. It makes an excellent fuel although its calorific value is less than wood (Francis and Peters, 1965). Utilization of rice husk, as alternative source of fuel has made it more valuablethan considering it as an agricultural waste for landfills.

2.2 Biomass as a Source of Fuel

Biomass is considered clean, for it has negligible contents of sulfur, nitrogen and ash, thereby lower emissions of sulfur oxides (SOx), nitrogen oxides (NOx) and soot than conventional fossil fuel. Biomass can be converted by thermal or biological routes into a range of useful energy carriers such as liquid fuels, synthesis gas, and chars. These products are utilized for the production of process heat, steam, motive power, and electricity etc. As demand for transportation fuels increases, so also the volatility in prices and uncertainty in supply, hence there has been a rapid rise in domestic production of bio-fuels in many countries. According to a report by the International Energy Agency (IEA), the global production of bio-fuels increased from 0.7 million barrel per day in 2007 to 0.8 million barrel per dayin 2008, roughly accounting for 1.5% of total transportation fuels. It reached 1.6 million barrel per dayin 2015 and is projected to rise up to 2.7million barrel per day in 2030. Biomass has traditionally supplied a large fraction of the energy needs in many developing countries, while its use is well advanced in some Western countries, including Finland (where it supplies 20% of energy needs), Sweden (16%), Austria (13%) and Brazil (23%).(IEA,2019)

2.3 Biomass Composition

Plants capture solar energy in the presence of sunlight, H_2O and CO_2,and store this energy as sugar polymers in a process called photosynthesis. Equation (2.1) describes this process.

$$CO_2 + H_2O + \text{Sunlight} \xrightarrow{\text{chlorophyll}} (CH_2O)_X + O_2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2.1)$$

Biomass is typically composed of 65–85 wt. % sugar polymers (principally cellulose and

hemicellulose), with another 10–25 wt. % corresponding to lignin. In terms of composition, cellulose, hemicellulose and lignin constitute lignocellulose. Other biomass components that are generally present in minor amounts include triglycerides, sterols, alkaloids and resins(Jahirul *et al*.,2012).

Table 2.1 shows the content of some selected biomass in terms of lignin, cellulose and hemicellulose. The composition of the biomass can eventually be a determining factor in the process of conversion and final products therefore characterizing and identifying the contents of the biomass is important.

Table 2. 1. Lignin, Cellulose and Hemicellulose;Content of Some Biomass materials(Demirbas, 2002).

Feedstock	**Lignin (%)**	**Cellulose (%)**	**Hemicellulose (%)**
Wood	25 – 30	35 – 50	20 –30
Wheat straw	15 –20	33 –40	20 –25
Switch grass	5 –20	30 –50	10 –40
Sugarcane bagasse	23 –32	19 –24	32 –48
Miscanthus	17	24	44
Corn stover	16 –21	28	35
Hazelnut shell	42.9	28.8	30.4
Olive husk	48.4	24	23.6
Corncob	15	50.5	31
Tea waste	40	30.20	19.9
Walnut shell	52.3	25.6	22.7
Almond shell	20.4	50.7	28.9
Sunflower shell	17	48.4	34.6
Nut shell	30 –40	25 –30	25 –30
Paper	0 –15	85 –99	0
Rice straw	18	32.1	24
Stored refuse	20	60	20
Leaves	0	15 –20	80 –85
Cotton seed hairs	0	80 –95	5 –20
Industrial waste paper	5 –10	60 –70	10 –20
Barley straw	14 – 15	31 – 34	24 – 29
Oat straw	14 –19	31 – 37	24 – 29
Bamboo	21 –31	26 –43	15 –26
Rye straw	16 –19	31 – 37	27 – 30
Coastal Bermuda grass	6.4	25	35.7
Jute fibre	21 –26	45 – 53	18 –21
Banana waste	14	13.2	14.8

2.3.1 Proximate and ultimate analysis

Proximate analysis is based on the products that evolve upon controlled heating which includes moisture content, volatile matter, fixed carbon, and ash. Moisture content is determined by weighing the biomass sample, drying between 45^0C and 105^0C for 1 to 3 days depending on the product and reweighing the sample; it is also determined in the first stage of proximate analysis. Volatile matter is the material that will convert to gases and escape at approximately 400^0C under an inert environment. The fixed carbon will then be driven off in the presence of oxygen. The remaining material at the end is ash, which contains a variety of mineral phases depending on the local soil chemistry and species of plant. Table 2.2 shows the proximate analysis result carried out for selected biomass.

Table 2. 2. Proximate Analysis of Selected Biomass (Singh *et al.*, 2013).

BIOMASS	**Moisture content (%)**	**Ash content (%)**	**Volatile matter (%)**	**Fixed carbon (%)**
Wheat husk	5.98	12.11	69.19	12.72
Wheat straw	6.40	12.59	71.34	9.67
Mustard straw	6.86	14.98	70.78	7.38
Rice husk	4.65	9.29	68.89	17.17

Ultimate analysis is based on the elements that make up the biomass, typically including carbon, hydrogen, oxygen, nitrogen, sulfur, and chlorine. This analysis also quantifies the moisture content and ash. The percentages of the elements are sometimes presented on a dry, ash-free basis. Both ultimate and proximate analysis are important considerations in thermochemical processes. Table 2.3 shows the elemental composition of selected biomass (Jahirul *et al.*, 2012).

Table 2. 3. Proximate Analysis of Selected Biomass (Jahirul *et al*., 2012).

Biomass	**Elemental composition**				
	C (%)	**N (%)**	**H (%)**	**S (%)**	**O (%)**
Wheat husk	41.47	2.55	5.83	0.10	37.95
Wheat straw	43.50	3.43	5.93	0.00	34.55
Mustard straw	41.98	0.00	5.71	0.48	36.86
Rice husk	43.10	0.00	5.33	0.00	42.27

2.3.2Heating Value

The higher heating value (HHV) and the lower heating value (LHV) categorize biomass by how much energy is contained within the chemical bonds in the biomass. The HHV is also referred to as the gross calorific value, while the LHV is also referred to as the net calorific value. HHV is the amount of heat released from the combustion including the latent heat of vaporization. The LHV simply does not include the contribution of the latent heat of vaporization(Efomah and Gbabo, 2015).

2.4 Pyrolysis

Biomass can be converted to energy via largely two routes; Biochemical and Thermochemical. Biochemical conversion is the degradation of biomass in the presence of living micro-organisms (bacteria, enzymes). This process usually requires little or no energy input but can be very time consuming (Alhinai *et al*., 2018). Thermochemical conversion of biomass is the decomposition of biomass components in the presence of heat. It can be subdivided into three categories. These are combustion (exothermic), gasification (exothermic) and pyrolysis (endothermic) (Frassoldati *et al*., 2006). Combustion is the oxidation of fuel in which biomass can be completely oxidized and converted

into heat. However, efficiency of this process is only about 10% and this manner of use is a source of substantial pollution. Gasification is a partly oxidizing process that converts a solid fuel into a gaseous fuel, while pyrolysis is the first stage of both combustion and gasification processes(Lin *et al*., 1998).

Therefore pyrolysis is not only an independent conversion technology, but also a part of gasification and combustion as stated by (Lin *et al*., 1998)with thermal degradation of the initial solid fuel into gases and liquids without an oxidizing agent.

The process of pyrolysis of organic matter is very complex and consists of both simultaneous and successive reactions when organic material is heated in a non-reactive atmosphere. In this process; thermal decomposition of organic components of biomass occurs approximately between 150 ^{o}C–550 ^{0}C. Figure 2.1 shows the rate of thermal decomposition of individual components of biomass.

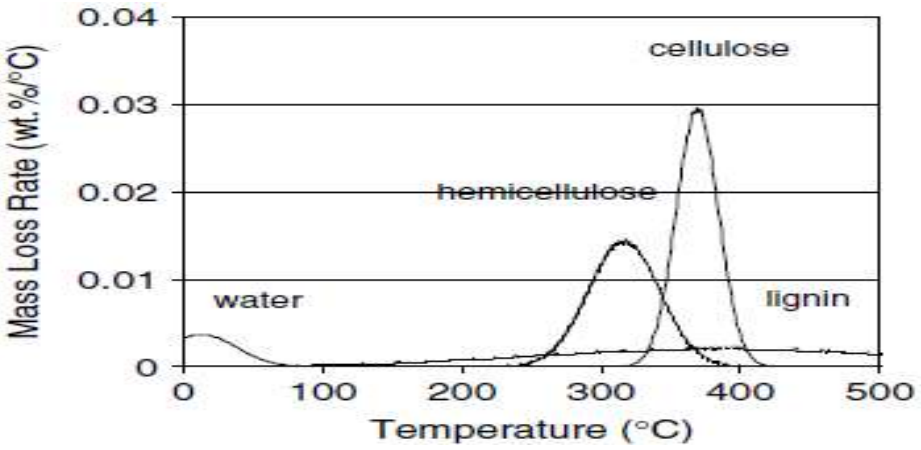


Figure 2. 1.Decomposition of Individual Biomass Components with Pyrolysis Temperature (Yan-fen*et al*., 2004).

The long chains of carbon, hydrogen and oxygen compounds in biomass break down into smaller molecules in the form of gases, condensable vapors (tars and oils) and solid charcoal under pyrolysis conditions. Rate and extent of decomposition of each of these components depend on the process parameters of the reactor (pyrolysis) temperature; biomass heating rate; pressure; reactor configuration;

and feedstock(Dayton, 2011). Figure 2.2 shows possible reaction pathways for the pyrolysis of wood biomass. These include three lumped product categories, starting with a first order reaction. At the beginning of the pyrolysis (250 ^{0}C–300 ^{0}C) process, most of the volatiles are released at a rate 10 times faster than the next step as reported byJahirul *et al*.(2012),however, pyrolysis processes cannot be limited to a single reaction path because of widely varying structure and compositional properties of biomass (Yan-fen*et al*., 2004).

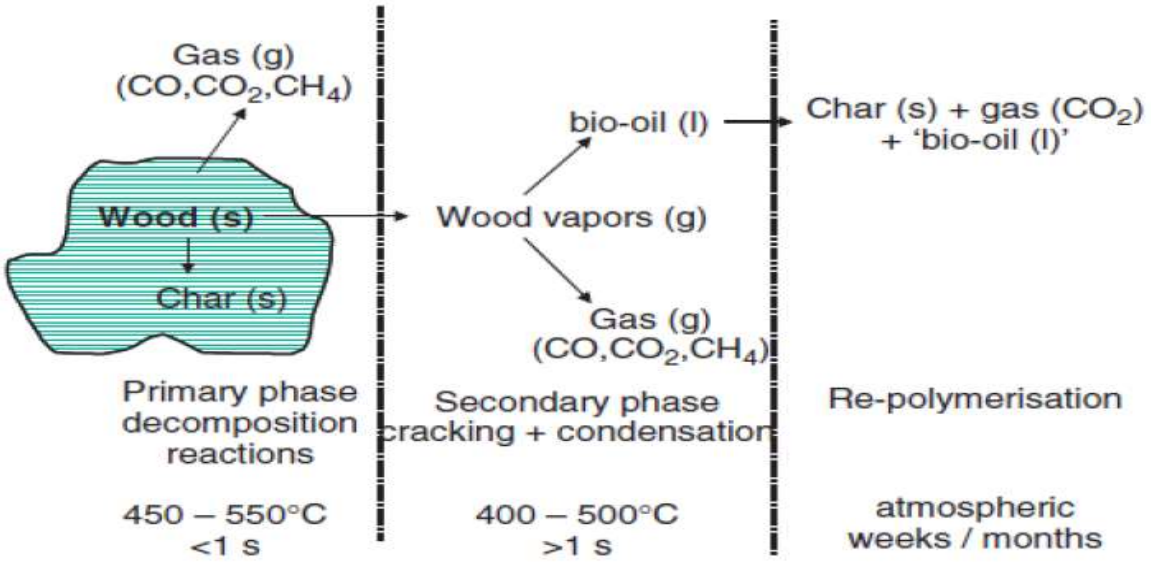


Figure 2. 2.Representation of the Reaction Paths for Wood Pyrolysis (Venderbosch and Prins, 2010)

2.4.1 Pyrolysis Classification

Depending on the operating condition, pyrolysis can be classified into three main categoriesconventional, fast and flash pyrolysis(Natarajan *et al*.,2009). These differ in process temperature, heating rate, solid residence time, biomass particle size, etc. However, relative distribution of products is dependent on pyrolysis type and pyrolysis operating parameters as shown in Table 2.4.

Table 2. 4. Typical Operating Parameters and Products for Pyrolysis Process (Balat *et al*., 2009; Bridgwater, 2007).

Pyrolysis Process	Solid Residence Time (s)	Heating Rate (K/s)	Particle Size (mm)	Temp. (K)	Product Yield (%)		
					Oil	Char	Gas
Slow	450 – 550	0.1 – 1	5 – 50	550 – 950	30	35	35
Fast	0.5 – 10	10 – 200	< 1	850 – 1250	50	20	30
Flash	< 0.5	> 1000	< 0.2	1050 – 1300	75	12	13

2.4.2 Pyrolysis Products

The three primary products obtained from pyrolysis of biomass are char, permanent gases, and vapors, which condense to a dark brown viscous liquid at ambient temperature. Maximum liquid production occurs at temperatures between 350 and 500 ℃ (Demirbas, 2002). This is because different reactions occur at different temperatures in pyrolysis processes. Relative proportions of the end products after pyrolysis of biomass at a range of temperatures are shown in Figure 2.3.

(Natarajan *et al*., 2009)reported on the slow pyrolysisexperiments of rice husk in a fixed bed reactor to determine the effect of temperature, heating rate, particle size and reactor length on the product yields. The gas yield increased from 32.83 to 38.42 % when the pyrolysis temperature was increased from 400 to 600℃, while the solid yield decreased from 39.98 to 32.53 % with the same temperature rise. The highest liquid yield was obtained at a pyrolysis temperature of 500℃,particle size of 1.18-1.80 mm, with a heating rate of 60℃/min in a 300 mm length reactor.

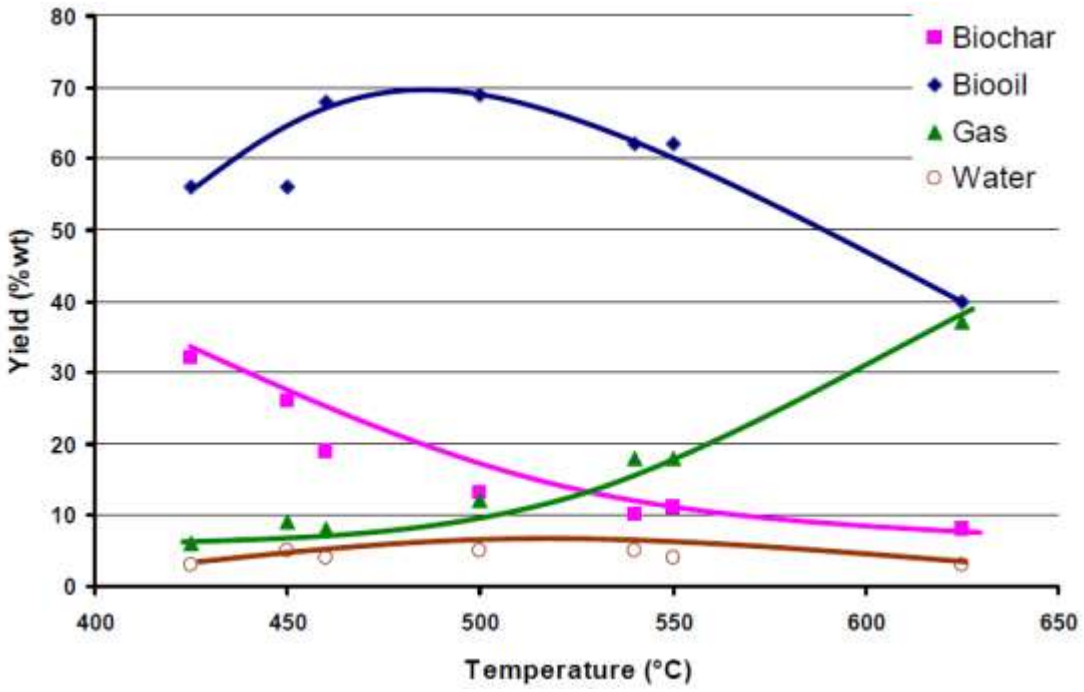


Figure 2. 3. Relative Proportions of end Products in Pyrolysis of Biomass (IEA, 2006).

Consequently, at higher temperatures, molecules present in the liquid and residual solid are broken down to produce smaller molecules which enrich the gaseous fraction. Yield of products resulting from biomass pyrolysis can be maximized as follows:

(1) Charcoal—a low temperature, low heating rate process,

(2) Liquid products—a low temperature, high heating rate, short gas residence time process, and

(3) Fuel gas—a high temperature, low heating rate, long gas residence time process.

Table 2.5 summaries the products created at different pyrolysis conditions. Products from pyrolysis processes also strongly depend on the water content in the biomass which produces large quantities of condensate water in the liquid phase (Demirbas, 2002). This contributes to the extraction of water-soluble compounds from the gaseous and tar phases, and thus a decrease in gaseous and solid products.

Table 2. 5. Pyrolysis Reactions at Different Temperatures.

Condition	Processes	Products
Below 350 ^{0}C	Free radical formation, water elimination and depolymerization	Formation of carbonyl and carboxyl, evolution of CO and CO_2, and mainly a charred residue
Between 350 ^{0}C and 450 ^{0}C	Breaking of glycosidic linkages of polysaccharide by substitution	Mixture of levoglucosan, anhydrides and oligosaccharides in the form of tar.
Between 450 ^{0}C and 500 ^{0}C	Dehydration, rearrangement and fission of sugar units	Formation of carbonyl compounds such as acetaldehyde, glyoxal and acrolein
Above 500 ^{0}C	A mixture of all above processes	A mixture of all above products
Condensation	Unsaturated products condense and cleave to the char	A highly reactive char residue containing trapped free radicals

2.4.3 Pyrolysis Reactor

With the advancement of pyrolysis technology, a number of reactor designs have been explored to optimize the pyrolysis performance and to produce high quality product. However, each reactor type has specific characteristics, advantages and limitations. Of the various reactor designs, the most popular types include thefixed bed reactor (FBR), fluidized bed reactor and a two stage pyrolysis reactor.

The fixed bed reactors generally operate with high carbon conservation, long solid residence time, low gas velocity and low ash carry over (Sisinni, *et al*.,2013). These types of reactor are being considered for small scale heat and power applications.

The fluidized-bed reactor consists of a fluid-solid mixture that exhibits fluid like properties. This is generally achieved by the introduction of pressurized fluid through the solid particulate substance. Fluidized-bed reactors appear to be popular for fast pyrolysis as they provide rapid heat transfer, good

control for pyrolysis reaction and vapor residence time, extensive high surface area contact between fluid and solid per unit bed volume, good thermal transport inside the system and high relative velocity between the fluid and solid phase (Clough and Fennell, 2008.)

In order to improve pyrolysis and formation of desired products, a second reactor was added to the existing reactor for further cracking of primary products. This enabled production of gases and liquids with reported yields being higher or similar to other systems.

A two-stage system was used by Waziri *et al*.(2019), The feed (LDPE) was thermally cracked in the first stage of the reactor, and the vapor formed flowed upward with the catalyst in second stage fixed bed reactor. The design avoids the direct contact of the catalysts with the feed. This causes several problems, which include difficulty in catalyst recovery and rapid deactivation of catalyst. In such systems, conversion of the feed will depend only on the temperature of the reactor.

The two stage system has the advantage of lower tar content and higher calorific value of producer gas. The work of Miguel *et al.* (2009), which investigated the sequential pyrolysis and catalytic hydro-reforming of waste agricultural residue gave similar results.

2.5 Catalytic Pyrolysis

Due to the low thermal conductivity of biomass and endothermic nature of thermal cracking (pyrolysis), the process consumes large amount of energy. Thus the use of certain catalysts have been identified to promote cracking at lower temperatures, resulting in reduced energy consumption and better conversion rates. Furthermore, a proper catalyst can increase the gas quality and energy efficiency of the products. Many types of catalysts have been studied in the past decades in the pyrolysis of biomass. The realization of large-scale production of synthetic zeolites as solid-acid catalysts revolutionized the petrochemical and chemical industries in many applications, such as

catalytic cracking, alkylation and isomerization. ZSM-5 zeolites which are known catalysts for catalytic cracking have been used more often than other zeolites for the cracking of biomass and bio-oil. Gayubo *et al.* (2004) explained the choice of this zeolite by suggesting that it provides a suitable compromise between activity, shape selectivity to less than C_{12} hydrocarbons, limited deactivation by coke, and high thermal stability.

Samolada *et al.* (2000) used ZSM-5 zeolites as catalysts for pyrolysis of biomass and reported that its introduction led to a decrease of the concentration of liquid products and to an increase of the quantity of gaseous products. Similarly Park *et al.* (2015) studied the pyrolysis of pepper stems and found that the gas yield significantly increased with the HZSM-5 catalyst. This can be directly related to the cracking activities of the catalyst, leading to a decrease of the molecular weight of the product molecules.

Figure 2. 4. Shows the catalytic pyrolysis of biomass

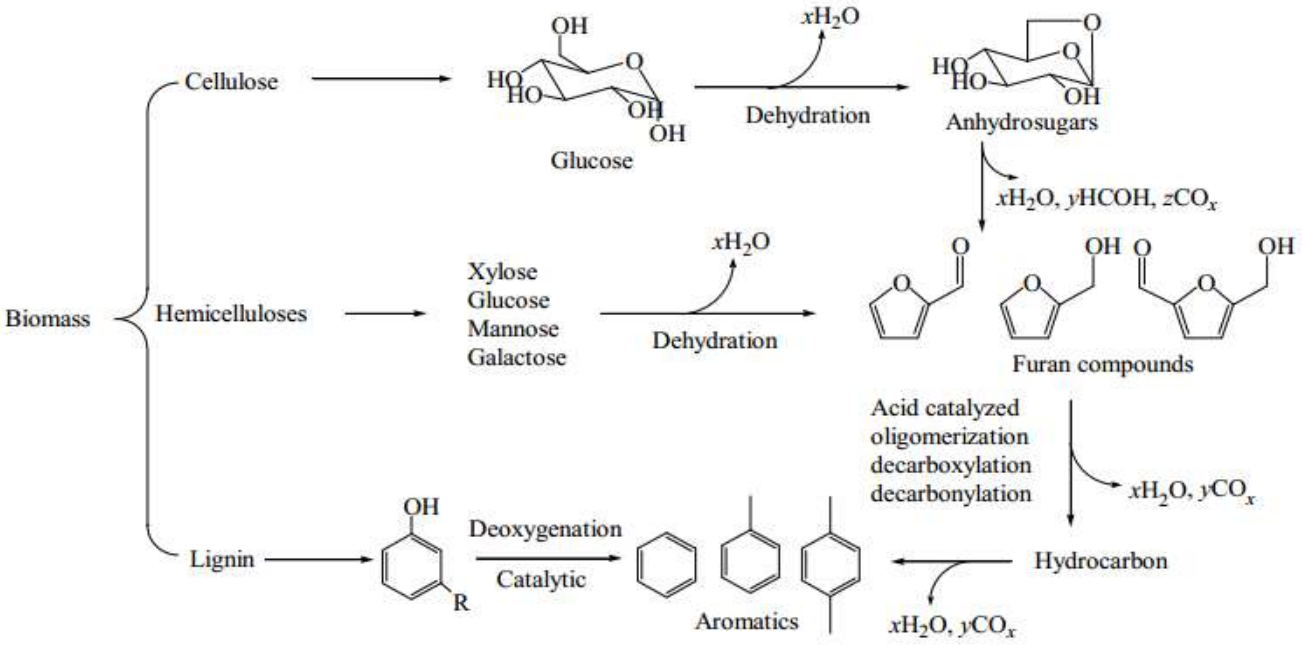


Figure 2. 5. Catalytic Pyrolysis of Biomass. (Carlson *et al.*, 2010).

2.6 Hierarchical ZSM-5 Catalyst

According to the classification of the International Union of Pure and Applied Chemistry (IUPAC), porous solids are divided into three categories: (1) microporous, with pores less than 2 nm in size; (2) mesoporous, with pores from 2 to 50 nm; and (3) macroporous, with pores between 50 and 1000 nm.

Among the different properties of zeolites, their pore structure; the size, shape, and interconnectivity of the pores, have an overarching effect across all applications. On one hand, these propertiesimpart different zeolites with unique and important capabilities, such as molecular sieving and shape/size selectivity while on the other, these properties not only exclude certain large molecules, such as some of the larger molecules in heavy petroleum feed from accessing the active sites that are located within the micropores of the zeolite, but they also impose significant diffusional limitations to molecules that can only tightly fit within the pores, for example, reactants, intermediates, and products in many reactions that are catalyzed by zeolites(Valtchev and Mintova, 2016). The diffusion of tightly fitting molecules into the micropores of zeolites, referred to as "configurational diffusion", is often the rate-limiting step of a catalyzed reaction because, as the size of the molecules approaches the dimension of the pores, the diffusion limitation also increases the possibility of coking, which deactivates the catalysts and shortens their catalytic life(Shun *et al*., 2013). To alleviate these limitations, hierarchical zeolites were conceived with the aim of adding secondary porosity to traditional zeolites.

The hierarchical porous material then is defined as a solid material that comprises at least two types of pores with sizes in distinctly different scale ranges. These also operate interdependently, enhancing desired properties such as mass transfer and diffusion of reactants and products within the pores. Therefore, the hierarchical zeolite can be described as a crystalline micro- porous material containing a system of larger (meso-/macro-) pores(Valtchev and Mintova, 2016).

Methods in synthesis of hierarchical zeolite catalyst can be classified as either ‘bottom-up’ which include hard templating, soft templating and non-templating or ‘top-down’ which include desilication, dealamination and recrystallization approaches. In bottom up approaches, the secondary porosity is introduced during the synthesis of zeolites whereas in the top-down approaches, secondary porosity is introduced on an already existing crystalline zeolite materials via post-synthetic modifications(Hartmann*et al.*, 2016).

Desilication by alkaline treatment involves leaching out the Si species from the zeoliteframework, which makes mesopores that are interconnected to each other accessible fromthe external surface of the zeolite crystal. The desilication process iseffective for high-silica zeolites (usually Si/Al > 20) than high Al zeolites (Groen *et al.*, 2004).

Figure 2. 6shows the effect of NaOH on Si/Al; ratio during desilication of ZSM-5

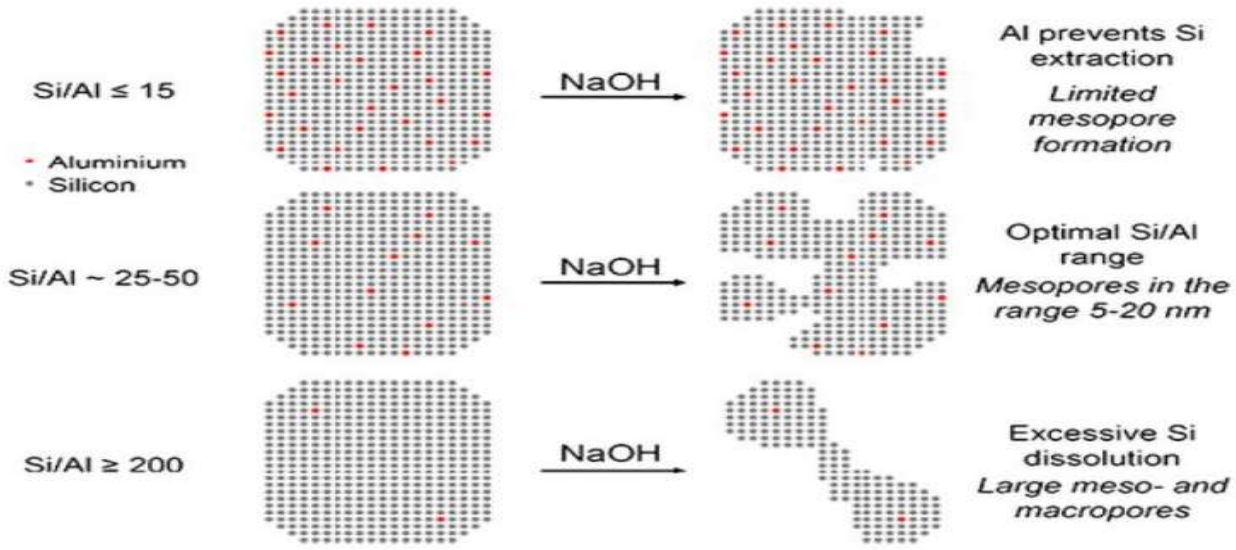


Figure 2. 7. Effect of NaOH on Si/Al; ratio During Desilication of ZSM-5 (Source: American Chemical society).

Hierarchical ZSM-5 catalyst was used in the enhancement of aromatic products from catalytic fast pyrolysis of lignite by Ren *et al.*, (2017)and it was observed that the selectivity of light aromatics such as benzene, toluene, ethylbenzene, naphthalene, xylene increased. SimilarlyDai *et al.*, (2018)reported on the study of the catalytic fast pyrolysis of terrified corn cob to produce aromatic hydrocarbons over Ni- modified hierarchical ZSM-5 catalyst, the use of hierarchical ZSM-5 catalyst led to higher yields of aromatic hydrocarbons.

2.7 CO_2 Capture

The reduction of CO_2 emissions is a topic of particular priority in the framework of sustainable energy, low-carbon energy technologies is a key issue in today's agenda of most of the developed and developing countries. By incorporating in situCO_2 capture in syngas production, a high-purity H_2 product emerges without any further separation of unwanted product gases, for direct utilization, i.e. in fuel cells. Most of the synthetic materials for capturer are expensive to produce (such as zeolites for physisorption and monoethanolamine) and their application is energy consuming (Rao and Rubin, 2006). Calcites including dolomite and dolomite-based sorbents offer smaller efficiency penalties than amine based sorbents. The suitability of metal oxides (Me_xO_y) in capturing CO_2 at temperatures between 550^0C and 750^0C at atmospheric pressure (101.3 kPa) has been demonstrated in the past (Dou *et al.*, 2010; Hyatt *et* al., 1958; Pimenidou *et al.*, 2010b; Squires, 1967). The key reaction for the capture of CO_2 by CaO is shown in Equations 2.2. and 2.3 respectively

$CaO_{(s)} + CO_{2(g)} \rightleftharpoons CaCO_{3(s)}$ ……..…… ……...(2.2)

$MgO_{(s)} + CaO_{(s)} + 2CO_{2(g)} \rightleftharpoons MgCa(CO_3)_{2(s)}$…… (2.3)

$CaCO_3$may be formed by the process of carbonation when CaO reacts with CO_2. The reveres reaction which is thermal decomposition (calcination) of the calcites.MgO gives stability in the sorbent's

structure which in the long term gives more durability to dolomiteas compared with limestone (Gupta and Fan, 2002).

2.8 Reaction Mechanism

2.8.1 Thermal Conversion of Lignocellulose Components

The pyrolysis reaction mechanisms of individual biomass macromolecular components, i.e., cellulose, hemicellulose and lignin have been studied extensively and various reactions paths have been predicted. The decomposition of cellulose starts with two competitive reactions; a slow reaction that produces char plus permanent gases (reaction R4) and depolymerization (reaction R1), to produce active cellulose by reducing the degree of the polymerization but without releasing any volatiles. The active cellulose, can be decomposed by competitive reactions fragmentation and trans glycosylation to produce levoglucosan (LGA) and other sugars, via reaction R2 and reaction R3 respectively. Reaction R2 dominates over reaction R3 at temperatures above 300 °C and can be strongly favored by catalytic effect of inorganics in the matrix(Anca-couce *et al.*, 2016). Studies including schemes proposed by Piskorz and Banyaszas reported by Yan-fen *et al.*(2004), suggest that the Low molecular weight compounds (LMWC), mainly carbonyls and fragmentation products such as hydroxyacetaldehyde (HAA) are not formed from secondary reactions of LGA or other sugars but directly from active cellulose. Figure 2.6 shows a cellulose pyrolysis scheme summarizing information available in the literature. The products of primary pyrolysis can further undergo secondary reactions including charring and cracking.

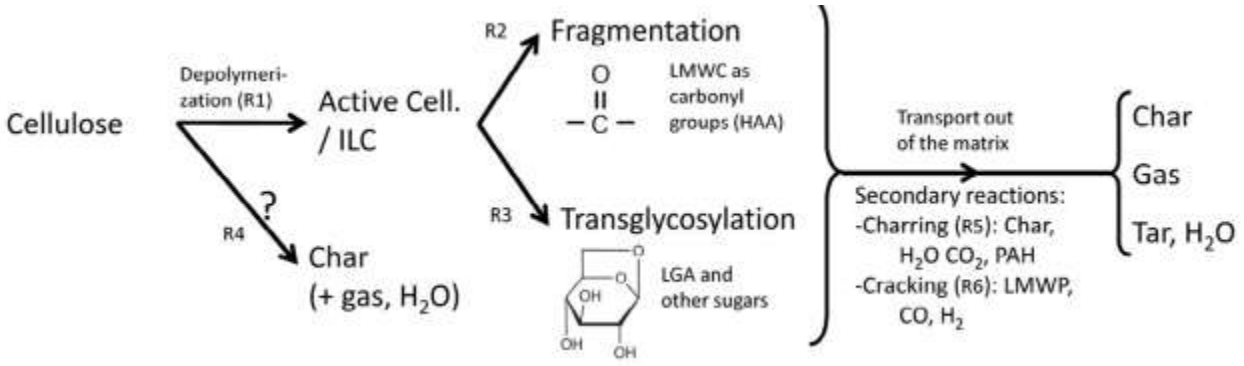


Figure 2. 8. Cellulose Pyrolysis Scheme (Andrés Anca-Couce 2016)

The reaction pathways of charring, (reaction R5) is associated with the production of H_2O, CO_2 and the formation of volatile Polyclic Aromatic Hydrocarbons (PAH). Secondary charring is favored at low temperatures and enhanced with increasing retention time of the volatiles, pressure and presence of inorganics. Cracking of the volatiles (reaction R6) can be induced inside (heterogeneously) or outside (homogeneously) the cellulosic matrix. Homogeneous tar cracking in the gas phase, which produces mainly CO, is relevant for temperatures above 500 °C.

Hemicellulose pyrolysis starts at lower temperatures and it produces more char and fewer sugars than cellulose. A work carried out by Patwardhan *et al.*(2011) demonstrated that most of the fundamental aspects of cellulose pyrolysis, summarised in Figure2.7, are also valid for hemicellulose.

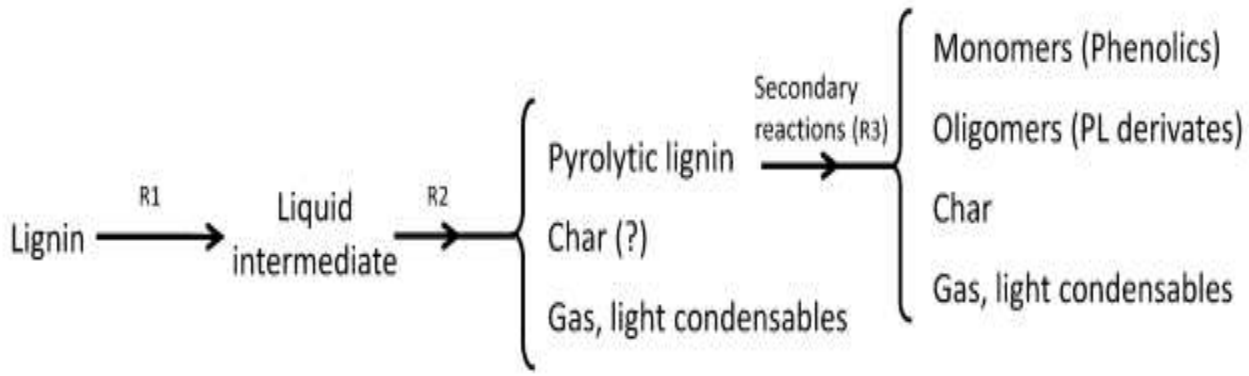


Figure 2. 9. Lignin Pyrolysis Scheme (Andrés Anca-Couce 2016);(Zhou *et al.*, 2014).

Competition occurs between the formation of sugars (xylan, instead of LGA) and fragmentation products. The presence of alkaline and alkaline earth metals (AAEM) increases the char and CO_2 yields while reducing the sugar yield, whereas no significant change in the yield of CO was been observed. Lignin has a more complex structure than the polysaccharides cellulose and hemicellulose, and its decomposition occurs over a wider temperature range. After ligninsoftening at 160 – 190 ^{0}C, dehydration reactions occur at around 200^{0}C, cleavage of C—C linkages at around 370 – 400 ^{0}C and cleavage of methoxyl groups at around 340 ^{0}C (Anca-couce *et al.*, 2016). Phenolic are the most distinctive group of volatile products resulting from lignin pyrolysis. Scheme for lignin pyrolysis, adapted from Zhou *et al.*(2014)inFigure2.7 shows lignin transformed into an intermediate liquid. Pyrolytic lignin can further react, producing not only other phenolic oligomers (Pyrolytic lignin derivate), but also phenolic monomers, char, gases and light condensable species. The molecular weight is onaverage reduced during these secondary reactions, but phenolic oligomers can also arise from re-oligomerisation.

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Materials and Equipment

Some of the materials, apparatus and equipment that was used during this research work are presented in Table 3.1

Table 3. 1: Materials, Apparatus and Equipment Used in thisStudy.

S/NO	Materials/ Apparatus/Equipment	Specifications/Availability
1	ZSM-5 ZEOLITE (Si/Al=50	Department Of Chemical Engineering,ABU Zaria
2	Dolomite	Nasarawa state
3	Sodium hydroxide	Sigma Aldrich
4	Rice Husk	Basawa, Zaria
5	Nitrogen gas	Department Of Chemical Engineering,ABU Zaria
6	Funnel	Pyrex
7	Round bottom flask	Pyrex
8	Ball Mill	Chemistry Department, ABU Zaria
9	Beaker (250- 500ml)	Pyrex
10	Digital weighing balance	AEAdam/PW184
11	GCMS Machine	Shimadzu/GCMS-QP2010 Plus
12	Condenser	Pyrex 24/29
13	Conical flask (50 ml- 2000 ml)	Pyrex
14	Fixed Bed catalytic reactor	Chemical Engineering, ABU. Zaria
15	Digital thermometer	Pyrex
16	Crucibles	Chemical Engineering, ABU. Zaria
17	Spatula	Chemical Engineering, ABU. Zaria
18	Measuring cylinder (500- 1000 ml)	Chemical Engineering, ABU. Zaria
19	Retort stand	Chemical Engineering, ABU. Zaria
20	Volumetric flask	Chemical Engineering, ABU. Zaria
21	Gas analyzer	Chemistry department, ABU Zaria
22	Oven	GallenKamp PA2345

3.2 Feed Preparation

The rice husk sample was obtained from a local rice mill in Basawa, Zaria. It was then sun dried for 2 days to reduce moisture, after which it was ground using a ball mill and screened by a sieve

separator to give fractions of less than 0.15mm.

3.3 Dolomite Preparation

Dolomite, was chosen to be used as the precursor of CaO for CO_2 capture, it was collected from a mining site in Toto local government area of Nasarawa state. It was size reduced to 0.212mm and calcined at 1000^0C for 3 hrs at a heating rate of 30^0C/min.

3.4 Catalyst Preparation

3.4.1 Calcination of NH_4 – ZSM-5

The parent ZSM-5 catalyst with Si/Al ratio 50 in the form of NH4–ZSM-5 was calcined to convert the zeolite catalyst from $NH4^+$ to H^- form zeolite. 50g of catalyst (in $NH4^+$ form) was weighed and poured into a crucible, and then heated in a furnace and calcined at 550 ^{0}C for 5 hrs at a heatingrate of 30 ^{0}C/min. After calcination, weight loss (about 2.26 g evolved, i.e.4.52% of the initialweight) which could be attributed to NH_3liberation as a result of transformation of thecatalyst to H^- form was observed.

3.4.2Desilication of HZSM-5 using NaOH

Hierarchical HZSM-5 was prepared by desilication of HZSM-5 using 0.2M sodium hydroxide solution. The solution was heated to 65^0C and then 40g of HZSM-5, was added to the solution as given inappendix A (I). The solution was stirred continuously for 90mins after which the slurry was cooled in an ice bath and filtered. The filtered cake was rinsed with distilled water to a neutral pH and dried in an oven at 70^0C for an hour. Single ion–exchange with 0.5M NH_4Cl at 70 ^{0}C was carried out on alkali treated catalyst for 3 hours and subsequently allowed to cool before filtration and washing. Drying was done at 95 ^{0}C then calcination followed at 550 ^{0}C for 5 hours to yield the hierarchical HZSM-5.

3.4.3Metal oxide impregnation on hierarchical HZSM-5 catalysts

Zinc oxide and Nickel oxide were impregnated on the hierarchical HZSM-5 catalysts. The amount of zinc and nickel precursor required to make 2wt%ZnO-2wt%NiO/H-ZSM-5 catalyst was calculated and is shown inappendix A (II).In a typical synthesis adapted from Dauda *et al.*, (2018),calculated amount of Zn $(NO_3)_2.6H_2O$ and Ni $(NO_3)_2.6H_2O$ containing 2 wt.% ZnO and 2 wt.% NiO wasdissolved in 100 ml of deionized water and subsequently introduced, drop-wisely intoanother beaker containing calculated amount of dispersed hierarchical H-ZSM-5. The resultant mixture was then evaporated at a temperature of 70 ^{0}C which wasstirred until dryness and then dried in an oven at 95^{0}C for 1 hour. Calcination was done at550 ^{0}C for 5 hours to obtain the hierarchical Zn-Ni/HZSM-5 catalysts. Figure 3.1 shows the flow chart of the methodology used for preparation of catalyst

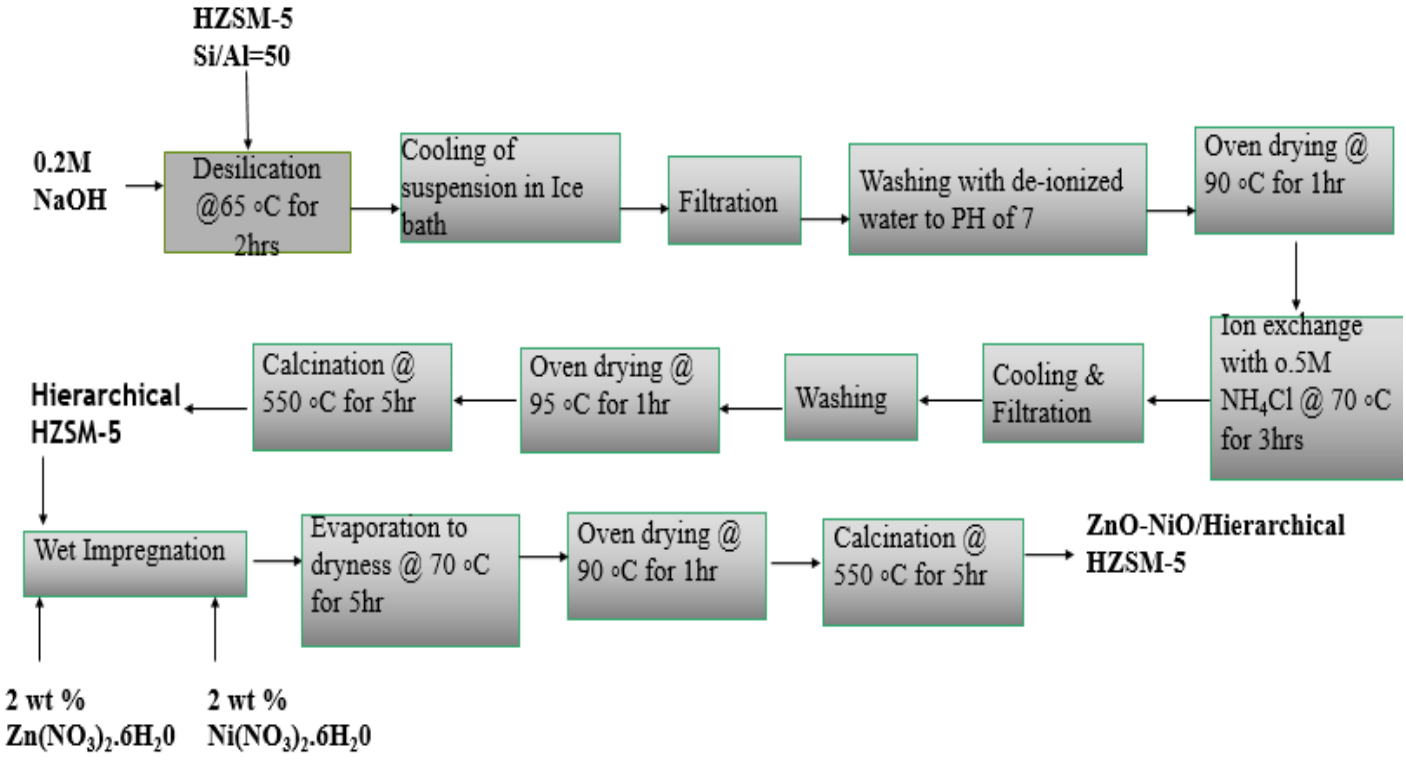


Figure 3. 1. Catalyst Preparation.

3.5 Catalysts and Dolomite Characterization

The catalysts (HZSM-5) used for the sample and CO_2collector (dolomite after calcination) were characterized using different techniques including X-ray diffraction (XRD), Thermo gravimetric analysis (TGA), and Brunauer-Emmett-Teller (BET). The X-ray powder diffraction (XRD) patterns were recorded using Rigaku MiniFlex 600 Cu Kα radiation source operating at 40 kV and 15 with a scan speed and step size of 10°/min and 0.02° respectively. The scanning for 2θ values was done between the range of 5–80^{o}.

Fourier transform infrared (FTIR) analysis was performedwith a Shimadzu (FTIR-8400S) spectrometer machine using potassium bromide (KBr) pellets. The infrared spectra ofthese samples were measured in the transmission mode within the wavelength number range of 4000 and 500 cm^{-1}. The morphology of the catalyst, such as specific surface area, pore volume and pore size, were analyzed by the Brunauer–Emmett–Teller (BET) method with N_2 adsorption desorption isotherm at -195.850 ℃, at an equilibrium interval of 10 seconds and a sample density of 1.000 g/cm³using Accelerated SurfaceArea and porosimetry system (ASAP 2000 Micromeritics)surface area analyser machine. The micropore area, micropore volumeand mesopore surfaceareas were calculated using the Langmuir surface area and t-plot methods, while the pore size distribution were calculated by the (BJH) method applied to the adsorption branch of the isotherm.

3.6 Experimental Setup and Conditions

3.6.1 Experimental Setup

The pyrolysis of rice husk was carried out with the aid of a heating mantle at a temperature of

450 ^{0}C at 5 ^{0}C /min. The rice husk was placed inside a round bottom flask coupled with an external thermocouple and a nitrogen line immersed in it while the product (volatiles) of pyrolysis then passed into the fixed bed reformer.

The reformer which was designed and fabricated at the National Research Institute for Chemical Technology (NARICT), Zaria, Nigeria is 20.5 cm long with a 2 cm diameter. It is made of stainless steel and surrounded by heating element. Prior to the reaction, the system was purged with nitrogen gas flowing at 200 ml/min, 1.5 bar, and 25 ^{0}C for 30 min to create an inert environment. The temperature of the reformer was allowed to rise to the desired temperature (650 ^{0}C), at the heating rate of 15 ^{0}C/ min, before the pyrolyser was switched on at the heating rate of 5 ^{0}C/min.

The gaseous products of the pyrolyser was passed through the fixed catalyst bed (in the reformer) where it came in contact with catalyst and CO_2sorbent (calcined dolomite).

The products formed during the reforming reactions flowed from the reactor into a knock-out drum insulated with an ice jacket. Condensable gases from the product were collected as liquids in a vile from the bottom of the knock-out drum, while the non-condensable gases escaped through a gas line connected to a gas analyser which identified the composition of the gas.

The composition of the condensate was analysed using a gas chromatography/mass spectrometry (GC/MS) machine (19091S-433UI Agilent). The column of the GC/MS was equipped with 30 m × 250 μm × 0.25 μm capillary. Helium was used as a carrier gas at 0.75633 ml/min flowrate. The GC/MS oven was initially held at 45 °C for 3 mins before being heated to 300 °C at 10 °C/min and held for 20 mins. The peaks of the resulting chromatographs were identified using the National Institute of Standards and Technology (NIST) standard reference database. The

percentage area of each compound identified was used to represent their relative amount or selectivity.

The condensate of each sample were alsoanalyzed using Fourier transform infrared spectroscopy (FTIR) by a Shimadzu FTIR-8400S machine to obtain the transmittance between at a range of 500–4000 cm^{-1} at chemistry department, Ahmadu Bello University, Zaria

Permanent gases were monitored online during the process using a Gas board 3100p gas analyser manufactured by Wuhan Cubic Optoelectronics Co.Ltd,which identifies the composition of five gases H_2, CO, CO_2, CH_4 and O_2.Figure 3.2 shows the flow chart procedure used for catalyst and adsorbent performance test

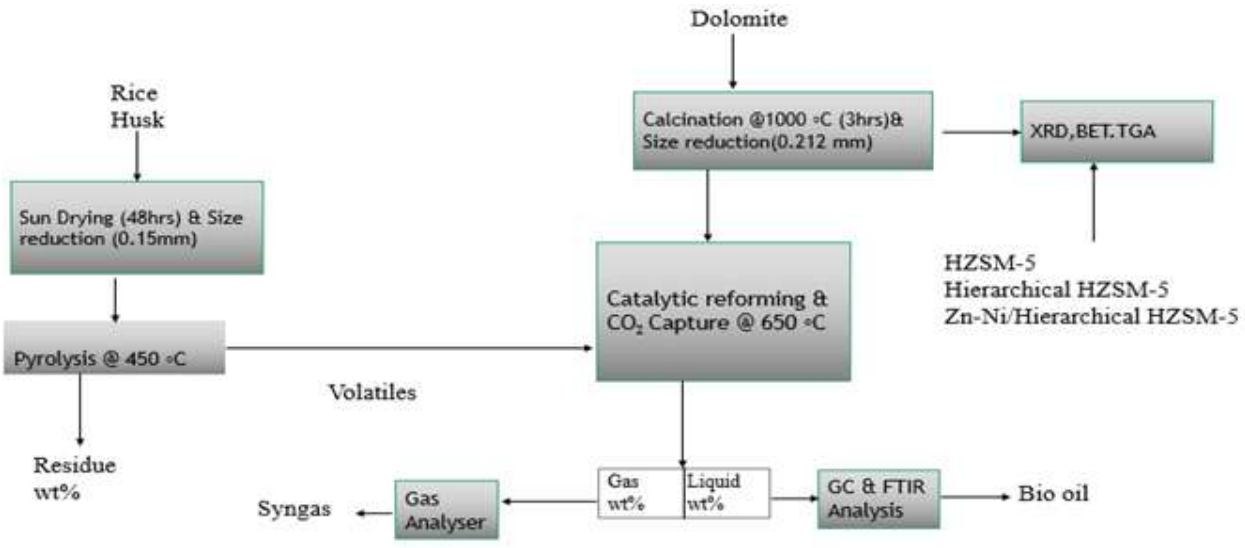


Figure 3. 2. Catalyst and Sorbent Performance Test.

3.6.2 Experimental conditions

In each experimental run, the temperature of pyrolyzer was set at 450^0C while 10 g of rice husk was used as biomass feed.

The temperature of the reformer bed used in this study was set at 650^0C which is reported to be the optimumtemperature for CO_2capture(Udomsirichakorn *et al.*, 2014). Figure 3.3 shows theprocess flow diagram of catalytic pyrolysis of rice husk volatiles with in-situ co_2 capture.

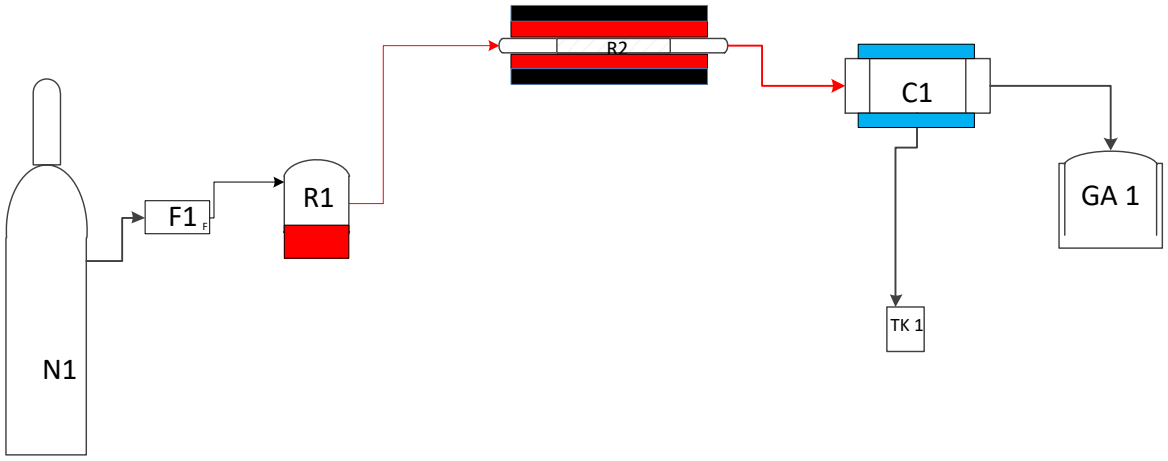


Figure 3. 3. Process Flow Diagram of Catalytic Pyrolysis of Rice husk Volatiles with In-Situ Co_2 Capture.

Key:

N 1	= Nitrogen gas cylinder	C 1	= Condenser	R 1	=Pyrolysis reactor	GA 1	=Gas analyser
F 1	= Flow meter	TK 1	= Condensate collector	R 2	= Fixed bed reformer		

The total amount of bed material (catalyst and CO_2 acceptor) at any given run was kept constant at 10g while the ratio of bed material was varied.

Hierarchical zeolite catalyst (HZSM-5) was used for the purpose of catalytic reforming while calcined dolomite for CO_2 capture at various loading ratios (0.5and9.5, 1and9, 1.5and8.5, 2and8, 3and7) g in the bed. The best in terms of syngas production (1.5and8.5) g was then tested using conventional ZSM-5 and hierarchical ZSM-5 with 2wt. %ZnO-2wt. %NiO.

Glass wool was used at both ends of the reformer and as a partition between the catalyst and the calcined dolomite in the reactor.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter entails all results and its discussion obtained during the research work.

4.1 Structural and Textural Properties of Catalyst and Sorbent

4.1.1 X-ray diffraction.

The X-ray diffraction (XRD) pattern of the parent, alkali-treated HZSM-5 and the metal impregnated hierarchical HZSM-5 catalyst (PZ), (HZ) and (ZN-HZ) respectively are shown in Figure 4.1. It is observed that all of the catalyst showed characteristic diffraction peaks of a MFI type zeolite at 2θ between 8 and10^0, 22 and 25^0, and 45^0(Waziri *et al*., 2019). Thissuggests that even after treatment with 0.2M NaOH concentration (desilication) the characteristic diffraction peaks of the MFI zeolite were still preserved indicating the structure was not damaged. Although upon closer examination it is observed that the intensities of the peaks between8 and10^0, 22^0 and 25^0decreased after alkaline treatment which infers a fractional dissolution of the HZSM-5 framework and a slight reduction in crystallinity as reported by Xiao *et al*. (2015) in their study on the effects of alkali-treated hierarchical HZSM-5 zeolites on the production of aromatic hydrocarbons from catalytic fast pyrolysis of waste cardboard.

Similar results have been reported by Shen *et al*. (2016) on the desilication of HZSM-5 using 0.1M and 0.2M NaOH with little effects on crystallinity. Furthermore there were no peak(s) to affirm the presence of ZnO and NiO on the Zn-Ni treated HZSM-5 from the diffraction pattern identified, suggesting that, the amounts of 2wt. % ZnO and NiO 2wt. % which was used to impregnate the hierarchical catalyst was below detection limit. Similar trends have been reported in the works of Dauda *et al.*(2018)where the amount of the metals impregnated were too low to

be identified using XRD. Figure 4.1 shows the XRD patterns of the parent HZSM-5 (PZ), hierarchical HZSM-5 (HZ) and Zn-Ni Hierarchical ZSM-5 (ZN-HZ)

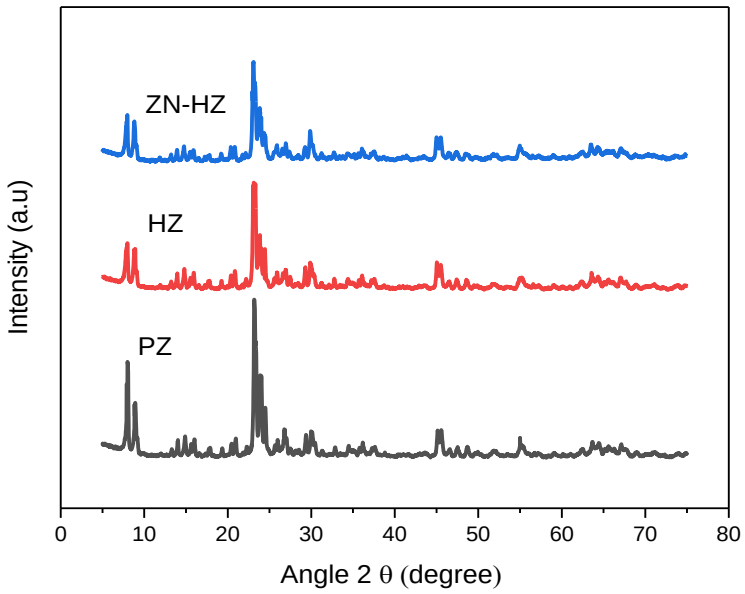


Figure 4. 1. XRD Patterns of the Parent HZSM-5 (PZ), Hierarchical HZSM-5 (HZ) and Zn-Ni Hierarchical ZSM-5 (ZN-HZ).

In Figure 4.2, peaks observedat 32.5, 37.2, 54.7 and 64.8°are evidence of CaO in the sample, while diffraction intensities detected at 43.2 and 62.6°represent MgO in agreement to a study byGruszeckakosowska and Wdowin, (2015) on the analysis of the chemistry, mineralogy and texture of calcined dolomite powder. Figure 4.2 shows theXRD pattern of calcined dolomite

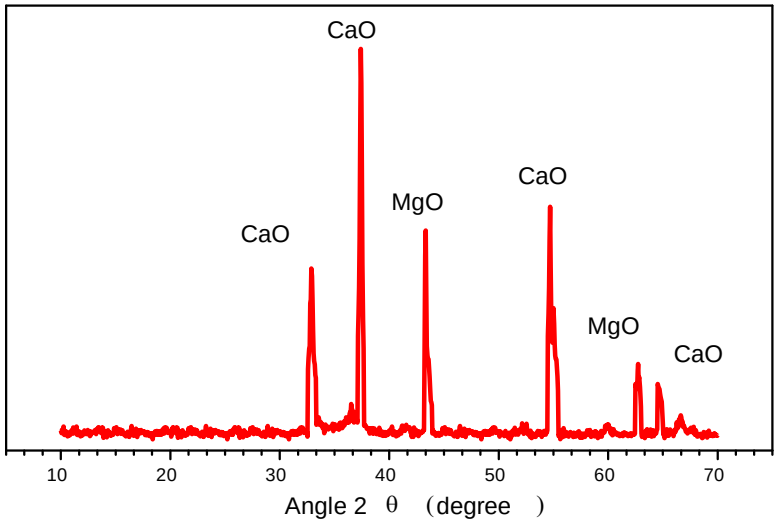


Figure 4. 2.XRD Pattern of Calcined Dolomite

4.1.2 Fourier transformed infrared (FTIR)analysis.

The FTIR spectra of parent (reference) and hierarchical HZSM-5 in the lattice vibration region between 400 and 4000 cm^{-1} are shown in Figure 4.3. Wave bands at 450 cm^{-1} which represents the T-O-T bending vibration (T=Si or Al) and 550 cm^{-1} which represents the five membered ring pentasil unit of HZSM-5 further supports the XRD report that even after alkaline treatment, HZSM-5 catalyst maintains its core crystalline framework.Although on critical examination of the band at 1100 cm^{-1}which signifies internal tetrahedral bridged Si-OH-Al vibrations in the asymmetric region, it appears that the peak has broadened on alkaline treatment of the catalyst using 0.2M NaOH,as compared to the shaper peak of the parent HZSM-5 coinciding with a claim in the work of Xiao *et al.* (2015) who studied the performance of hierarchical HZSM-5 zeolites prepared by NaOH treatments in the aromatization of glycerol. Figure 4.3 shows the FTIR spectra of parent ZSM-5 (PZ), hierarchical ZSM-5(HZ) and metal treated hierarchical ZSM-5 (ZN-HZ)

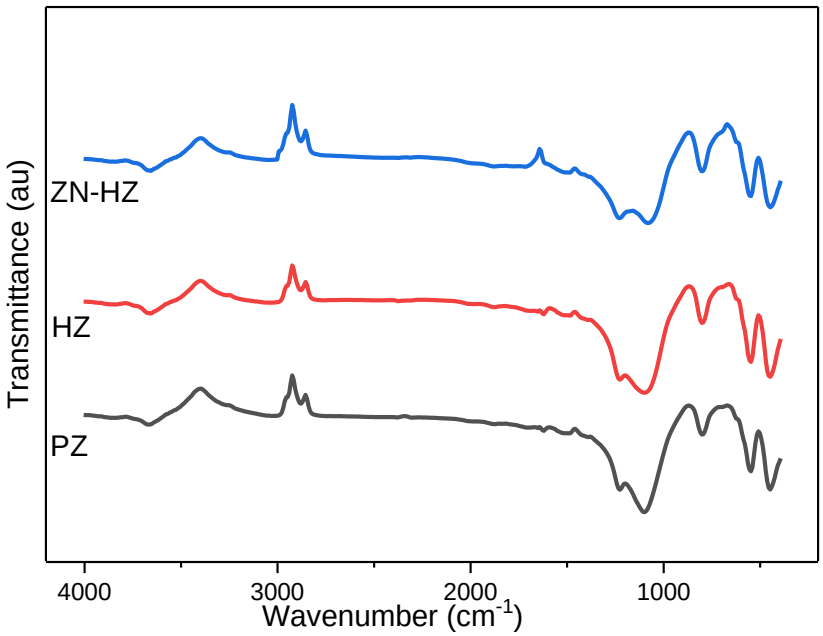


Figure 4. 3. FTIR Spectra of Parent ZSM-5 (PZ), Hierarchical ZSM-5(HZ) Zn-Ni- Hierarchical ZSM-5 (ZN-HZ)

The bands at 790 and 1225 cm^{-1} represents the external symmetric and asymmetric stretching of the Si-O-Si bond while the band at 3400 cm^{-1} implies the existence of hydroxyl groups (OH^{-}) of absorbed water on the surface of ZSM-5 similar to FTIR analysis done by Shirazi *et al*. (2008), Waziri *et al*. (2019) also made a parallel report. Figure 4.4 shows the FTIR spectra of calcineddolomite.

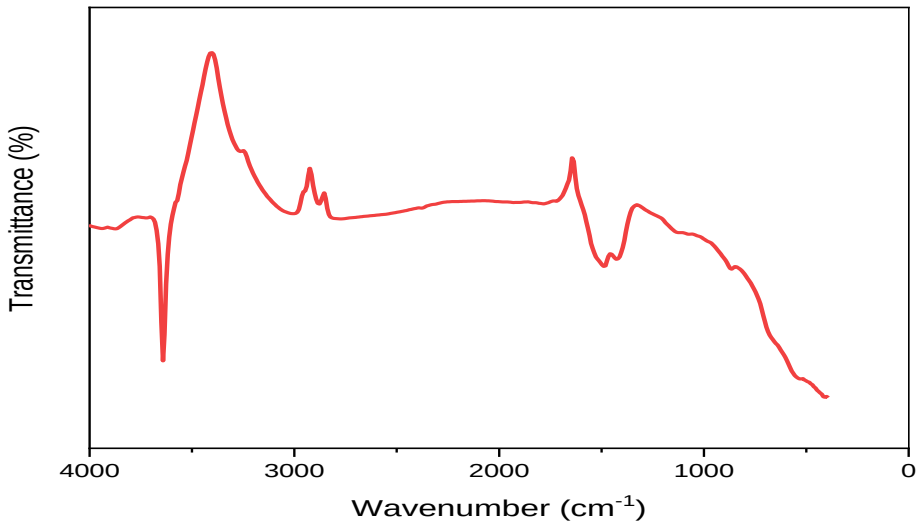


Figure 4. 4. FTIR spectra of CalcinedDolomite

Shahraki and Dabiri, (2009) observed the thermal behaviour of dolomite mine (central Iran), the FTIR of calcined dolomite showed bands at 3640, 1800, and 870 cm^{-1},whch are due to the formation of $Ca(OH)_2$ while the broad band at 450cm^{-1} indicated the presence of MgO. Similar peaks can be seen in Figure 4.4 which shows the FTIR analysis done on thecalcined dolomite sample.

4.1.3Nitrogen sorption studies

Figure 4.5shows the N_2 adsorption-desorption isotherms while Table 4.1 shows some structural and textural properties of thecatalyst and calcined dolomite samples. As illustrated in Figure 4.5the parent HZSM-5 catalyst presented a typical Type I isotherm, according to the IUPAC classification (International Union of Pure and Applied Chemistry) confirming it as amicroporous material while the alkali-treated HZSM-5 shows a Type IV isotherm with an underlying H3hysteresis loop indicating a migration from a microporous material to a

hierarchical porous system combining microporosity and mesoprosity in likeness to worksof Horikawa *et al*. (2011) upon desilication. An increase in the surface mesopores is observed after the alkaline treatment using 0.2M NaOH of HZSM-5 catalyst (Si/Al 50) at 65^0C on parent HZSM-5 (PZ). Hierarchical HZSM-5 (HZ) had an external surface of $141m^2$ /g in contrast with $111m^2$/g for the parent. Increase in mesoprosity can be attributed to desilication caused by alkaline treatment.

Table 4. 1. PhysiochemicalProperties of Sorbent and Catalyst.

SAMPLES	S_{BET} [1]	S_{micro} [2]	S_{meso} [3]	S_{meso} [4]	V_{total} [5]	V_{micro} [6]	V_{meso} [7]	V_{meso} [8]	Average Pore Width [9]
	(m^2/g)	(m^2/g)	(m^2/g)	(%)	($cm^{3/}$g)	($cm^{3/}$g)	($cm^{3/}$g)	(%)	(nm)
CALCINED DOLOMITE	8.77	0.53	8.24	94	0.037	0.000083	0.037	99.49	20.11
(PZ)	386	275	111	28.8	0.202	0.110	0.092	41.8	2.03
(HZ)	416	275	141	33.9	0.221	0.086	0.119	53.8	5.10
(ZN-HZ)	387	251	136	35.1	0.225	0.106	0.119	52.9	5.04

1 From N_2 adsorption measurement (BET method)

2 From N_2 adsorption measurement (t–plot)

3 $S_{MESO} = (S_{BET} - S_{MICRO})$

4 % Surface Mesopores

5 From N_2 adsorption measurement at P/P0 = 0.9882

6 From N_2 adsorption measurement (t–plot)

7 Vmeso = (Vtotal - Vmicro)

8 % Volume Mesopores

9 BJH adsorption average pore diameter

Furthermore there was an increase in the volume mesopores after alkaline treatment, may be both hierarchical HZSM-5 sample and Zn-Ni hierarchical HZSM-5 sample had a mesopore volume of 0.119 cm^3/g compared to 0.092 cm^3/g for the parent. However, the formation of mesoprosity on the surface of ZSM-5 hardly led to substantial decreases in microporous surface areas and volumes. This denoted that the micropores were mostly retained in the samples. Similar trends have been recorded by Ren *et al.* (2017) for desilication using NaOH concentrations of ≤ 0.2M.Barrett, Joyner and Halenda(BJH) Average pore size was reported as 2.03nm for the parent HZSM-5 and increased significantly after the alkaline treatment to 5.10nm for the hierarchical HZSM-5 and 5.04nm for the metal treated hierarchical HZSM-5.Figure 4.5 shows nitrogen adsorption and desorption isotherms of parent ZSM-5, hierarchical ZSM-5 and Zn-Ni hierarchical ZSM-5.

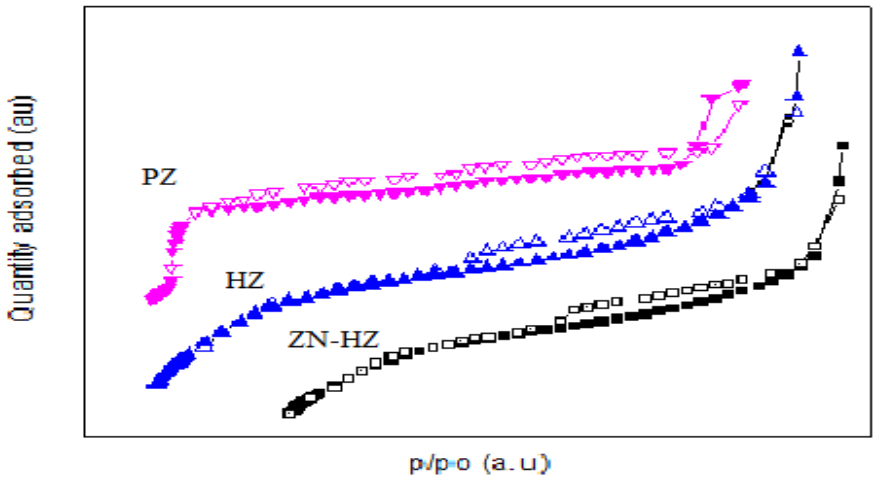


Figure 4. 5. Nitrogen Adsorption and Desorption Isotherms of Parent ZSM-5(PZ), Hierarchical ZSM-5(HZ) and Zn-Ni Hierarchical ZSM-5(ZN-HZ).

Dolomite which has been reported to have a low surface area was affirmed by this result. BET surface area was reported to be 8.77 m^2 /g which is within the range reported byMawanga *et*

al.(2017)having BET surface area between a range of 7.3 m^2 /g and 11.14 m^2 /g.The isotherm of calcineddolomite was characterized by type IV isotherm in Figure 4.6 affirming its mesoporous nature without the presence of micropores.The type IV was also concluded of the hierarchical ZSM-5 but with certain level of microporosity. The hysteresis loop were defined as a type H3 suggesting slit-shape pores, this results is also in agreement with the work of (Gruszecka-kosowska and Wdowin, 2015).Figure 4.6 shows the nitrogen adsorption and desorption Isotherms of calcineddolomite

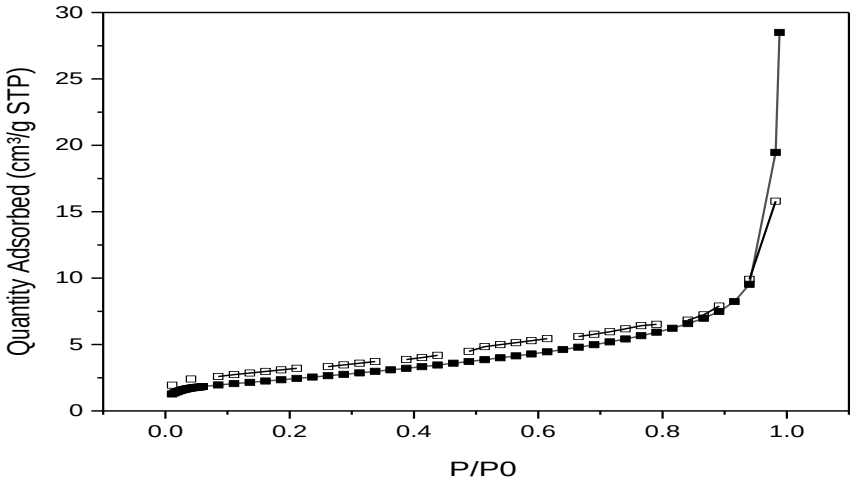


Figure 4. 6**.**Nitrogen Adsorption and Desorption Isotherms of CalcinedDolomite

4.1.2 Thermo gravimetricanalysis

Thermo gravimetric analysis of the catalyst was carried out between the temperatures of20- 900^0 C to determine the thermal stability of the catalyst and sorbentand has beenillustrated in Figure 4.7.Parent and alkaline treated catalyst had three regions of weight loss at 20-150 ^{0}C, 150 ^{0}C-

400 ^{0}C and a sharp thermal step at 400 ^{0}C. Weight loss between three thermal regionscan be assigned to desorption of water molecules(Huang *et al*., 2005). All the catalyst have shown to have athermal effect at 400 ^{0}C but ultimately thermally stable which reflects crystalline stability affirmed by the XRD and presence of basic functional groups after desilication and metal impregnation using FTIR technique. Figure 4.7 shows theTGA of parent ZSM-5, hierarchical ZSM-5 and Zn-Ni hierarchical ZSM-5.

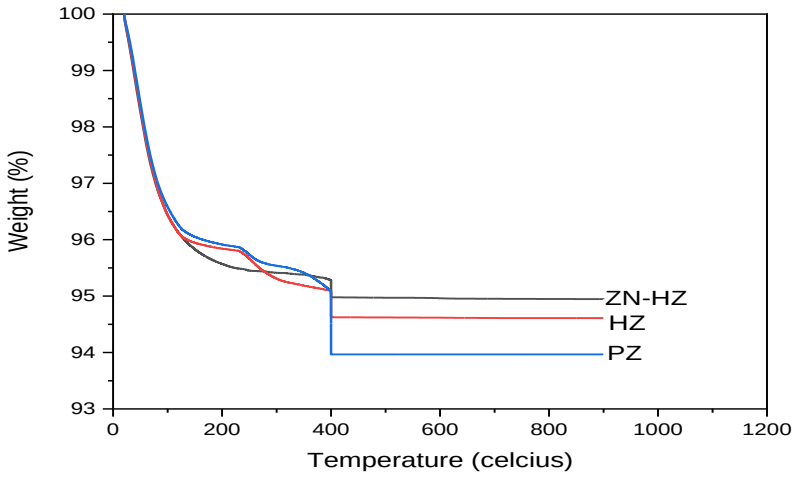


Figure 4. 7. TGA of Parent ZSM-5(PZ), Hierarchical ZSM-5 (HZ) and Zn-Ni Hierarchical ZSM-5 (ZN-HZ).

4.2 Effects of Catalyst and Sorbent on Pyrolysis Product Distribution

Rice husk pyrolysis producedchar yield of about 22 wt.% for all experiments carried out. This was in tandem with results from Tsai*et al*. (2007) who carried out pyrolysis of rice husk at 450

^{0}C. The volatiles generated from pyrolysis served as feed to the catalytic bed reformer. Figure4.8 and Figure 4.9 show the material balance of liquids and gas using different ratios of bed material. It can been observed that with the addition of calcineddolomite the gas yield after condensation increases to 46 % as compared to 37% in the blank run.This can be as a result of ring rupturing effect associated with CaO when it comes in contact with aromatic components of tar(Udomsirichakorn *et al*., 2014). Addition of hierarchical HZSM-5in the reformer improved to3.0 g of hierarchical HZSM-5 catalyst and 7.0 gcalcineddolomite had the highgest amount of gas liberated. This could be attributed to secondary cracking and deoxygenation of pyrolysis volatiles in the reformer. Similar result has been reported byStefanidis *et al*.(2011),Shun *et al*.(2013), and Akubo *et al*. (2018). It is also noteworthy to state that in comparison to parent HZSM-5, hierarchical HZSM-5 liberated more amount of permanent gases Thus suggesting that widening of the micropores improves cracking of hydrocarbons and in turn conversion of productsinto gases. Figure 4.8 shows the product composition of liquids and gas using various ratio of bed material. It shows the percentage ratio of liquid to gas using hierarchical ZSM-5 catalyst ratio tocalcined dolomite. The percentage of gas increased from 37% to 64% due to increased cracking reaction taking place in the reformeraromatics(Yanming *et al*., 2016).

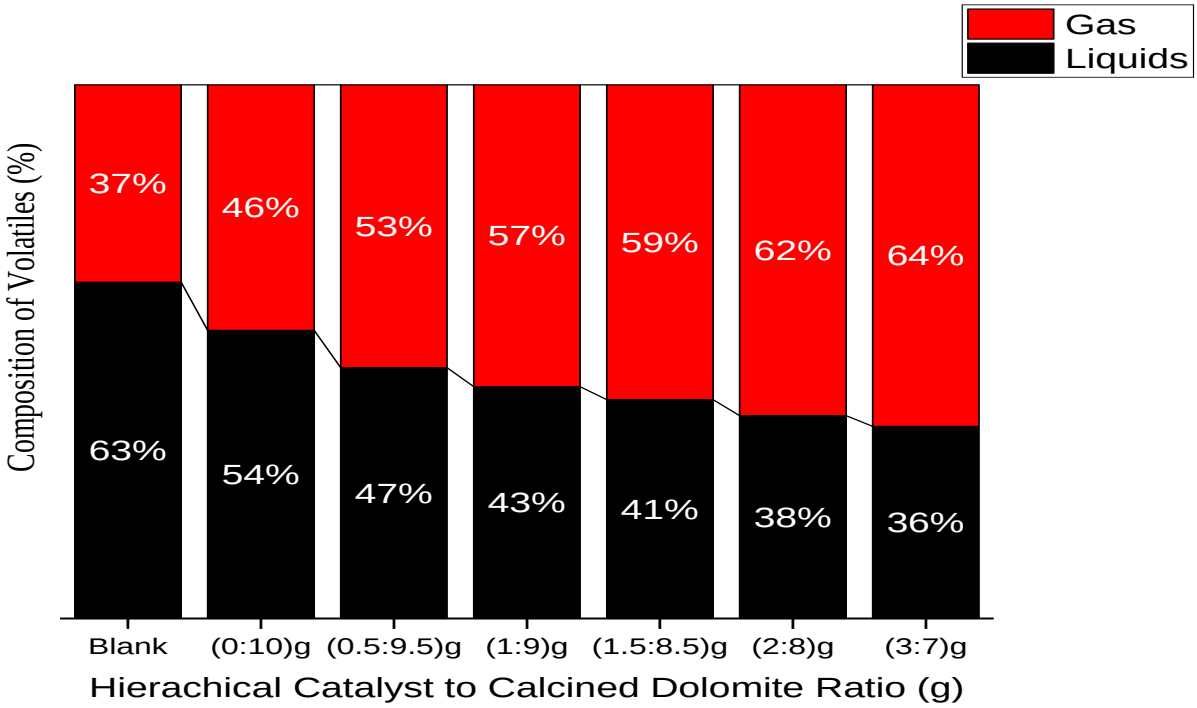


Figure 4. 8. Product Composition of Liquids and Gas Using Various Ratio of Bed Material.

Figure 4.9 shows the product yield of liquids and gas using different catalyst as bed material. It shows the percentages ratio of gas to liquids.The gas increased from 37% to 62% as a result of increased cracking, and the effect of the bimetallic hierarchical catalyst which aids in dehydrogenation reactions taking place in the reactor.

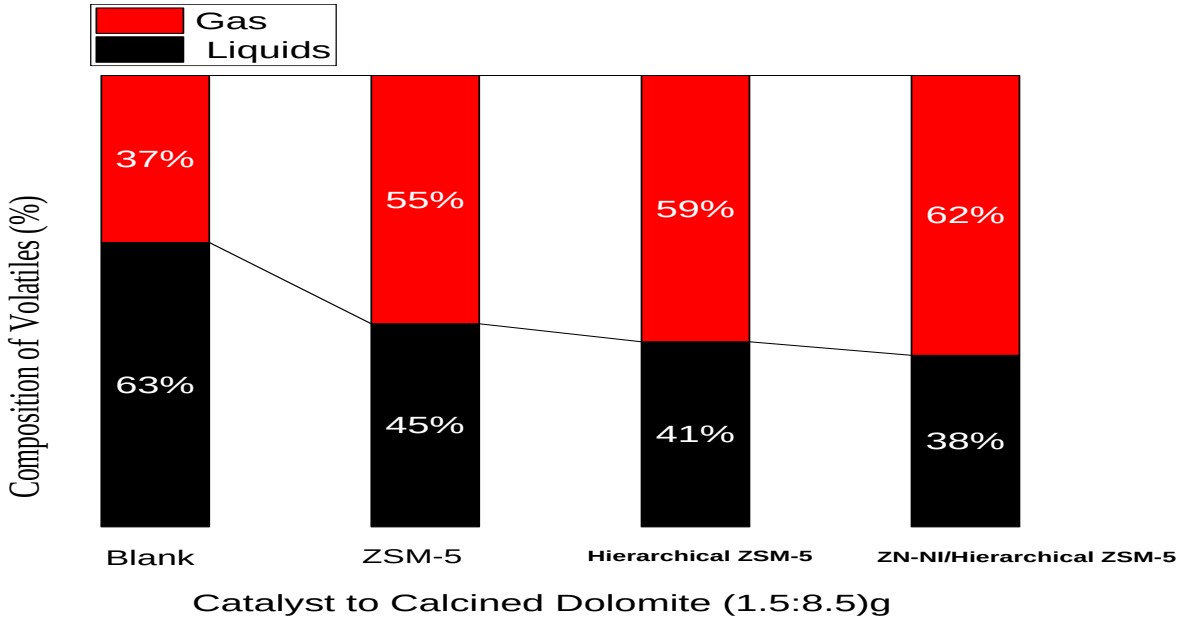


Figure 4. 9. Product Composition of Liquids and Gas Using Different Catalyst as Bed Material.

4.3Effect of Catalyst and Sorbent on Non-Condensable Reformed Products

Non-condensable products (permanent gases) where monitored on line using a Garboard 3100P gas analyzer. The amounts of the four major gases (CO, H_2, CO_2, and CH_4) liberated with time using various bed material are representedin percentage volume from Figure 4.10 to4.19. It can be seen in Figure 4.10 that the amount of CO is the highest among thesefour gaseswhen no reforming catalyst and adsorbent where used in the set (blank run) as shown in Figure 4.10. It got to a maximum value of 53% after 30min of the reaction. CO_2 was the second highest with its peak value at 25% at 35min. similar results were reported by Li *et al.* (2017) with CO being the highest of the gases liberated. This is mainly credited to the thermal cleavage of C-O and C=O groups at high temperatures.

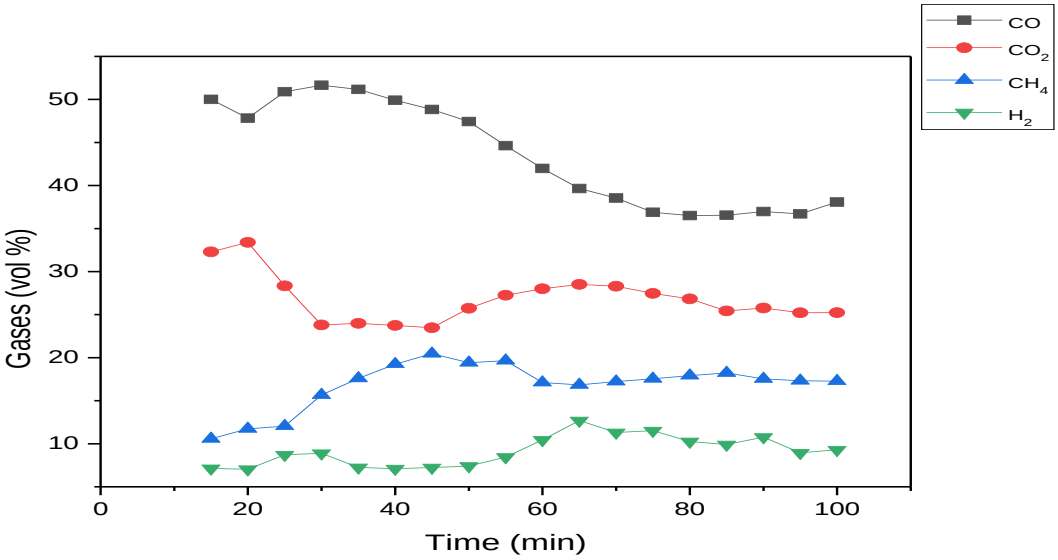


Figure 4. 10. Gas Composition for Blank run.

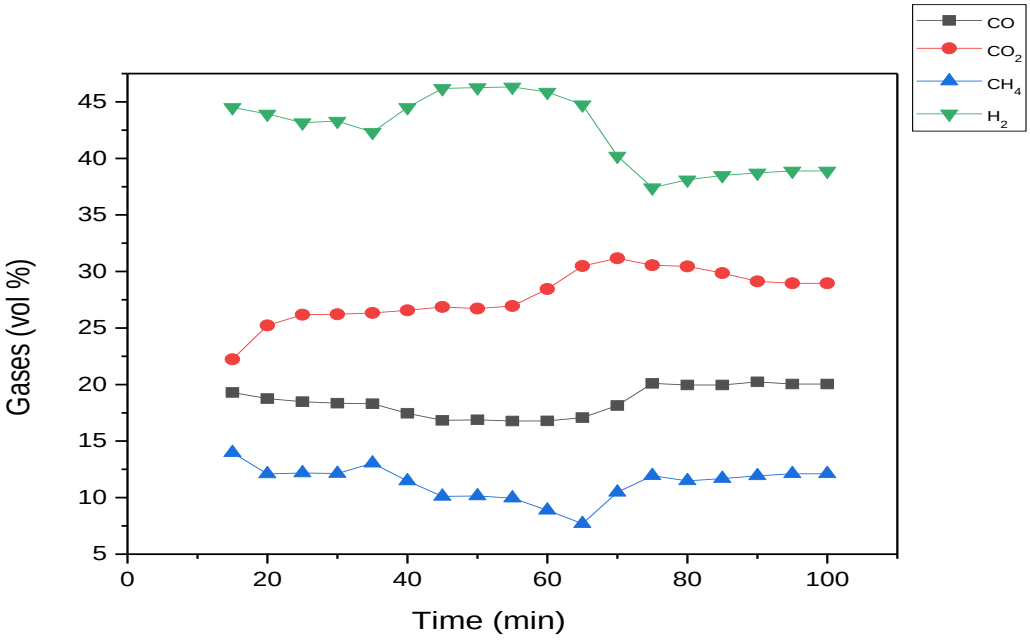


Figure 4. 11. Gas Composition Using 10.0 g CalcinedDolomite (N_2 flow rate 100 ml/min).

Whencalcineddolomite (adsorbent) was introduced to the reactor while using a flow rate of 100 ml/min for the carrier gas (nitrogen), there was an evident increase in H_2 and a decrease in CO and CO_2. Effect of calcineddolomiteabsorbed CO_2 and lowered its partial pressure,as reported by Udomsirichakorn *et al.* (2014) and Fermoso *et al.* (2012).Therefore, moving water-gas shift reaction in forward direction results in lowering its partial pressure. Further reduction of the flow rate of carrier gas (N_2) to 50 ml/min increased the amount of H_2released with a peak value of 51% at 20 min. This could be attributed to intimate contact between the pyrolysis gases and calcineddolomite, caused by the decrease in carrier flow rate and longer residence time for capture. It was also observed that CO and CO_2 values dropped as a result of this. Figure 4.12 shows the gas composition using 10.0 g calcineddolomite (N_2 flow rate 50 ml/min) while Figure 4.13 shows the gas composition using 0.5 g hierarchical ZSM-5 and 9.5 g calcineddolomite respectively.

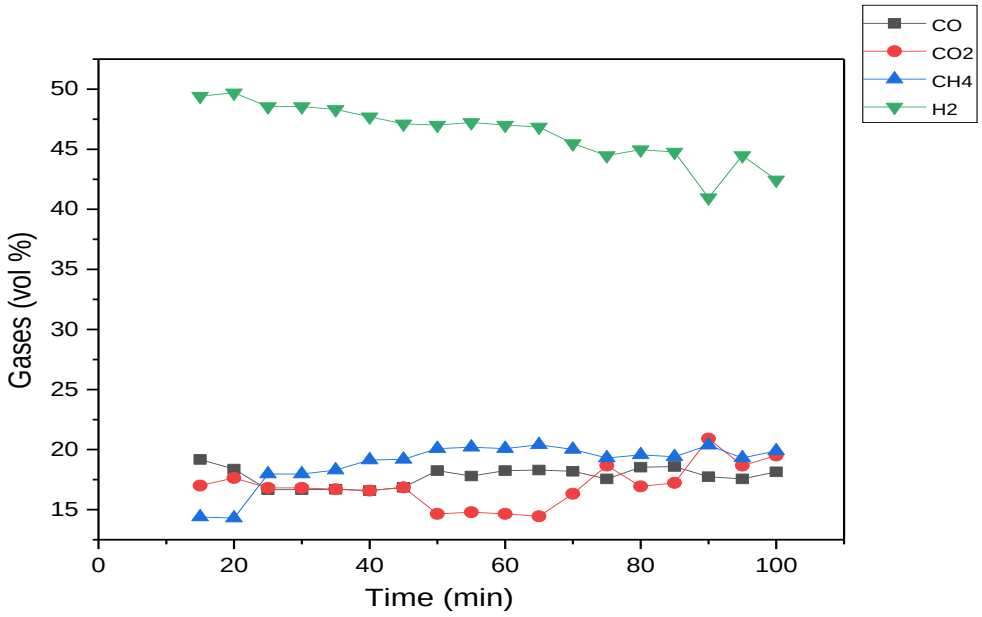


Figure 4. 12. Gas Composition Using 10.0 g Calcined Dolomite (N_2 flow rate 50 ml/min).

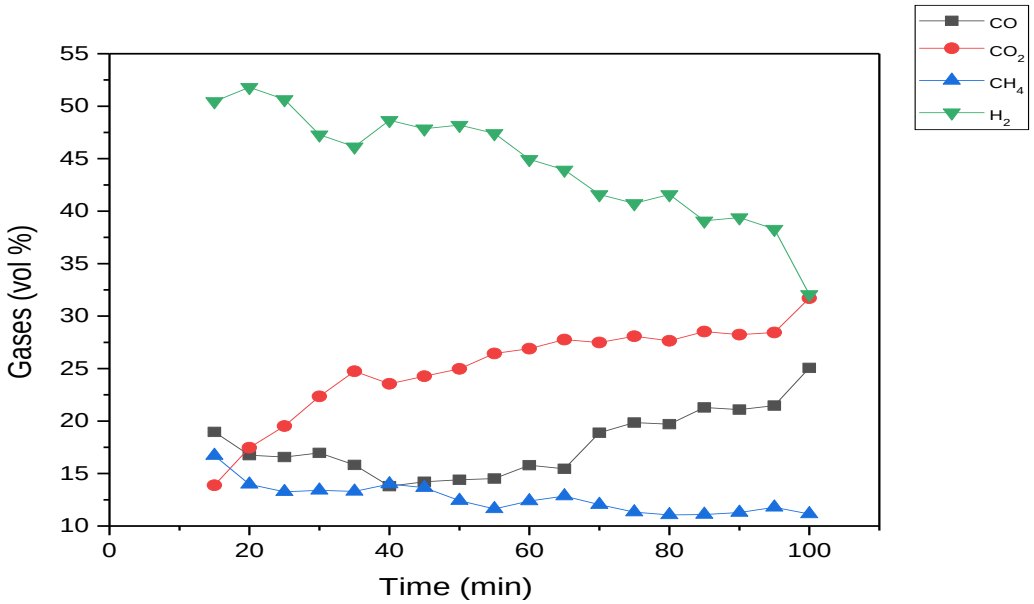


Figure 4. 13. Gas Composition Using 0.5g Hierarchical ZSM-5 and 9.5g CalcinedDolomite.

Increase in amount of gases liberated was observed upon introduction of 0.5g, 1.0g, 1.5g, 2.0g and 3.0 g of hierarchical ZSM-5 while maintaining the total amount of bed material at 10.0 g. The increase in gas products may be attributed to the large surface area of ZSM-5 catalyst as demonstrated in the BET and the active sites which aids in catalytic hydrocarboncracking and reforming, deoxygenation (decarbonylation, decarboxylation and dehydrogenation)reactions. The oxygen is removed from pyrolysis volatiles in the form of CO_2, CO and H_2O as previously mentioned, which resulted in reduction of the total liquid condensates and organic fractions in the compositional study of the liquids affirmed by the GC-MS. The selectivity of H_2got to a peak at 1.5g catalystand 8.5g calcineddolomite with 79 (volume %) at 55minutes. It also had the least amount of CO_2 which suggest an inclination towards successful CO_2 capture hence promoting hydrocarbon reforming and water gas shift reactions and eventually improving H_2 yields.

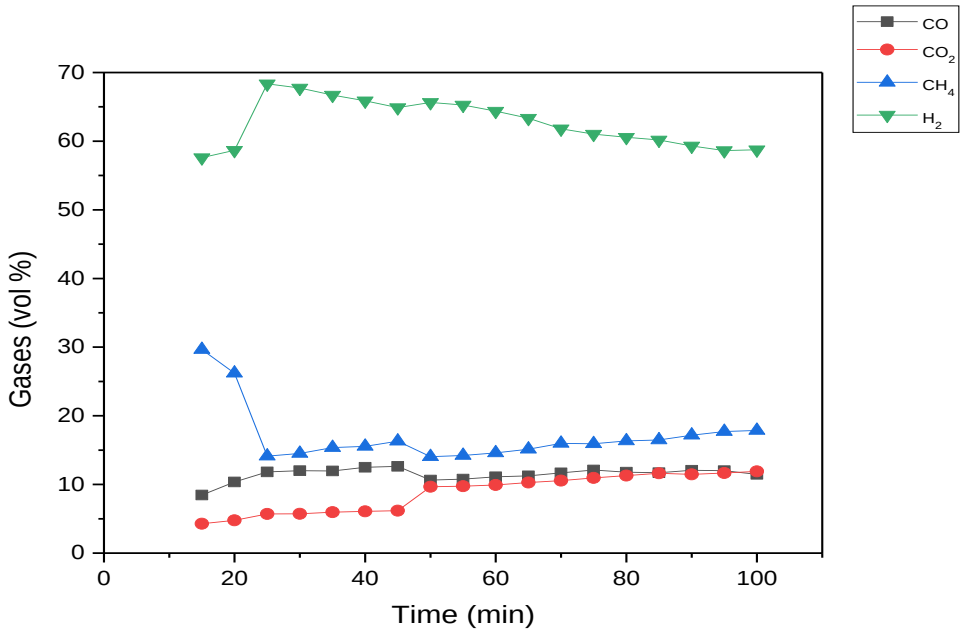


Figure 4. 14. Gas Composition Using 1g Hierarchical ZSM-5and 9.0g CalcinedDolomite.

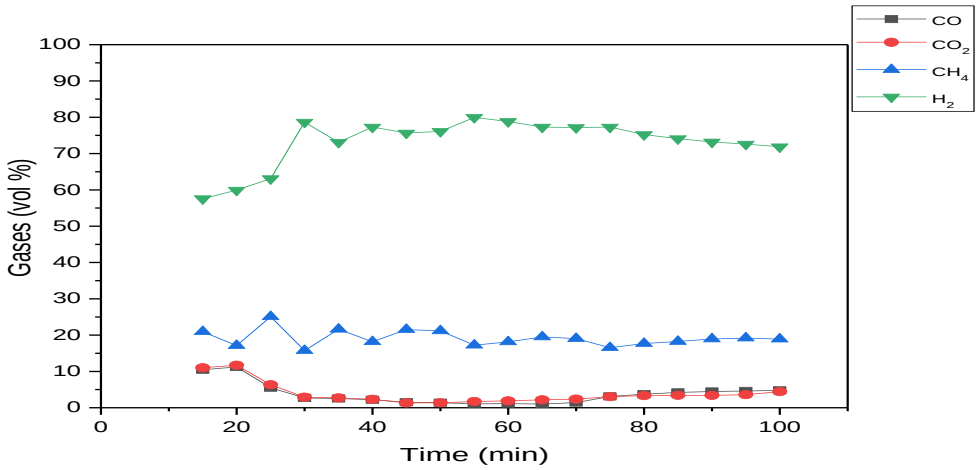


Figure 4. 15. Gas Composition Using 1.5g Hierarchical ZSM-5and 8.5g CalcinedDolomite.

Upon further loading of hierarchical ZSM-5 catalyst(2g hierarchical ZSM-5 and 8.0 g calcineddolomite, 3.0 g hierarchical ZSM-5 and 7.0 g calcineddolomite) as seen in Figure 4.16 and Figure 4.17, an increase in CO_2 and CO was observed which suggest a bias towards enhanced catalytic cracking, and fragmentation of C-O and C=O bonds (decarboxylation and decarbonylation) reactions.

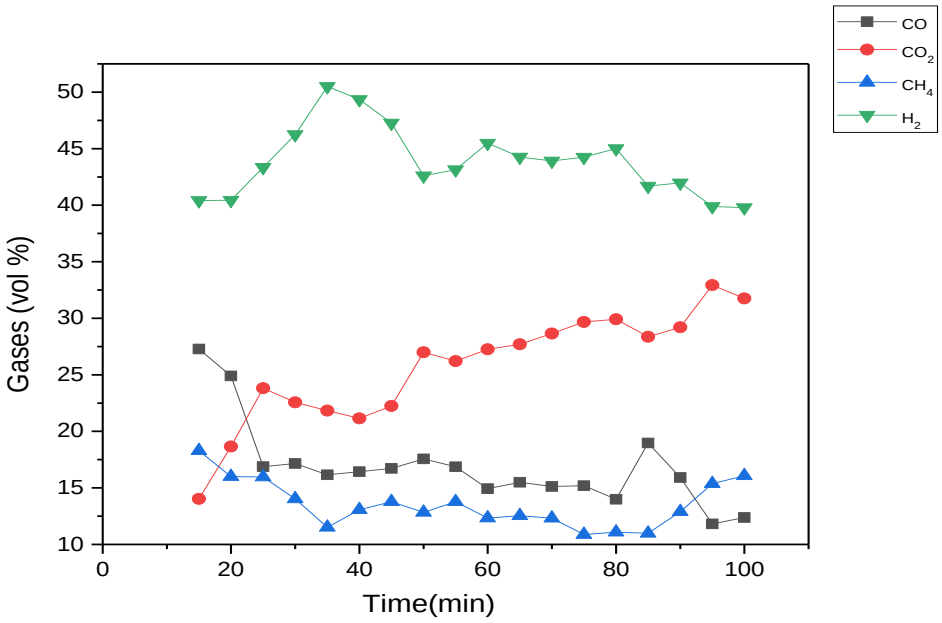


Figure 4. 16. Gas Composition Using 2.0 g Hierarchical ZSM-5and 8.0 g CalcinedDolomite.

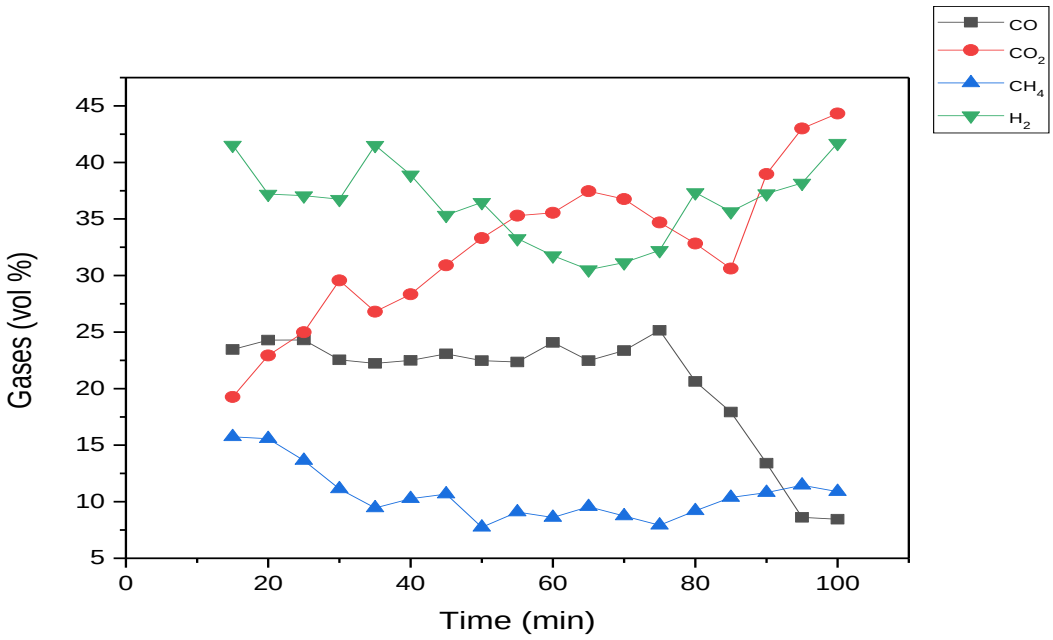


Figure 4. 17. Gas Composition Using 3.0 g Hierarchical ZSM-5and 7.0 gCalcined Dolomite.

In comparison to parent ZSM-5 (Figure 4.18), hierarchical ZSM-5 (Figure 4.17) showed better selectivity towards the production of H_2 and it was further improved upon doping the hierarchical ZSM-5 with 2wt.% ZnO – 2wt.% NiO/ hierarchical ZSM-5 (Figure 4.19).Li *et al.*(2017)suggested that active metal sites which improve dehydrogenation reaction is responsible for this. The $CO_2$and CO liberated for the parent ZSM-5 were much higher with a peak of 30 (volume %) after 65 minutes and 25 (volume %) after 96 minutes respectively in contrast to both hierarchical ZSM-5 and 2wt. % Zn – 2wt.% Ni/ hierarchical ZSM-5 which only showed traces of CO and CO_2 with less than 10 (volume %) at any instance during the runs. Parent ZSM-5 catalyst had its highest amount of H_2 at 45 minutes with a value of 45 (volume %) as compared

to 79 (volume %) and 88 (volume %) for hierarchical ZSM-5 and 2wt. % Zn – 2wt. % Ni/ hierarchical ZSM-5 respectively.

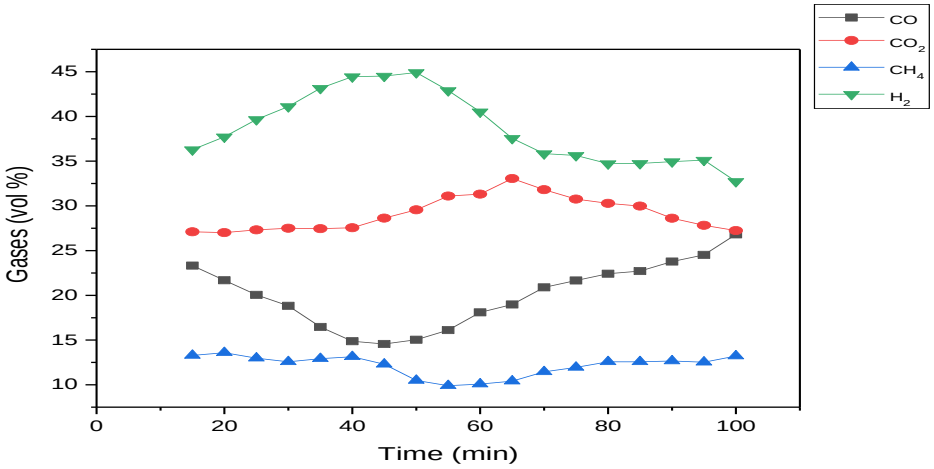


Figure 4. 18. Gas Composition Using 1.5g Parent ZSM-5and 9.5gCalcined Dolomite.

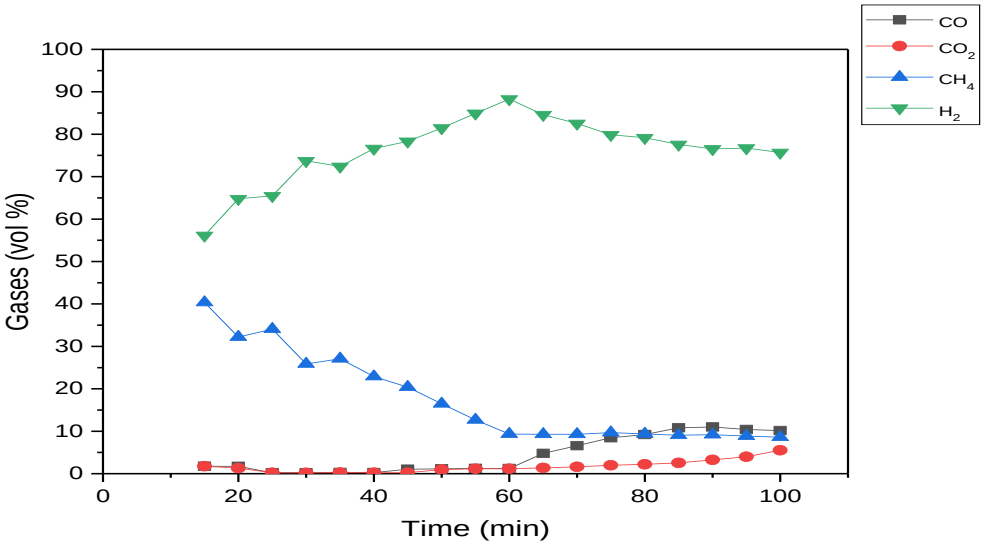


Figure 4. 19. Gas Composition Using 1.5g (2wt. % Zn- 2wt.% Hierarchical ZSM-5) and 8.5g CalcinedDolomite.

4.3Effect of Catalyst and Sorbent On Non-Condensable Reformed Products

Figure 4.20 shows the FTIR analysis of bio oils produced from the blank run, 0.5.ghierarchical HZSM-5 and 9.5gcalcineddolomite, 1ghierarchical ZSM-5 and 9.0 gcalcineddolomite, 1.5ghierarchical ZSM-5 and 8.5gcalcineddolomite, 2.0 ghierarchical ZSM-5 and 8.0 gcalcineddolomite, 3ghierarchical ZSM-5 and 7.0 gcalcineddolomite respectively while Figure 4.20shows the FTIR analysis of bio oils produced from the blank run, 10.0 gcalcined dolomite, 1.5g parent ZSM-5and 8.5gcalcined dolomite, 1.5g hierarchical ZSM-5 and8.5gcalcineddolomite, and 1.5g 2wt. % ZnO – 2wt.% NiO / hierarchical ZSM-5and 8.5g calcineddolomite respectively. The compositional analysis of the functional group of the reformed pyrolyzed biomass condensates shows characteristic bands range from 500 – 4000 cm^{-1}.

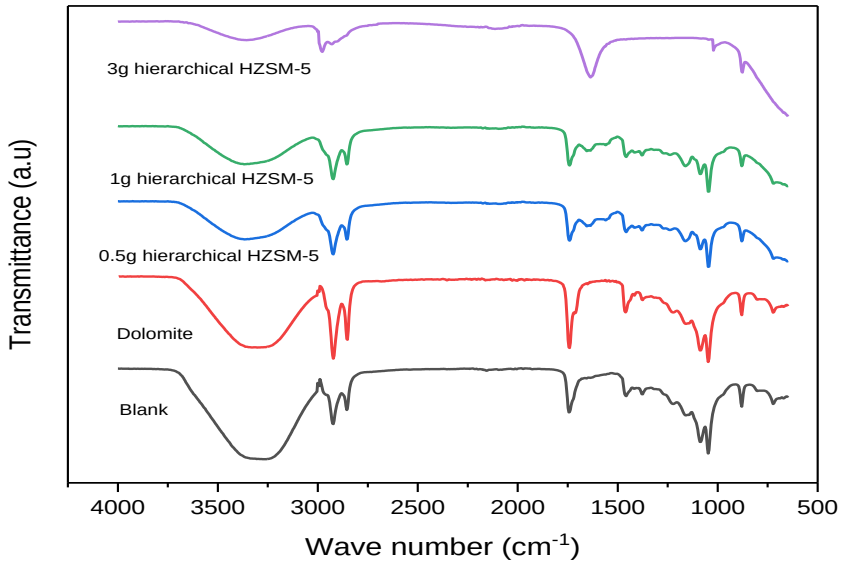


Figure 4. 20. FTIR Analysis of Bio oils;Blank run, 0.5g Hierarchical ZSM-5 and 9.5g CalcinedDolomite, 1.0 g Hierarchical ZSM-5 and 9.0 g CalcinedDolomite, 1.5g Hierarchical ZSM-5 and 8.5g CalcinedDolomite, 2.0 g Hierarchical ZSM-5 and 8.0 g CalcinedDolomite, 3.0 g Hierarchical ZSM-5 and 7.0 g CalcinedDolomite.

The uncatalyzed rice husk pyrolysis oil (blank run) shows the presence of oxygenated groups. For example,peaks representing O–H vibrations between 3050 and 3600 cm^{-1}, C-O stretching vibrations between 1650 and 1850 cm^{-1}, C–O stretching vibrations between 850 and 950 cm^{-1} and C-Ostretching and O–H in-plane deformations between 950 and 1325 cm^{-1}were all present in theunanalyzed(blank and calcineddolomite) oil. The oxygenated compounds represented by the functional groups discussed are represented by a wide range of oxygenated compounds which have been identified in biomass pyrolysis oils using GC-MS. Figure 4.21 shows the FTIR analysis of bio oils;blank run, 1.5g parent ZSM-5and 9.5g calcineddolomite, 1.5g hierarchical ZSM-5and 8.5g calcineddolomite, 1.5g Zn-Ni/ hierarchical ZSM-5and 8.5g calcined dolomite.

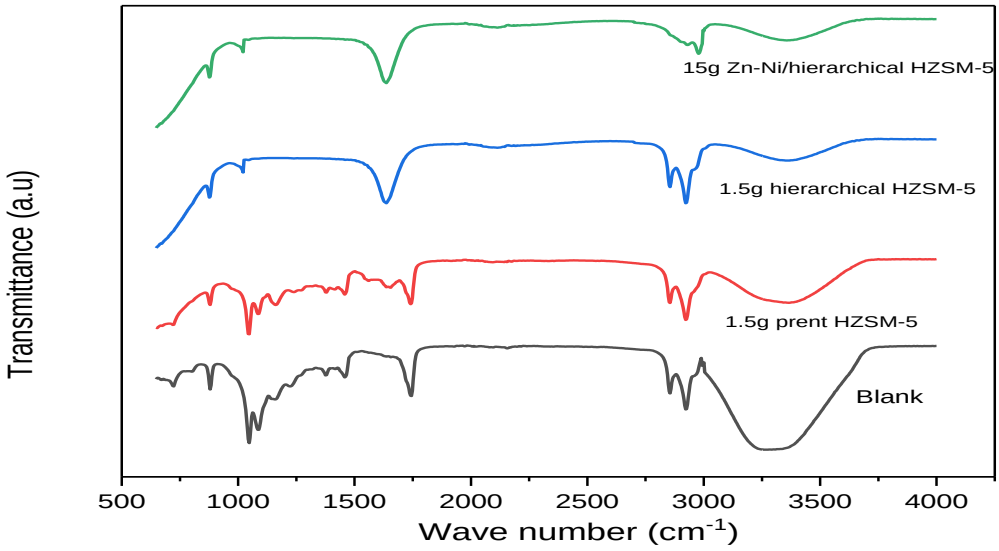


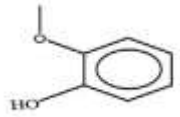
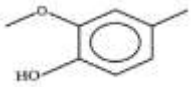
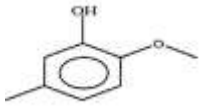
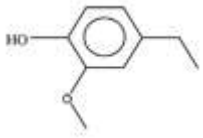
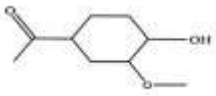
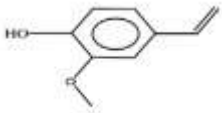
Figure 4. 21. FTIR Analysis of Bio oils;Blank run, 1.5g Parent ZSM-5and9.5gCalcinedDolomite, 1.5g Hierarchical ZSM-5and8.5gCalcinedDolomite, 1.5g Zn-Ni/ Hierarchical ZSM-5and8.5gCalcinedDolomite.

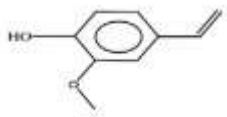
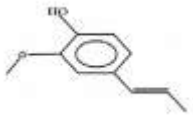
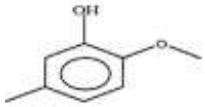
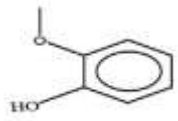
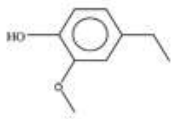
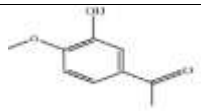
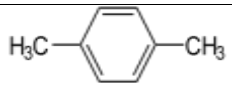
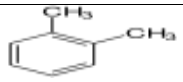
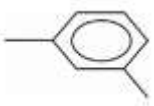
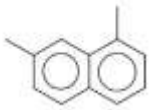
These include alcohols such as6,11-Dimethyl-2,6,10-dodecatrien-1-ol, 2-methyl-3-Penten-1-ol,butanol , carboxylic acids for example, n-Hexadecanoic acid, ketones and aldehydes including, acetaldehyde, benzaldehyde, acetone, pentanone, indanone,Ethanone.It also contains derivatives of phenol, alkylated phenols and oxyphenols as shown in appendix A.Also present in the uncatalyzed oils were peaks representative of non-oxygenated compounds. For example, the C–H stretching vibrations between 2800 and 3000 cm^{-1} and C–H deformation vibrations between 1350 and 1475 cm^{-1} indicate the presence of the chemical functional groups, –CH3, –CH2 and –CH which are characteristic of alkane groups. Similar compounds were produced by Chen-Pei Hsu *et al.*(2015) from the pyrolysis of rice husk at 550 ^{0}C and Akubo *et al*. (2018) who carried out pyrolysis of rice husk at 600^{0}C . However, upon application of HZSM-5 catalyst, some of these peaks representing oxygenated compoundsand the long chain alkane groups appeared to have dipped suggestingthat the hierarchical ZSM-5 catalyst aided in converting these species to other products mainly aromatics, and permanent gases as affirmed by the GC-MS and gas analysis respectively.The absorptionpeaks between 675 and 900 cm^{-1} and 1575 and 1625 cm^{-1} are characteristic of single ringaromatic compounds and polycyclic aromatic compounds. Transmittance peaks were sharpest using the Zn/Ni-hierarchical catalyst and decreased with loading of the hierarchical catalyst within the bed. This is attributed to recombination/oligomerization, isomerization, cyclization, and dehydrogenation caused by the ZSM-5 catalyst(Jeon *et al*., 2012).

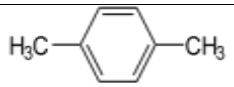
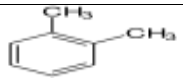
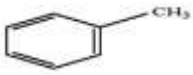
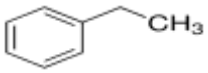
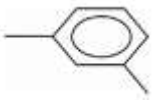
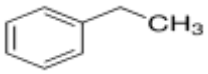
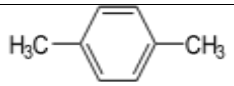
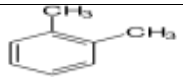
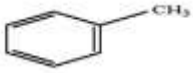
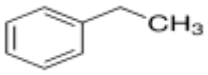
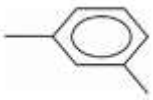
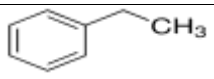
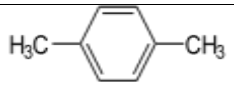
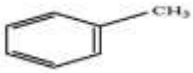
The compositional analysis of the reformed pyrolysis condensable volatiles was done using GC-MS to confirm the FTIR results. Figure 4.21 shows the characterisation of the condensates using GC-MS technique. The chromatographsidentify the molecules by their respective retention times, and the height of the peaks gives the amount of those particles present in the

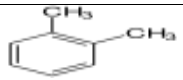
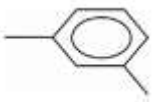
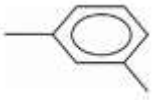
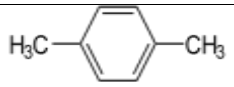
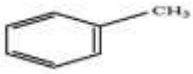
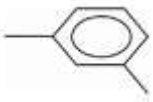
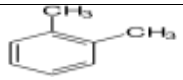
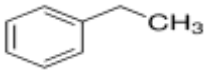
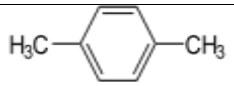
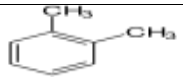
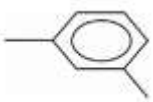
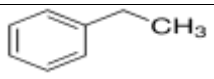
detector.Table 4. 2 Shows the summary of the most abundant components from GC-MS of the condensates.

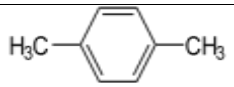
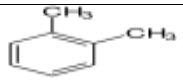
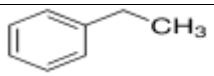
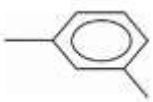
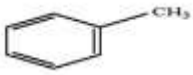
Table 4. 3. Summary of the Most Abundant Components from GC-MS of the Condensates.

Catalyst	**Name of the Hydrocarbon**	**Retention time (min)**	**Relative area (%)**	**Types**	**Structures**
Blank run	2-methoxy Phenol	18.51	10.14	PH	
	2-methoxy-4-methyl-Phenol	23.65	9.96	PH	
	2-Methoxy-5-methylphenol	23.71	6.92	PH	
	4-ethyl-2-methoxy- Phenol	27.88	5.83	PH	
	n-Hexadecanoic acid	53.1	5.63	AC	
	1-(4-hydroxy-3-methoxyphenyl)ethan-1-one	42.59	5.39	KT	
	2-Methoxy-4-vinylphenol	28.33	5.06	PH	

CalcinedDolomite Run	2-Methoxy-4-vinyl-phenol	28.33	10.13	PH	
	Trans-Isoeugenol	34.97	8.42	PH	
	2-Methoxy-5-methyl-phenol	23.71	8.44	PH	
	2-methoxy Phenol	18.51	4.91	PH	
	2-methoxy-4-ethyl- Phenol	27.88	5.88	PH	
	1-(3-hydroxy-4-methoxyphenyl)ethan-1-one	36.24	2.11	KT	
0.5HZ	P-Xylene	6.88	11.58	AR	
	O-Xylene	6.98	5.60	AR	
	Toluene	4.89	3.82	AR	
	1,3-dimethyl- Benzene	6.93	2.63	AR	
	1,7-dimethyl- Naphthalene	14.47	2.51	AR	

1 HZ	P-Xylene	6.88	12.51	AR	
	O-Xylene	6.98	8.93	AR	
	Toluene	4.89	9.0	AR	
	Ethylbenzene	6.30	1.28	AR	
	1,3-dimethyl-Benzene	6.93	3.13	AR	
	1,2,4-trimethyl- Benzene	9.08	1.28	AR	
1.5HZ	P-Xylene	6.88	22.51	AR	
	O-Xylene	6.98	10.93	AR	
	Toluene	4.89	9.06	AR	
	Ethylbenzene	6.30	4.10	AR	
	1,3-dimethyl- Benzene	6.93	2.13	AR	
	1,2,4-trimethyl- Benzene	9.08	2.38	AR	
2HZ	P-Xylene	6.88	19.10	AR	
	Toluene	4.89	9.12	AR	

	O-Xylene	6.98	9.06	AR	
	1,3-dimethyl- Benzene	6.93	4.51	AR	
	Benzene,(1,2-dimethyl-1-propenyl)	12.57	2.81	AR	
3 HZ	P-Xylene	6.88	20.10	AR	
	Toluene	4.89	9.77	AR	
	1,3-dimethyl- Benzene	6.93	8.51	AR	
	O-Xylene	6.98	10.12	AR	
	Ethylbenzene	6.30	5.21	AR	
1.5 PZ	P-Xylene	6.88	13.51	AR	
	O-Xylene	6.98	8.93	AR	
	1,3-dimethyl- Benzene	6.93	2.51	AR	
	Ethylbenzene	6.30	4.02	AR	
	Toluene	4.89	7.09	AR	

1.5 ZN-HZ	P-Xylene	6.88	27.21	AR	
	O-Xylene	6.98	14.62	AR	
	Ethylbenzene	6.30	4.42	AR	
	1,3-dimethyl- Benzene	6.93	9.00	AR	
	Toluene	4.89	9.03	AR	

Key:KT=Ketone, PH=Phenols, AR=Aromatics and AC=Acids

As shown in the Table 4.2,most of the hydrocarbon identified in the blank run and 10g calcineddolomite runwere a wide range of compounds including phenols a thermal product of the lignin component of the rice husk while aldehydes, ketones and aliphatic can be attributed to the fragmentation of the rice husk at high temperatures. The peaks of these compounds with highest abundance (2-methoxyPhenol,2-methoxy-4-methylPhenol, 2-Methoxy-5-methylphenol, 4-ethyl-2-methoxyPhenol, n-Hexadecanoic acid,2-Methoxy-4-vinylphenol, 1,2-dihydroxybenzene, 4-Hydroxy-2-methoxycinnamaldehyde) are shown in the chromatogram in Figures 4.21, 4.22 and 4.23 at their respective retention. It can also be observed from Table 4.2and Figures 4.21, 4.22 and 4.23 that there is a shift in the distribution of compounds produced in the bio-oil generated with an increase in catalyst loading from phenols, aldehydes, acids aliphatics in the blank and calcineddolomite runs to single ring aromatics (Benzene, Toulene and Xylene) and polyclic aromatic hydrocarbons (PAHs) such as naphthalene and Indene. Dai *et al*. (2018) and Khan *et al*. (2019) inferred that this can be attributed to the active acid sites and the shape selectivity that hierarchical ZSM-5 offers.

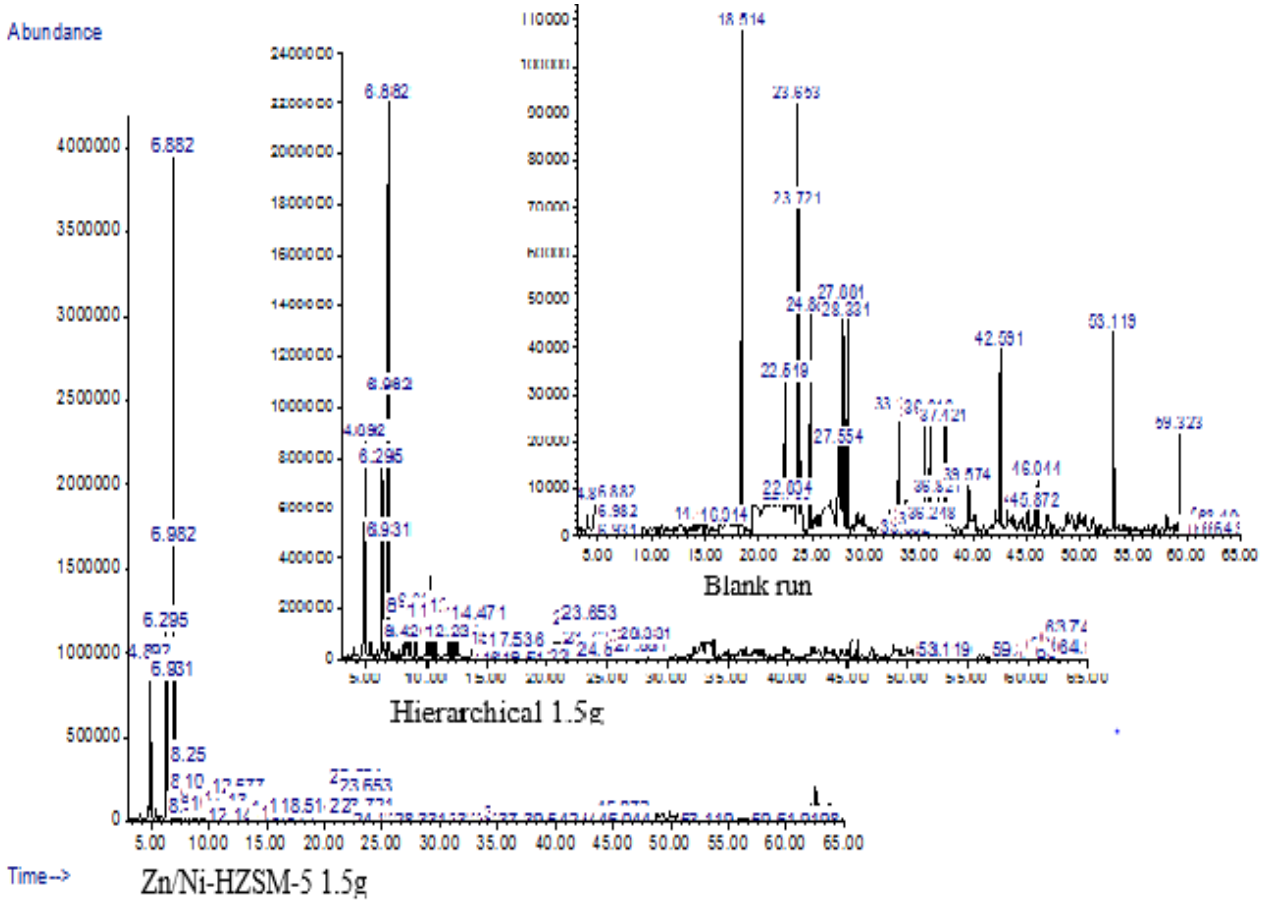


Figure 4. 22.Chemical Compositions of the Condensates from GC-MS Analysis of Blank run, 1.5g Hierarchical ZSM-5and 8.5gCalcinedDolomite run, 1.5g 2wt. % Zn- 2wt. % Ni - Hierarchical ZSM-5and 8.5g CalcinedDolomite run at 450^0C.

Upon incorporating the hierarchical HZSM-5 with 2wt. % ZnO and 2. Wt.% NiO through wetness impregnation method, the selectivity of the catalyst towards production of aromatics increases as it can be observed from Table4.3 and the chromatogram in Figures 4.22.

GC-MS (Figures 4.22), results show that, the aromatic hydrocarbons composition increased relatively to about 71% of the reformed condensates when Zn/Ni- hierarchical HZSM-5 was used as compared to 61% for hierarchical HZSM-5 and 58% for the parent HZM-5. Also Xylene accounted for a larger percentage of these aromatics. The active sites generated could effectively enhance the process of dehydrogenation and aromatization thus improving selectivity towards productionof BTXthis is responsible for the increase in aromatics(Yanming *et al*., 2016).

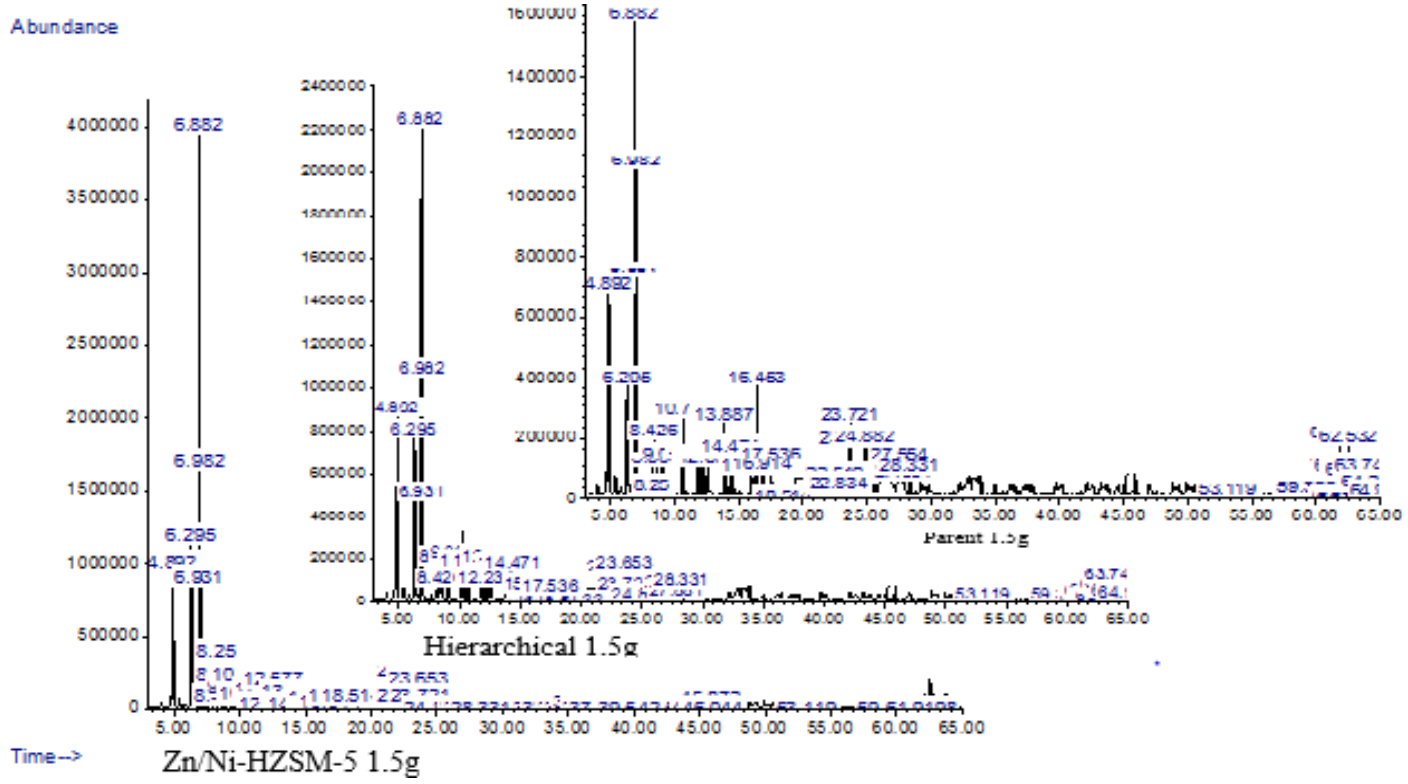


Figure 4. 23. Chemical Compositions of the Condensates from GC-MS Analysis of , 1.5g 2wt % Zn- 2wt. % Ni - Hierarchical ZSM-5and 8.5g CalcinedDolomite run, 1.5g Hierarchical ZSM-5and 8.5g CalcinedDolomite run, 1.5g parent ZSM-5and 8.5g CalcinedDolomite run at 450^0C.

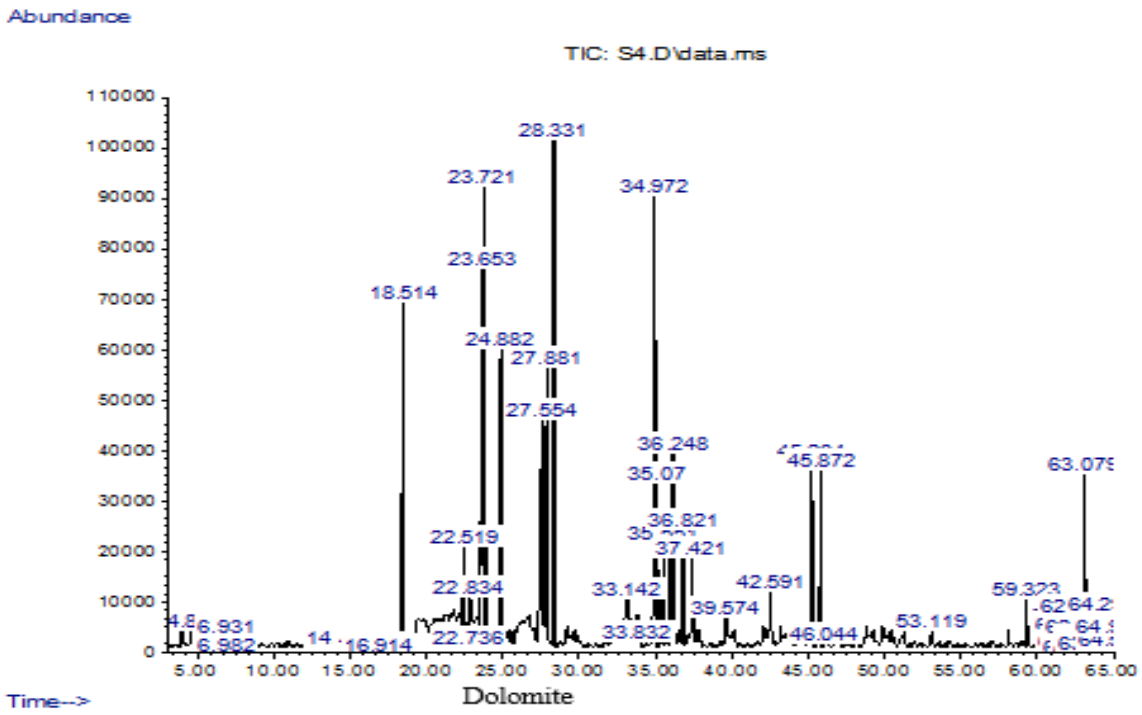


Figure 4. 24.Chemical Compositions of the Condensates from GC/MS Analysis of CalcinedDolomite run.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study has been conducted to investigate the effect of Hierarchical-HZSM-5 catalysts and calcineddolomite on the catalytic reforming and CO_2capture of the volatile products of rice husk pyrolysis syngas; (H_2, CO, CH_4, CO_2)and liquids (bio-oil). Within the scope of this work, the following conclusions were made

i. CO_2 sorbent (calcineddolomite), was successfully prepared and characterized using FTIR, XRD, and BET techniques.The FTIR report ofcalcineddolomite showed typical bands at wavelengths of 3640, 1800, and 870 cm^{-1}whichare due to the formation of $Ca(OH)_2$ while the broad band at 450cm^{-1} indicated the presence of MgO. This if further supported by the basic crystallinity peaks of the XRD pattern at 32.5, 37.2, 54.7 and 64.8° which are evidence of CaO and intensity peaks at 43.2 and 62.6° represent MgO while the BET report affirmed its mesoprosity and low surface area with a type IV isotherm (mesopores) and a surface area of 8.77 m^2 /g.

ii. Hierarchical ZSM-5 catalyst was successfully synthesized from the parent HZSM-5 catalyst. The FTIR and the XRD results indicate that the zeolite structure of ZSM-5 was maintained even after treatment with NaOH (desilication) though there was some loss of crystallinity after desilication while the BET results show that on desilication, surface mesoporesincreased from 111m^2/g for the parent to 141m^2 /g for the hierarchical catalyst. Increase in volume mesopores and average pore width were also observed.

iii. A hierarchical ZSM-5 catalyst with 2wt%Zn-2wt%Ni was successfully prepared. Upon FTIR analysis it was observed that even after metal impregnation the catalyst maintained its basic

ZSM-5 functional groups. There were no visible diffraction lines for zinc and nickel in the XRD pattern of the sample. However the BET reports showed clear mesoposity as compared to the parent ZSM-5 with an increase in surface mesopores from 111m^2/g for the parent to 136m^2/g for the 2wt. %Zn-2wt%Ni/ hierarchical ZSM-5 catalyst, Increase in volume mesopores and average pore width were also observed.

iv. For Non-condensable products, 2 wt. % Zn – 2 wt. % Ni/hierarchical ZSM-5 had the highest selectivity towards production of H_2 which was recorded as 88 % (volume) at 60 min.It was also showed the best selectivity towards the production of single ring aromatics (BTX). The 2.wt. % Zn – 2 wt. % Ni/hierarchical ZSM-5 had better performance in conversion of oxygenates present in the bio oil to aromatics with about 70 % of total condensates in relation to 61 % for hierarchical ZSM-5 and 58 % for the parent ZM-5 respectively.

5.2 Recommendations

The following recommendations may be considered based on this research work.

1. In this work, the catalysts and sorbent loading were varied to attain a total of 10.0 g Bed material. Thus, it is recommended that further experiment should be carried outusing a reactor with a higher capacity toimprove CO_2sequestration and in turn improve H_2 generation.
2. Further analysis like NH_3-TPD should be carried out for the quantification of the bronsted and Lewis acids. SEM should also be used in checking the external morphology of zeolite and TEM to determine the extent of metal dispersion within the framework of the zeolite.
3. Further analysis of physical properties such as viscosity, pore point etc. of the condensates should be carried out in order to compare it with the conventional fuels.

4. Other precursors of $CaCO_3$ such as eggshells should be tested as sorbent for CO_2 trapping to compare their performance againstcalcined dolomite.

REFERENCES

Agbro, E.B. and Ogie, N.A. (2012) A Comprehensive Review of Biomass Resources and Biofuel Production Potential in Nigeria. *Research Journal in Engineering and Applied Sciences*. 1, 149-155.

Akubo, K., Nahil, M. A., and Williams, P. T. (2018). Pyrolysis-catalytic steam reforming of agricultural biomass wastes and biomass components for production of hydrogen / syngas. *Journal of the Energy Institute*.1, 1–10.

Alhinai, M., Azad, A. K., Bakar, M. S. A., & Phusunti, N. (2018). Characterisation and Thermochemical Conversion of Rice Husk for Biochar Production. *International Journal of Renewable Energy Research*.*8*(3), 232-239

Anca-couce, A. (2016). Reaction mechanisms and multi-scale modelling of lignocellulosic biomass pyrolysis. *Progress in Energy and Combustion Science*.*53*, 41–79.

Balat, M. and Balat, H. (2009). Recent trends in global production and utilization of bio-ethanol fuel. *Applied Energy. 86(11), 2273–2282*. doi:10.1016/j.apenergy.2009.03.015

Bridgwater T. (2007).The production of biofuels and renewable chemicals by fast pyrolysis of biomass 160 *International Journal of Global Energy. 27*(2),160-202DOI: 10.1504/IJGEI.2007.013654 ·

Clough, P. T. and Fennell, P. S. (2018). Hydrogen Production by Sorption Enhanced Steam Reforming (SESR) of Biomass in a Fluidised-Bed Reactor Using Combined Multifunctional Particles. *Materials, 2(5) 234-241*. https://doi.org/10.3390/ma11050859

Dai, L., Wang, Y., Liu, Y., Ruan, R., Duan, D., Zhao, Y. and Jiang, L. (2018). Catalytic fast pyrolysis of torrefied corn cob to aromatic hydrocarbons over Ni-modified hierarchical ZSM-5 catalyst. *Bioresource Technology*.*3*, 106-09 https://doi.org/10.1016/j.biortech.2018.10.062

Dauda I. B.and Atta A. Y. (2018).Synthesis, Characterization and Performance Evaluation of Hierarchical ZnO/ZSM-5 Catalysts for Propane Aromatization. Ahmadu Bello University, Zaria. 37- 44.

Dayton, D. C. (2011). Catalytic Processes in Biomass Gasification and Pyrolysis.*Biomass Technical Journal 44,* 101-03.

Demirbas, A. (2002). Gaseous products from biomass by pyrolysis and gasification : effects of catalyst on hydrogen yield. *Energy Conversion and Management*. *43*, 897–909.

Dhyani, V.and Bhaskar, T. (2017). A comprehensive review on the pyrolysis of lignocellulosic biomass. *Renewable Energy*. *4(2),* 123-131. https://doi.org/10.1016/j.renene.2017.04.035

Dou, B., Wang, C., Song, Y., Chen, H., Jiang, B., Yang, M., & Xu, Y. (2016). Solid sorbents for in-situ CO 2 removal during sorption-enhanced steam reforming process : A review. *Renewable and Sustainable Energy Reviews*. *53*, 536–546.

https://doi.org/10.1016/j.rser.2015.08.068

Efomah, A. N., and Gbabo, A. (2015). The Physical , Proximate and Ultimate Analysis of Rice Husk Briquettes Produced from a Vibratory Block Mould Briquetting Machine, *International Journal of Innovative Science, Engineering & Technology*. *2*(5), 814–822.

Fermoso, J., and Chen, D. (2012). Environmental Science Sorption enhanced catalytic steam gasification process : a direct route from lignocellulosic biomass to high purity hydrogen , *Energy & Environmental Science*. 2(5), 6358–6367. https://doi.org/10.1039/c2ee02593k

Francis, W., and Peters, M. C. (1965).Fuel and Fuel Technology", *Pergamon Press Publishing, United Kingdom.2,101-106.*

Groen, J.C., Jansen J.C, Moulijn J.A., Pe´rez-Ramı´rez, J. (2004) Recovery of wood preservatives from wood pyrolysis tar by solvent extraction. *Journal of Physical Chemistry*. 51, 214–218

Grønli, M.G., Várhegyi,G. and Blasi, C. D. (2002). Thermogravimetric analysis and devolatilization kinetics of wood. *Industrial and Engineering Chemistry Research*, *41*(17), 4201–4208.

Gruszecka-kosowska, A., and Wdowin, M. (2015). An analysis of the chemistry , mineralogy and texture of dolomite powder. *Geology Geophysics and Environment.*41 (4) 343–352. https://doi.org/10.7494/geol.2015.41.4.343

Gupta, H. and Fan, L.-S. (2002). Carbonation−Calcination Cycle Using High Reactivity Calcium Oxide for Carbon Dioxide Separation from Flue Gas. *Industrial & Engineering Chemistry Research, 41(16), 4035–4042*. doi:10.1021/ie010867l

Hartmann, M., Machoke, G., Schwieger, W.and Hartmann, M. (2016). Catalytic test reactions for the evaluation of hierarchical zeolites. *Chemical Society Reviews*. 4(3) 160-203. https://doi.org/10.1039/C5CS00935A

Horikawa, T., Do, D. D., & Nicholson, D. (2011). Capillary condensation of adsorbates in porous materials Amount adsorbed. *Advances in Colloid and Interface Scienc*e. *169*, 40–58. https://doi.org/10.1016/j.cis.2011.08.003

Hsu, C., Huang, A., & Kuo, H. (2015). Analysis of the Rice Husk Pyrolysis Products from a Fluidized Bed Reactor. *Procedia Engineering*, *102*, 1183–1186. https://doi.org/10.1016/j.proeng.2015.01.244

Huang, Z., Luan, D., Shen, S., Hidajat, K., and Kawi, S. (2005). Supercritical fluid extraction of the organic template from synthesized porous materials : Effect of pore size Supercritical fluid extraction of the organic template from synthesized porous materials : effect of pore size. *Journal of Supercritical Fluid*s.5(2) 605-618 https://doi.org/10.1016/j.supflu.2004.11.001

Ifeanyi, M. (2013). Carbon , Capture and Storage form Fossil Fuel and Biomass - Uses , Transportation , Cost and Potential Role in Stabilizing the Atmosphere. *Academic Journal of Interdisciplinary Studies.2*(13), 9–18. https://doi.org/10.5901/ajis.2013.v2n13p9

International Energy Agency (2006). Annual Report on Biomass Pyrolysis. 2(3) 1-7.

Jahirul, M. I., Rasul, M. G., Chowdhury, A. A. and Ashwath, N. (2012). Biofuels Production through Biomass Pyrolysis—A Technological Review. *Energies*. 5, 4952-5001 https://doi.org/10.3390/en5124952

Jeon, M., Kim, S., Jeon, J., Park, S. H., Kim, J. M., Sohn, J. M., Park, Y. (2012). Catalytic pyrolysis of waste rice husk over mesoporous materials. *Nanoscale research letters.* 7, 1–5.

Khan, W., Jia, X., Wu, Z., and Choi, J. (2019). Incorporating Hierarchy into Conventional Zeolites for Catalytic Biomass Conversions : A Review. *Catalysts*. 9, 127-150 https://doi.org/10.3390/catal9020127

Kumar, A., Jones, D. D., and Hanna, M. A. (2009). Thermochemical Biomass Gasification: A Review of the Current Status of the Technology. *Energies*. 2 (3). https://doi.org/10.3390/en20300556

Li, Z., Jiang, E., and Xu, X. (2017). The complete utilization of rice husk for production. *RSC Advances*. *7*, 33532–33543. https://doi.org/10.1039/C7RA04554A

Lin, K. S., Wang, H. P., Lin, C. and Juch, C. (1998). A process development for gasification of rice husk. *Fuel Processing Technology*. 55. 185–192.

Matin, A., and Sedak, I. (2016). Proximate , Ultimate , and Energy Values Analysis of Plum Biomass By-products Case Study : Croatia ' s Potential. *Journal of Agricultural science and Technology*. *18*, 1655–1666.

Mawanga, M. (2017). Dolomite-based Sorbents for High Temperature Carbon dioxide capture. Norwegian University of Science and Technology. 99-125.

Mineral and Chemical Composition of Pure Lime l stone. (2011). Missouri Department of Natural Resources, Division of Geology and Land Survey.

Natarajan, E., E, G. S., Material, A. R.,and Husk, R. (2009). Pyrolysis of Rice Husk in a Fixed Bed Reactor. *International Journal of Mechanical and Mechatronics Engineering*. *3*(8), 959–963.

Pricewaterhousecoppers. (2018). Boosting rice production through increased mechanisation. 1, 1-4. www.pwc.com/ng.

Ren, X., Cao, J., Zhao, X., Yang, Z., Liu, S., and Wei, X. (2017). Enhancement of aromatic products from catalytic fast pyrolysis of lignite over hierarchical HZSM-5 by piperidine-assisted desilication Enhancement of aromatic products from catalytic fast pyrolysis of lignite over hierarchical HZSM-5 by piperidine-assisted desilication. *RSC Advances*. *3(2)*,234-241. https://doi.org/10.1021/acssuschemeng.

Shahraki, B. K., and Dabiri, R. (2009). Thermal behavior of Zefreh dolomite mine (Central Iran).*Journal of materials Iran*. 7(3) 237-245. https://doi.org/10.2298/JMMB0901035S

Shirazi, L., Jamshidi, E., and Ghasemi, M. R. (2008). The effect of Si / Al ratio of ZSM-5 zeolite on its morphology , acidity and crystal size. *Crystals Research and Technology*. *1306*(12), 1300–1306. https://doi.org/10.1002/crat.200800149

Shun, T. A. N., Zhijun, Z., Jianping, S. U. N. and Qingwen, W. (2013). Recent progress of catalytic pyrolysis of biomass by HZSM - 5. *Chinese Journal of Catalysis*.*34*(4), 641–650. https://doi.org/10.1016/S1872-2067(12)60531-2

Singh, R. N., Singh, S. P., and Balwanshi, J. B. (2014). Tar removal from Producer Gas : A Review. *Research Journal of Engineering Sciences*.*3*(10), 16–22.

Sisinni, M., Carlo, A. Di, Bocci, E., Micangeli, A., and Naso, V. (2013). Hydrogen-Rich Gas Production by Sorption Enhanced Steam Reforming of Woodgas Containing TAR over a Commercial Ni Catalyst and Calcined Dolomite as CO2 Sorbent. *Energies*. 3167–3181. https://doi.org/10.3390/en6073167

Stefanidis, S. D., Kalogiannis, K. G., Iliopoulou, E. F., Lappas, A. A., and Pilavachi, P. A. (2011). Bioresource Technology In-situ upgrading of biomass pyrolysis vapors : Catalyst screening on a fixed bed reactor. *Bioresource Technology*.*102*(17), 8261–8267. https://doi.org/10.1016/j.biortech.2011.06.032

Tsai, W. T., Lee, M. K., & Chang, Y. M. (2007). Fast pyrolysis of rice husk : Product yields and compositions. *Bioresource Technology*. *98*, 22–28. https://doi.org/10.1016/j.biortech.2005.12.005

Udomsirichakorn, J., and Salam, P. A. (2014). Review of hydrogen-enriched gas production from steam gasi fi cation of biomass : The prospect of CaO-based chemical looping gasification. *Fuel Processing Technology Journal*.*30*, 565–579. https://doi.org/10.1016/j.rser.2013.10.013

Valtchev, V. and Mintova, S. (2016). Hierarchical zeolites. *Material Research Society*.2,689–693. https://doi.org/10.1557/mrs.2016.171

Venderbosch,R. H. and Prins, W (2010). Fast pyrolysis technologyDevelopment (www.interscience.wiley.com); DOI: 10.1002/bbb.205; *Biofuels, Bioproduction and Biorefinery*. *4,178-208*.

Waziri, A. Y., Osigbesan, A. A., Dabai, F. N., Shuwa, S. M., and Atta, A. Y. (2019). Catalytic reforming of gaseous products from pyrolysis of low - density polyethylene over iron - modified ZSM - 5 catalysts. *Applied Petrochemical Research*, (0123456789). https://doi.org/10.1007/s13203-019-0230-4

Xiao, G.Xiao, W. and Wang, F. (2015).Performance of hierarchical HZSM-5 zeolites prepared by NaOH treatments in the aromatization of glycerol. *RSC Advances*. 7 (6) 1234-1248.https://doi.org/10.1039/b000000x

Yan-fen, L., Shu-rong, W. and Xiao-qian, M. (2004). Study of reaction mechanisms in cellulose pyrolysis. *Chemical Society Division*. *1*, 407–411.

Yang, H., Yan, R., Chen, H., Zheng,C., Dong, H. L. andLiang, D. T. (2006). In-Depth Investigation of Biomass Pyrolysis Based on Three Major Components: Hemicellulose, Cellulose and Lignin.*Energy and Fuels*.1,388-393.

Yanming, J., Junwen, W., Kan, Z., Wei, F., Shibin, L., Chuanmin, D.and Ping, L. (2016). Promoted effect of zinc – nickel bimetallic oxides supported on HZSM-5 catalysts in aromatization of methanol. *Journal of Energy Chemistry*. 3(1), 104-207. https://doi.org/10.1016/j.jechem.2016.10.014

Zhang, H., Shen, D., Xiao, R. D. and Shen, K.(2016).Enhancement of hydrocarbon production and catalyst stability during catalytic conversion of biomass pyrolysis-derived compound over hierarchical HZSM-5.*RSC Advances*. https://doi.org/10.1039/C6RA05356D

Zwart, R. W. R. (2009). Tar formation in pyrolysis and gasification. *Energy Research Centre*.9, 1-5.

APPENDICES.

Appendix A: Calculations on NaOH Concentration and Metal Impregnation on Reference and Hierarchical ZSM-5 Catalysts

Appendix A (I):Calculations on NaOH Concentration.

Table A1 Molecular weights of NaOH components

Component	Molecular weight (g/mol)
Sodium (Na)	23
Oxygen (O)	16
Hydrogen (H)	1

The molecular weight of NaOH = (23+16+1) = 40g/mol

(*Molecular weight* (*mol g*)) ×*molarity* (*M*) ×*amount of water* (*ml*) ÷ 1000 (*ml*)

(40×0.2×500)/1000= 4g of NaOH is needed in 500ml of H_2O for the preparation of 0.2M NaOH.

Appendix A (II):Calculations on Zinc and Nickel metals impregnation on Hierarchical ZSM-5 catalyst.

Table A2– Molecular weight of zinc nitrate (precursor) components

Component	Molecular Weight (g mol^{-1})
Zinc (Zn)	65.49
Nitrogen (N)	14
Hydrogen (H)	1
Oxygen (O)	16
Nickel	58.69

2wt % ZnO- 2wt% NiO/ZSM-5 catalyst contains 0.96 weight fraction of H-ZSM-5 and 0.02 weight fraction of Zinc oxide and 0.02 weight fraction of Nickel oxide.

The molecular weight of $Zn(NO_3)_2.6H_2O$ = 297.49 g mol^{-1} .

The molecular weight of Ni $(NO_3)_2.\ 6H_2O$ = 182.70 g mol^{-1}

For a total weight of 10g of 2wt% ZnO- 2wt% NiO/HZSM5 catalyst, we have 0.2g ZnO, 0.2g NiO and 9.6g of H-ZSM5 mass fractions. i.e.

297.49 g Zn $(NO_3)_2\ .6H_2O \rightarrow$ 81.49 g ZnO

X g Zn $(NO_3)_2\ 6H_2O \rightarrow$ 0.2g ZnO

$X = 0.2/81.49 \times 297.49 = 0.73g$

182.70 g Ni $(NO_3)_2\ .6H_2O \rightarrow$ 74.69 g NiO

X g Ni $(NO_3)_2\ 6H_2O \rightarrow$ 0.2g NiO

$X = 0.2/74.69 \times 182.70 = 0.49g$.

Appendix B: BET Report.

Full Report Set
MicroActive 5.00

ASAP 2420 V2.09
Serial # 180 Unit

Sample:	Dolomite
Operator:	Lee
Submitter:	Suleiman
Bar Code:	
File:	D:\External Work\
Started:	11/03/2019 11:25
Completed:	12/03/2019 12:04
Report time:	12/03/2019 15:54
Sample mass:	0.2837 g
Analysis free space:	49.1746 cm³
Low pressure dose:	None
Automatic degas:	Yes

Summary Report

Surface Area

Single point surface area at p/p° = 0.300000000:	8.5543 m²/g
BET Surface Area:	8.7688 m²/g
t-Plot Micropore Area:	0.5309 m²/g
t-Plot external surface area:	8.2380 m²/g
BJH Adsorption cumulative surface area of pores between 2.0000 nm and 150.0000 nm width:	8.7692 m²/g
BJH Desorption cumulative surface area of pores between 2.0000 nm and 150.0000 nm width:	8.8223 m²/g

Pore Volume

t-Plot micropore volume:	0.000083 cm³/g
BJH Adsorption cumulative volume of pores between 2.0000 nm and 150.0000 nm width:	0.044093 cm³/g

BJH Desorption cumulative volume of pores between 2.0000 nm and 150.0000 nm width:	0.023274 cm^3/g
Single point total pore volume at p/p° = 0.988749:	0.037028 cm^3/g
Pore Size	
Adsorption average pore diameter (4V/A by BET):	20.1054 nm
Desorption average pore diameter (4V/A by BET):	11.1407 nm
BJH Adsorption average pore width (4V/A):	20.1128 nm
BJH Desorption average pore width (4V/A):	10.5521 nm

Full Report Set
MicroActive 5.00

ASAP 2420 V2.09
Serial # 180 Unit 1 Port 4

Sample:	Parent HZSM-5
Operator:	Lee
Submitter:	Suleiman
Bar Code:	
File:	D:\External Work\UoN\Sulieman\B.SMF
Started:	11/03/2019 11:25:15
Completed:	12/03/2019 12:04:14
Report time:	12/03/2019 15:58:52
Sample mass:	0.1906 g
Analysis free space:	49.9050 cm³
Low pressure dose:	None
Automatic degas:	Yes

Summary Report

Surface Area

Single point surface area at p/p° = 0.041172496:	380.7785 m²/g
BET Surface Area:	385.9937 m²/g
t-Plot Micropore Area:	274.7432 m²/g
t-Plot external surface area:	111.2505 m²/g
BJH Adsorption cumulative surface area of pores between 2.0000 nm and 50.0000 nm width:	61.3847 m²/g
BJH Desorption cumulative surface area of pores between 2.0000 nm and 50.0000 nm width:	68.7845 m²/g

Pore Volume

t-Plot micropore volume:	0.110182 cm³/g
BJH Adsorption cumulative volume of pores between 2.0000 nm and 50.0000 nm width:	0.100431 cm³/g

BJH Desorption cumulative volume of pores
between 2.0000 nm and 50.0000 nm width: 0.090171 cm^3/g

Single point total pore volume at p/p° = 0.988749: 0.2021824 cm^3/g

Pore Size

Adsorption average pore diameter (4V/A by BET): 1.6617 nm

Desorption average pore diameter (4V/A by BET): 1.3371 nm

BJH Adsorption average pore width (4V/A): 3.3041 nm

BJH Desorption average pore width (4V/A): 2.8111 nm

Full Report Set
MicroActive 5.00

ASAP 2420 V2.09
Serial # 180 Unit 1 Port 5

Sample:	Hierarchical HZSM-5
Operator:	Lee
Submitter:	Suleiman
Bar Code:	
File:	D:\External Work\UoN\Sulie
Started:	11/03/2019 11:25:15
Completed:	12/03/2019 12:04:18
Report time:	12/03/2019 16:01:51
Sample mass:	0.2117 g
Analysis free space:	48.0529 cm^3
Low pressure dose:	None
Automatic degas:	Yes

Summary Report

Surface Area

Single point surface area at p/p° = 0.059908422:	413.7231 m^2/g
BET Surface Area:	416.8843 m^2/g
t-Plot Micropore Area:	275.6952 m^2/g
t-Plot external surface area:	141.1891 m^2/g
BJH Adsorption cumulative surface area of pores between 2.0000 nm and 150.0000 nm width:	55.5943 m^2/g
BJH Desorption cumulative surface area of pores between 2.0000 nm and 150.0000 nm width:	62.0682 m^2/g

Pore Volume

t-Plot micropore volume:	0.08637 cm^3/g
BJH Adsorption cumulative volume of pores between 2.0000 nm and 150.0000 nm width:	0.125464 cm^3/g

BJH Desorption cumulative volume of pores between 2.0000 nm and 150.0000 nm width:	0.101605 cm^3/g
Single point total pore volume at p/p° = 0.988749:	0.220537 cm^3/g
Pore Size	
Adsorption average pore diameter (4V/A by BET):	2.6513 nm
Desorption average pore diameter (4V/A by BET):	2.4181 nm
BJH Adsorption average pore width (4V/A):	5.10324 nm
BJH Desorption average pore width (4V/A):	5.4057 nm

Full Report Set
MicroActive 5.00

ASAP 2420 V2.09
Serial # 180 Unit 1 Pc

Sample:	Zn-Ni/ hierarchical HZS
Operator:	Lee
Submitter:	Suleiman
Bar Code:	
File:	D:\External Work\UoN\
Started:	11/03/2019 11:25:15
Completed:	12/03/2019 12:04:21
Report time:	12/03/2019 16:04:50
Sample mass:	0.2188 g
Analysis free space:	48.2968 cm^3
Low pressure dose:	None
Automatic degas:	Yes

Summary Report

Surface Area

Single point surface area at p/p° = 0.028621335:	383.4459 m^2/g
BET Surface Area:	386.5782 m^2/g
t-Plot Micropore Area:	250.6257 m^2/g
t-Plot external surface area:	135.9525 m^2/g
BJH Adsorption cumulative surface area of pores between 2.0000 nm and 150.0000 nm width:	62.1613 m^2/g
BJH Desorption cumulative surface area of pores between 2.0000 nm and 150.0000 nm width:	68.5690 m^2/g

Pore Volume

BJH Desorption cumulative volume of pores between 2.0000 nm and 150.0000 nm width:	0.103274 cm^3/g
Single point total pore volume at p/p° = 0.988749:	0.225278 cm^3/g
Pore Size	
Adsorption average pore diameter (4V/A by BET):	2.7162 nm
Desorption average pore diameter (4V/A by BET):	2.4529 nm
BJH Adsorption average pore width (4V/A):	5.0434 nm
BJH Desorption average pore width (4V/A):	5.9271 nm

Appendix C: GC/MS.

MULTI-USER SC. RES. LAB. ABUZ Library Search Report

Data Path : D:\MassHunter\GCMS\1\data\Sulaiman chem 2652019\
Data File : S3.D
Acq On : 27 May 2019 20:25
Operator : Multi-User Science Reasearch Laboratory
Sample : Sample Blank
Misc :
ALS Vial : 12 Sample Multiplier: 1

Search Libraries : D:\MassHunter\Library\NIST14.L Minimum Quality: 0

Unknown Spectrum : Apex
Integration Events : RTE Integrator - rteint.p

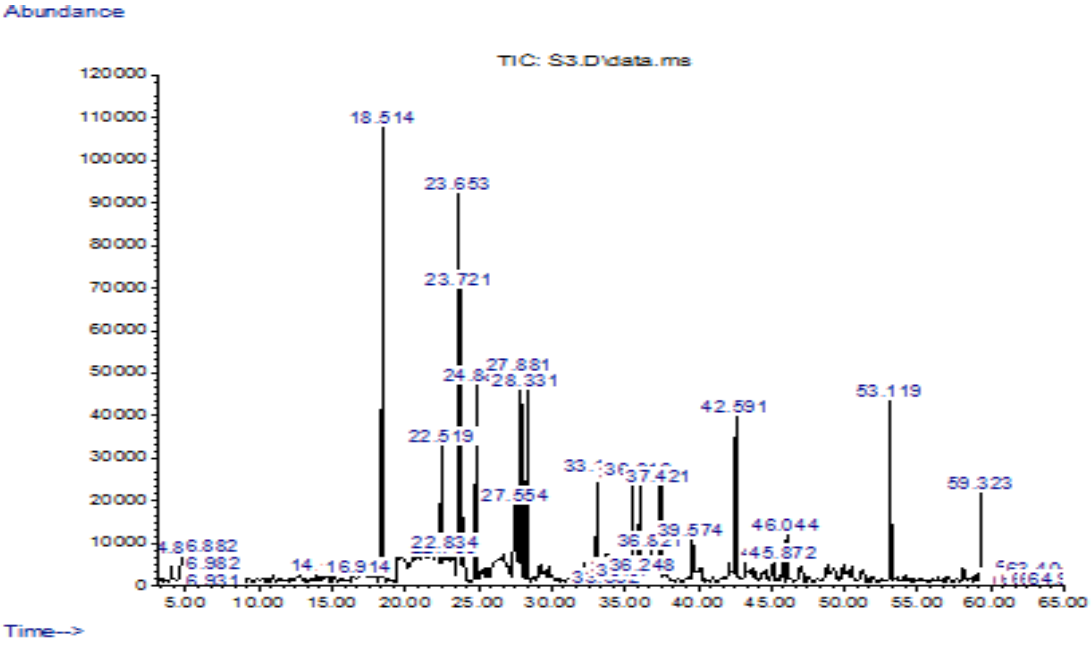
Pk#	RT	Area%	Library/ID	Ref#	CAS#	Qual
1	4.892	0.06	D:\MassHunter\Library\NIST14.L			
			Toluene	9475	000108-88-3	97
			Toluene	9473	000108-88-3	96
			Toluene	9472	000108-88-3	97
2	6.295	0.03	D:\MassHunter\Library\NIST14.L			
			p-Xylene	5160	000106-42-3	89
			p-Xylene	5162	000106-42-3	91
			Ethylbenzene	5172	000100-41-4	94
3	6.882	0.01	D:\MassHunter\Library\NIST14.L			
			1,3-dimethyl-Benzene	5186	000108-38-3	91
			1,3-dimethyl-Benzene	5187	000108-38-3	88
			p-Xylene	5160	000106-42-3	91
4	6.982	0.03	D:\MassHunter\Library\NIST14.L			
			o-Xylene	5166	000095-47-6	97
			o-Xylene	5163	000095-47-6	92
			o-Xylene	5162	000095-47-6	97
5	14.471	0.29	D:\MassHunter\Library\NIST14.L			
			1,7-dimethyl-Naphthalene	12197	000575-37-1	94
			Naphthalene	12108	000575-37-1	97
			1,7-dimethyl-Naphthalene	12193	000575-37-1	94
6	16.453	2.17	D:\MassHunter\Library\NIST14.L			
			1,2-dione-3-Methylcyclopentane	74550	1000411-55-2	74
			1-Hexadecanol	104433	036653-82-4	49
			1-Hexadecanol	104432	036653-82-4	49
7	16.914	0.16	D:\MassHunter\Library\NIST14.L			
			2-Cyclopenten-1-one,	74563	000080-71-7	74
			2-Cyclopenten-1-one,	74560	000080-71-7	74
			2-Cyclopenten-1-one,	74562	000080-71-7	74
8	18.514	10.14	D:\MassHunter\Library\NIST14.L			
			2-methoxy-Phenol	85893	00090-05-1	77
			2-methoxy-Phenol	85892	00090-05-1	73

			Hexadecane	89844	000544-76-3	75
9	22.519	3.27	D:\MassHunter\Library\NIST14.L			
			3,5-dimethyl-Phenol	85685	000108-68-9	83
			3,5-dimethyl-Phenol	85686	000108-68-9	85
			Naphthalene	12178	0091-20-3-9	83
10	22.736	0.29	D:\MassHunter\Library\NIST14.L			
			Naphthalene	12178	00091-20-3	85
			Naphthalene	12174	00091-20-3	84
			Naphthalene	12179	00091-20-3	85
11	22.834	0.28	D:\MassHunter\Library\NIST14.L			
			1-methylene-1H-Indene	22223	02471-84-3	88
			1-methylene-1H-Indene	22220	02471-84-3	83
			Nonadecane	128834	00629-92-5	97
12	23.653	9.96	D:\MassHunter\Library\NIST14.L	83224	00093-51-6	75
			2-methoxy-4-methyl-Phenol	83221	00093-51-6	75
			2-methoxy-4-methyl-Phenol	85892	00090-05-1	73
			2-methoxy-Phenol			
13	23.721	6.92	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
			2-Methoxy-5-methylphenol	85700	1195-09-1	70
			2-Methoxy-5-methylphenol	85701	1195-09-1	72
14	24.882	0.05	D:\MassHunter\Library\NIST14.L			
			1,2-dihydroxybenzene	81220	00120-80-9	67
			1,2-dihydroxybenzene	81222	00120-80-9	67
			Tritetracontane	273205	07098-21-7	63
15	27.554	0.12	D:\MassHunter\Library\NIST14.L			
			2-methyl-Naphthalene	12544	00091-57-6	65
			2-methyl-Naphthalene	12543	00091-57-6	62
			Carbonic acid eicosyl	219345	1000382-54-3	55
16	27.881	5.83	D:\MassHunter\Library\NIST14.L			
			4-ethyl-2-methoxy-Phenol	85340	2785-89-9	75
			4-ethyl-2-methoxy-Phenol	85342	2785-89-9	75
			4-ethyl-2-methoxy-Phenol	85343	2785-89-9	75
17	28.331	5.06	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
			2-Methoxy-4-vinylphenol	85231	7786-61-0	73
			2-Methoxy-4-vinylphenol	85232	7786-61-0	73
18	33.142	2.32	D:\MassHunter\Library\NIST14.L			
			Supraene	65623	7683-64-9	55
			1-Octadecene	113633	000112-88-9	52
			Carbonic acid hexadecyl prop-1-en -2-yl ester	184482	1000382-90-3	51
19	33.832	1.41	D:\MassHunter\Library\NIST14.L			
			Benzaldehyde,3-hydroxy-4-methoxy-	123236	0621-59-0	54
			Benzaldehyde,3-hydroxy-4-methoxy-	123235	0621-59-0	54
			Benzaldehyde,3-hydroxy-4-methoxy-	123232	0621-59-0	54

20	34.972	0.46	D:\MassHunter\Library\NIST14.L			
			Trans-Isoeugenol	39841	5932-68-3	43
			Trans-Isoeugenol	39840	5932-68-3	43
			Isoeugenol	39810	5932-68-3	43
21	35.07	0.24	D:\MassHunter\Library\NIST14.L			
			Eugenol	39242	1000282-78-3	33
			Eugenol	39241	1000282-78-3	33
			Eugenol	39240	1000282-78-3	33
22	35.551	2.37	D:\MassHunter\Library\NIST14.L			
			Phenol,2-methoxy-4-(1-propenyl)-	85721	0097-54-1	28
			Phenol,2-methoxy-4-(1-propenyl)-	85722	0097-54-1	28
			Phenol,2-methoxy-4-(1-propenyl)-	85722	0097-54-1	28
23	36.013	2.52	D:\MassHunter\Library\NIST14.L			
			Benzenepropanol,4-hydroxy-3-methoxy	3912	2305-13-7	53
			Benzenepropanol,4-hydroxy-3-methoxy	3910	2305-13-7	53
			Benzenepropanol,4-hydroxy-3-methoxy	3915	2305-13-7	53
24	36.248	0.73	D:\MassHunter\Library\NIST14.L			
			Ethanone,1-(3-hydroxy-4-methoxyphenyl	74230	6100-74-9	50
			Ethanone,1-(3-hydroxy-4-methoxypheny	174232	6100-74-9	50
			Ethanone,1-(3-hydroxy-4-methoxyphenyl	74235	6100-74-9	50
25	36.821	2.04	D:\MassHunter\Library\NIST14.L			
			2,4-Di-tert-butylphenol	82342	0096-76-4	25
			2,4-Di-tert-butylphenol	82341	0096-76-4	25
			2,4-Di-tert-butylphenol	82340	0096-76-4	25
26	37.421	2.05	D:\MassHunter\Library\NIST14.L			
			3-Allyl-6-methoxyphenol	82455	0501-19-9	43
			3-Allyl-6-methoxyphenol	82453	0501-19-9	43
			3-Allyl-6-methoxyphenol	82452	0501-19-9	43
27	39.574	0.88	D:\MassHunter\Library\NIST14.L			
			4-(1-Hydroxyallyl)-2-methoxyphenol	82375	112465-50-6	38
			4-(1-Hydroxyallyl)-2-methoxyphenol	82372	112465-50-6	38
			4-(1-Hydroxyallyl)-2-methoxyphenol	82370	112465-50-6	38
28	42.591	5.39	D:\MassHunter\Library\NIST14.L			
			Apocynin	15622	0498-02-2	47
			Apocynin	15623	0498-02-2	47
			Apocynin	15621	0498-02-2	47
29	45.234	0.92	D:\MassHunter\Library\NIST4.L			
			4-Hydroxy-2-methoxycinnamaldehyde	13235	127321-19-1	37
			4-Hydroxy-2-methoxycinnamaldehyde	13234	127321-19-1	37
			4-Hydroxy-2-methoxycinnamaldehyde	13232	127321-19-1	37
30	45.872	0.91	D:\MassHunter\Library\NIST14.L			
			(E)-4-(3-Hydroxyprop-1-en-1-yl)-2-methoxyphenol	83400	32811-40-8	42
			(E)-4-(3-Hydroxyprop-1-en-1-yl)-2-methoxyphenol	83400	32811-40-8	42
			(E)-4-(3-Hydroxyprop-1-en-1-yl)-2-methoxyphenol	83400	32811-40-8	42
31	46.044	1.37	D:\MassHunter\Library\NIST14.L			

			Coniferyl aldehyde	77201	0458-36-6	50
			Coniferyl aldehyde	77201	0458-36-6	50
			Coniferyl aldehyde	77201	0458-36-6	50
32	53.119	5.63	D:\MassHunter\Library\NIST14.L			
			n-Hexadecanoic acid	72134	0057-10-3	43
			n-Hexadecanoic acid	72134	0057-10-3	43
			n-Hexadecanoic acid	72134	0057-10-3	43
33	59.323	2.25	D:\MassHunter\Library\NIST14.L			
			4,4'-(1-methylethylidene)bis-Phenol	84552	0080-05-7	38
			4,4' -(1-methylethylidene)bis-Phenol	84552	0080-05-7	38
			4,4' -(1-methylethylidene)bis-Phenol	84552	0080-05-7	38
34	61.793	0.78	D:\MassHunter\Library\NIST14.L			
			Nerolidol	85685	000142-50-7	42
			Nerolidol	85685	000142-50-7	42
			Nerolidol	85685	000142-50-7	42
35	61.852	1.74	D:\MassHunter\Library\NIST14.L			
			2-Methyl-3-methyl-but-2-enyl oxetane	85794	000144-10-2	50
			2-Methyl-3-methyl-but-2-enyl oxetane	85794	000144-10-2	50
			2-Methyl-3-methyl-but-2-enyl oxetane	85794	000144-10-2	50
36	61.919	1.73	D:\MassHunter\Library\NIST14.L			
			2-methyl-3-Penten-1-ol	3939	062238-37-3	35
			2-methyl-3-Penten-1-ol	3939	062238-37-3	35
			2-methyl-3-Penten-1-ol	3939	062238-37-3	35
37	61.953	1.59	D:\MassHunter\Library\NIST14.L			
			1-Methylene-3-dimethylcyclohexane	85817	1000144-10-6	53
			1-Methylene-3-dimethylcyclohexane	85817	1000144-10-6	53
			1-Methylene-3-dimethylcyclohexane	85817	1000144-10-6	53
38	62.180	0.55	D:\MassHunter\Library\NIST14.L			
			2,6,10-Dodecatrien-1-ol	85761	003790-71-4	28
			2,6,10-Dodecatrien-1-ol	85761	003790-71-4	28
			2,6,10-Dodecatrien-1-ol	85761	003790-71-4	28
39	62.381	0.23	D:\MassHunter\Library\NIST14.L			
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	25
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	25
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	25
40	62.53	0.90	D:\MassHunter\Library\NIST14.L			
			Cyclopropanecarboxylic acid	82450	0501-19-9	43
			Cyclopropanecarboxylic acid	82450	0501-19-9	43
			Cyclopropanecarboxylic acid	82450	0501-19-9	43
41	62.649	0.10	D:\MassHunter\Library\NIST14.L			
			2-Oxabicyclo	72553	122723-58-4	38
			2-Oxabicyclo	72553	122723-58-4	38
			2-Oxabicyclo	72553	122723-58-4	38
42	62.83	0.50	D:\MassHunter\Library\NIST14.L			
			Bicyclo[3.1.1]heptan-3-one	72668	1000163-96-5	47
			Bicyclo[3.1.1]heptan-3-one	72668	1000163-96-5	47

			Bicyclo[3.1.1]heptan-3-one	72668	1000163-96-5	47
43	63.07	0.33	D:\MassHunter\Library\NIST4.L			
			Cyclopropanecarboxylic acid	111703	1000282-78-3	37
			Cyclopropanecarboxylic acid	111703	1000282-78-3	37
			Cyclopropanecarboxylic acid	111703	1000282-78-3	37
44	63.08	0.81	D:\MassHunter\Library\NIST14.L			
			Podocarpa-6,13-diene, 13-isopropyl-	85788	5939-62-8	42
			Podocarpa-6,13-diene, 13-isopropyl-	85788	5939-62-8	42
			Podocarpa-6,13-diene, 13-isopropyl-	85788	5939-62-8	42
45	63.40	0.01	D:\MassHunter\Library\NIST14.L			
			1-Bromo-pentyl-cyclopropane	56420	088106-30-3	30
			Cyclopropane	56441	088106-30-3	33
			1-Bromo-pentyl-cyclopropane	56420	088106-30-3	30
46	63.69	1.28	D:\MassHunter\Library\NIST14.L			
			1,3-Trimethyl-2-hydroxymethylcyclohexene	85818	1000144-10-7	43
			1,3-Trimethyl-2-hydroxymethylcyclohexene	85818	1000144-10-7	43
			1,3-Trimethyl-2-hydroxymethylcyclohexene	85818	1000144-10-7	43
47	63.749	0.77	D:\MassHunter\Library\NIST14.L			
			1-Methylene cyclohexane		1000144-10-6	38
			1-Methylenecyclohexane		1000144-10-6	35
			Cyclohexane		1000144-10-6	33
48	64.29	0.93	D:\MassHunter\Library\NIST14.L			
			2,6,10-Dodecatrien-1-ol	85762	003790-71-4	42
			2,6,10-Dodecatrien-1-ol	85762	003790-71-4	42
			2,6,10-Dodecatrien-1-ol	85762	003790-71-4	42
49	64.52	1.25	D:\MassHunter\Library\NIST14.L			
			1-Formyl-2,2-dimethylcyclohexane		1000144-10-0	50
			1-Formyl-2,2-dimethylcyclohexane		1000144-10-0	50
			1-Formyl-2,2-dimethylcyclohexane		1000144-10-0	50
50	64.90	1.51	D:\MassHunter\Library\NIST14.L			
			Cyclohexane,4-ethyl-, trans-	72753	054934-94-0	35
			Cyclohexane, 4-ethyl-, trans-	72753	054934-94-0	35
			Cyclohexane, 4-ethyl-, trans-	72753	054934-94-0	35


Abundance
TIC: S3.D\data.ms
18.514
23.653
23.721
27.881
28.331
42.591
53.119
59.323
22.519
27.554
37.421
39.574
46.044
45.872
36.248
4.886
6.982
14.
16.914
22.834
Time-->

MULTI-USER SC. RES. LAB. ABUZ Library Search Report

Data Path : D:\MassHunter\GCMS\1\data\Sulaiman chem 2652019\
Data File : S4.D
Acq On : 27 May 2019 20:25
Operator : Multi-User Science Reasearch Laboratory
Sample : Sample Dolomite
Misc :
ALS Vial : 12 Sample Multiplier: 1

Search Libraries: D:\MassHunter\Library\NIST14.L Minimum Quality: 0

Unknown Spectrum : Apex
Integration Events : RTE Integrator - rteint.p

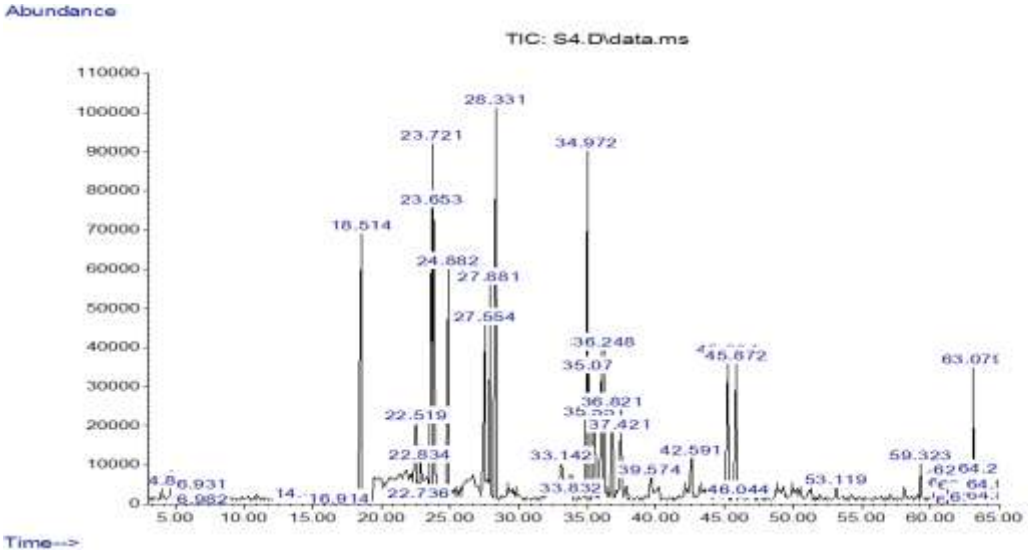
Pk#	RT	Area%	Library/ID	Ref#	CAS#	Qual
1	4.892	0.06	D:\MassHunter\Library\NIST14.L	9475	000108-88-3	97
			Toluene	9475	000108-88-3	97
			Toluene	9475	000108-88-3	97
			Toluene			
2	6.295	0.02	D:\MassHunter\Library\NIST14.L			
			p-Xylene	5160	000106-42-3	91
			p-Xylene	5160	000106-42-3	91
			Ethylbenzene	5172	000100-41-4	91
3	6.882	0.06	D:\MassHunter\Library\NIST14.L			
			Benzene,1,3-dimethyl-	5186	000108-38-3	91
			Benzene,1,3-dimethyl-	5186	000108-38-3	91
			p-Xylene	5160	000106-42-3	91
4	6.982	0.01	D:\MassHunter\Library\NIST14.L			
			o-Xylene	5166	000095-47-6	97
			o-Xylene	5166	000095-47-6	97
			o-Xylene	5166	000095-47-6	97
5	14.471	4.02	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			2-Tridecene, (Z)-	49690	041446-59-7	86
6	16.453	0.18	D:\MassHunter\Library\NIST14.L			
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
			1-Hexadecanol	104433	036653-82-4	71
7	16.914	0.15	D:\MassHunter\Library\NIST14.L			
			2-Cyclopenten-1-one,	74560	000080-71-7	74
			2-Cyclopenten-1-one,	74560	000080-71-7	74
			2-Cyclopenten-1-one,	74560	000080-71-7	74
8	18.514	4.91	D:\MassHunter\Library\NIST14.L			
			Phenol, 2-methoxy-	85892	00090-05-1	77

			Phenol, 2-methoxy-	85892	00090-05-1	77
			Hexadecane	89842	00544-76-3	76
9	22.519	2.29	D:\MassHunter\Library\NIST14.L			
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
			Phenol,3,5-dimethyl-	85685	000108-68-9	85
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
10	22.736	0.29	D:\MassHunter\Library\NIST14.L			
			Naphthalene	12178	00091-20-3	85
			Naphthalene	12178	00091-20-3	88
			Naphthalene	12178	00091-20-3	85
11	22.834	0.28	D:\MassHunter\Library\NIST14.L			
			1H-Indene,1-methylene-	22223	02471-84-3	88
			1H-Indene,1-methylene-	22223	02471-84-3	87
			1H-Indene,1-methylene-	22223	02471-84-3	88
12	23.653	8.94	D:\MassHunter\Library\NIST14.L			
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	74
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	72
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
13	23.721	8.44	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-5-methylphenol	85703	1195-09-1	70
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
			2-Methoxy-5-methylphenol	85703	1195-09-1	71
14	24.882	0.05	D:\MassHunter\Library\NIST14.L			
			1,2-dihydroxybenzene	81220	00120-80-9	67
			1,2-dihydroxybenzene	81220	00120-80-9	65
			1,2-dihydroxybenzene	81220	00120-80-9	63
15	27.554	2.12	D:\MassHunter\Library\NIST14.L			
			Naphthalene,2-methyl-	12543	00091-57-6	63
			Naphthalene,2-methyl-	12543	00091-57-6	65
			Naphthalene,2-methyl-	12543	00091-57-6	62
16	27.881	5.88	D:\MassHunter\Library\NIST14.L			
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75
17	28.331	10.35	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
18	33.142	1.25	D:\MassHunter\Library\NIST14.L			
			Supraene	65623	7683-64-9	55
			Phenanthrene	46274	6885-01-8	45
			Diphenylacetylene	46283	000501-65-5	48
19	33.832	0.41	D:\MassHunter\Library\NIST14.L			
			Benzaldehyde,3-hydroxy-4-methoxy-	123232	0621-59-0	54
			Benzaldehyde,3-hydroxy-4-methoxy-	123232	0621-59-0	54
			Benzaldehyde,3-hydroxy-4-methoxy-	123232	0621-59-0	54

20	34.972	8.42	D:\MassHunter\Library\NIST14.L			
			Trans-Isoeugenol	39840	5932-68-3	43
			Trans-Isoeugenol	39840	5932-68-3	43
			Isoeugenol	39780	5932-68-3	42
21	35.07	3.55	D:\MassHunter\Library\NIST14.L			
			Eugenol	39240	1000282-78-3	33
			Eugenol	39240	1000282-78-3	33
			Eugenol	39240	1000282-78-3	33
22	35.551	2.37	D:\MassHunter\Library\NIST14.L			
			Phenol,2-methoxy-4-(1-propenyl)-	85720	0097-54-1	28
			Phenol,2-methoxy-4-(1-propenyl)-	85720	0097-54-1	28
			Phenol,2-methoxy-4-(1-propenyl)-	85720	0097-54-1	28
23	36.013	1.13	D:\MassHunter\Library\NIST14.L			
			Benzenepropanol,4-hydroxy-3-methoxy	3910	2305-13-7	53
			Benzenepropanol,4-hydroxy-3-methoxy	3910	2305-13-7	52
			Benzenepropanol,4-hydroxy-3-methoxy	3910	2305-13-7	51
24	36.248	2.11	D:\MassHunter\Library\NIST14.L			
			Ethanone,1-(3-hydroxy-4-methoxyphenyl)	74232	6100-74-9	50
			Ethanone,1-(3-hydroxy-4-methoxyphenyl)	74232	6100-74-9	50
			Ethanone,1-(3-hydroxy-4-methoxyphenyl)	74232	6100-74-9	50
25	36.821	1.04	D:\MassHunter\Library\NIST14.L			
			2,4-Di-tert-butylphenol			
			2,4-Di-tert-butylphenol	82340	0096-76-4	25
			2,4-Di-tert-butylphenol	82340	0096-76-4	25
				82340	0096-76-4	25
26	37.421	2.05	D:\MassHunter\Library\NIST14.L			
			3-Allyl-6-methoxyphenol	82450	0501-19-9	43
			3-Allyl-6-methoxyphenol	82450	0501-19-9	43
			3-Allyl-6-methoxyphenol	82450	0501-19-9	43
27	39.574	0.88	D:\MassHunter\Library\NIST14.L			
			4-(1-Hydroxyallyl)-2-methoxyphenol	82370	112465-50-6	38
			4-(1-Hydroxyallyl)-2-methoxyphenol	82370	112465-50-6	38
			4-(1-Hydroxyallyl)-2-methoxyphenol	82370	112465-50-6	38
28	42.591	2.81	D:\MassHunter\Library\NIST14.L			
			Apocynin	15621	0498-02-2	47
			Apocynin	15621	0498-02-2	47
			Apocynin	15621	0498-02-2	47
29	45.234	1.97	D:\MassHunter\Library\NIST4.L			
			4-Hydroxy-2-methoxycinnamaldehyde	13236	127321-19-1	37
			4-Hydroxy-2-methoxycinnamaldehyde	13236	127321-19-1	37
			4-Hydroxy-2-methoxycinnamaldehyde	13236	127321-19-1	37
30	45.872	3.81	D:\MassHunter\Library\NIST14.L			
			(E)-4-(3-Hydroxyprop-1-en-1-yl)-2-methoxyphenol	83400	32811-40-8	42
			(E)-4-(3-Hydroxyprop-1-en-1-yl)-2-methoxyphenol	83400	32811-40-8	42
			(E)-4-(3-Hydroxyprop-1-en-1-yl)-2-methoxyphenol	83400	32811-40-8	42
31	46.044	0.37	D:\MassHunter\Library\NIST14.L			

			Coniferyl aldehyde	77201	0458-36-6	50
			Coniferyl aldehyde	77201	0458-36-6	50
			Coniferyl aldehyde	77201	0458-36-6	50
32	53.119	3.12	D:\MassHunter\Library\NIST14.L			
			n-Hexadecanoic acid	72134	0057-10-3	43
			n-Hexadecanoic acid	72134	0057-10-3	43
			n-Hexadecanoic acid	72134	0057-10-3	43
33	59.323	1.25	D:\MassHunter\Library\NIST14.L			
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
34	61.793	0.78	D:\MassHunter\Library\NIST14.L			
			Nerolidol	85685	000142-50-7	42
			Nerolidol	85685	000142-50-7	42
			Nerolidol	85685	000142-50-7	42
35	61.852	0.74	D:\MassHunter\Library\NIST14.L			
			2-Methyl-3-methyl-but-2-enyl oxetane	85794	1000144-10-2	50
			2-Methyl-3-methyl-but-2-enyl oxetane	85794	1000144-10-2	50
			2-Methyl-3-methyl-but-2-enyl oxetane	85794	1000144-10-2	50
36	61.919	0.73	D:\MassHunter\Library\NIST14.L			
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	35
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	35
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	35
37	61.953	0.59	D:\MassHunter\Library\NIST14.L			
			1-Methylene-hydroxymethylcyclohexane	85817	1000144-10-6	53
			1-Methylene-hydroxymethylcyclohexane	85817	1000144-10-6	53
			1-Methylene-hydroxymethylcyclohexane	85817	1000144-10-6	53
38	62.180	0.55	D:\MassHunter\Library\NIST14.L			
			2,6,10-Dodecatrien-1-ol,	85761	003790-71-4	28
			2,6,10-Dodecatrien-1-ol,	85761	003790-71-4	28
			2,6,10-Dodecatrien-1-ol,	85761	003790-71-4	28
39	62.381	0.23	D:\MassHunter\Library\NIST14.L			
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	25
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	25
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	25
40	62.53	0.90	D:\MassHunter\Library\NIST14.L			
			Cyclopropanecarboxylic acid	82450	0501-19-9	43
			Cyclopropanecarboxylic acid	82450	0501-19-9	41
			Cyclopropanecarboxylic acid	82450	0501-19-9	42
41	62.649	0.10	D:\MassHunter\Library\NIST14.L			
			2-Oxabicyclo[4.4.0]	72553	122723-58-4	38
			2-Oxabicyclo[4.4.0]	72553	122723-58-4	38
			2-Oxabicyclo[4.4.0]	72553	122723-58-4	37
42	62.83	0.50	D:\MassHunter\Library\NIST14.L			
			Bicyclo[3.1.1]	72668	1000163-96-5	47

			Bicyclo[3.1.1]	72668	1000163-96-5	46
			Bicyclo[3.1.1]	72668	1000163-96-5	47
43	63.07	0.33	D:\MassHunter\Library\NIST4.L			
			Cyclopropanecarboxylic acid	111703	1000282-78-3	36
			Cyclopropanecarboxylic acid	111703	1000282-78-3	35
			Cyclopropanecarboxylic acid	111703	1000282-78-3	37
44	63.08	3.72	D:\MassHunter\Library\NIST14.L			
			Podocarpa-6,13-diene, 13-isopropyl-	85788	5939-62-8	42
			Podocarpa-6,13-diene, 13-isopropyl-	85788	5939-62-8	41
			Podocarpa-6,13-diene, 13-isopropyl-	85788	5939-62-8	42
45	63.40	0.01	D:\MassHunter\Library\NIST14.L			
			(1-Bromo-pentyl)-cyclopropane	56420	088106-30-3	30
			(1-Bromo-pentyl)-cyclopropane	56420	088106-30-3	33
			(1-Bromo-pentyl)-cyclopropane	56420	088106-30-3	30
46	63.69	0.28	D:\MassHunter\Library\NIST14.L			
			1,3,3-Trimethyl-2- cyclohexene	85818	1000144-10-7	43
			1,3,3-Trimethyl-2- cyclohexene	85818	1000144-10-7	43
			1,3,3-Trimethyl-2- cyclohexene	85818	1000144-10-7	43
47	63.749	0.19	D:\MassHunter\Library\NIST14.L			
			1-Methylene-cyclohexane	89066	1000144-10-6	38
			1-Methylene-cyclohexane	89066	1000144-10-6	36
			cyclohexane	89066	1000154-10-6	38
48	64.29	0.93	D:\MassHunter\Library\NIST14.L			
			2,6,10-Dodecatrien-1-ol (Z,E)-	85762	003790-71-4	42
			2,6,10-Dodecatrien-1-ol (Z,E)-	85762	003790-71-4	42
			2,6,10-Dodecatrien-1-ol (Z,E)-	85762	003790-71-4	42
49	64.52	0.25	D:\MassHunter\Library\NIST14.L			
			1-Formyl-2-cis-cyclohexane		1000144-10-0	50
			1-Formyl-2-ciscyclohexane		1000144-10-0	50
			cyclohexane	89066	1000154-10-6	42
50	64.90	0.51	D:\MassHunter\Library\NIST14.L			
			Cyclohexane-4-ethyl-, trans-	72753	054934-94-0	35
			Cyclohexane-4-ethyl-, trans-	72753	054934-94-0	35
			Cyclohexane-4-ethyl-, trans-	72753	054934-94-0	35


Abundance
TIC: S4.D\data.ms
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
28.331
23.721
34.972
23.653
18.514
24.882
27.881
27.554
36.248
35.07
45.672
83.071
36.821
35.251
37.421
22.519
22.834
33.142
42.591
39.574
59.323
64.2
53.119
4.8
6.931
6.982
14.
16.814
22.738
33.832
46.044
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
Time-->

MULTI-USER SC. RES. LAB. ABUZ Library Search Report

Data Path : D:\MassHunter\GCMS\1\data\Sulaiman chem 2652019\
Data File : S5.D
Acq On : 27 May 2019 20:25
Operator : Multi-User Science Research Laboratory
Sample : Sample 0.5H
Misc :
ALS Vial : 12 Sample Multiplier: 1

Search Libraries: D:\MassHunter\Library\NIST14.L Minimum Quality: 0

Unknown Spectrum: Apex
Integration Events: RTE Integrator - rteint.p

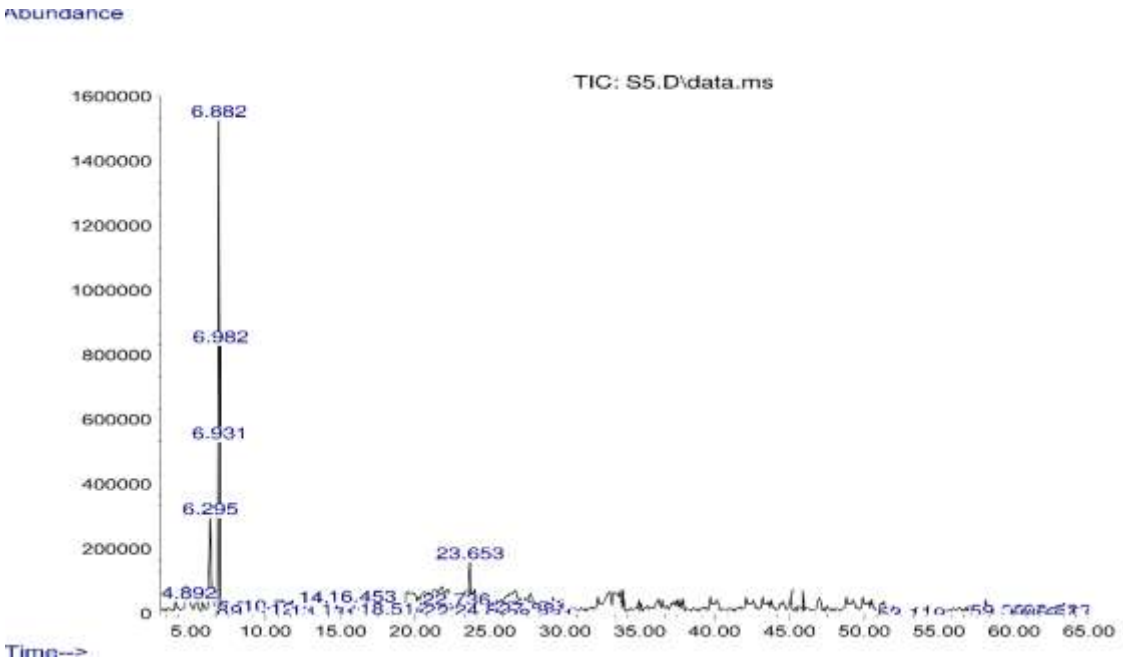
Pk#	RT	Area%	Library/ID	Ref#	CAS#	Qual
1	4.892	3.82	D:\MassHunter\Library\NIST14.L			
			Toluene	9475	000108-88-3	97
			Toluene	9475	000108-88-3	97
			Toluene	9475	000108-88-3	97
2	6.295	2.28	D:\MassHunter\Library\NIST14.L			
			Ethylbenzene	5172	000100-41-4	94
			Ethylbenzene	5172	000100-41-4	94
			Benzene, 1,3-dimethyl-	5187	000108-38-3	95
3	6.882	11.58	D:\MassHunter\Library\NIST14.L			
			p-Xylene	5160	000106-42-3	91
			p-Xylene	5160	000106-42-3	91
			o-Xylene	5160	000095-47-6	90
4	6.931	2.63	D:\MassHunter\Library\NIST14.L			
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
5	6.982	5.60	D:\MassHunter\Library\NIST14.L			
			o-Xylene	5166	000095-47-6	97
			o-Xylene	5166	000095-47-6	97
			Benzene, 1,2,3-trimethy	5166	000095-47-6	94
6	8.25	2.65	D:\MassHunter\Library\NIST14.L			
			Benzene,propyl-	9580	000103-65-1	90
			Benzene,propyl-	9580	000103-65-1	90
			Benzene,propyl-	9580	000103-65-1	90
7	8.426	1.63	D:\MassHunter\Library\NIST14.L			
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
			Benzene, 1-ethyl-2-methyl-	9606	000611-14-3	93
8	8.568	1.57	D:\MassHunter\Library\NIST14.L			
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97

			Benzene, (1-methylethyl)-	9591	000098-82-8	76
9	9.08	1.34	D:\MassHunter\Library\NIST14.L			
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
			Benzene,1,2,3-trimethyl-	9601	000095-63-6	95
10	10.095	1.17	D:\MassHunter\Library\NIST14.L			
			Indene	8563	000095-13-6	93
			Indene	8563	000095-13-6	93
			Indene	8563	000095-13-6	93
11	10.263	1.69	D:\MassHunter\Library\NIST14.L			
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
			Benzene,1-methyl-2-propyl-	15193	001074-55-1	82
12	10.716	2.83	D:\MassHunter\Library\NIST14.L			
			o-Cymene	15144	000527-84-4	97
			-Cymene	15144	000527-84-4	97
			Benzene, 2-ethyl-1,4-dimethyl-	15225	001758-88-9	70
13	11.831	1.76	D:\MassHunter\Library\NIST14.L			
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
			1H-Indene,2,3-dihydro-5-methyl-	14390	000874-35-1	93
			1H-Indene,2,3-dihydro-5-methyl-	14395	000874-35-1	93
14	12.234	1.22	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
			1H-Indene, 1-methyl-	13387	000767-59-9	96
15	12.577	1.96	D:\MassHunter\Library\NIST14.L			
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
16	13.887	1.30	D:\MassHunter\Library\NIST14.L			
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
			1H Indene,4,7-dimethyl-	20943	006974-97-6	91
			1H-Indene, 1-methylene-	12199	002471-84-3	94
17	14.471	2.51	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
18	15.967	1.96	D:\MassHunter\Library\NIST14.L			
			Naphthalene,2-ethyl-	29399	000939-27-5	91
			Naphthalene, 1-methyl-	19724	000090-12-0	96
			Naphthalene,2-ethyl-	29399	000939-27-5	91
19	16.453	0.20	D:\MassHunter\Library\NIST14.L			
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74

			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
20	16.914	0.20	D:\MassHunter\Library\NIST14.L			
			2-Cyclopenten-1-one,	74560	000080-71-7	74
			2-Cyclopenten-1-one,	74560	000080-71-7	74
			2-Cyclopenten-1-one,	74560	000080-71-7	74
21	17.536	0.33	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
			Dodecane	39972	000112-40-3	42
22	18.514	1.94	D:\MassHunter\Library\NIST14.L			
			Phenol, 2-methoxy-	85892	00090-05-1	77
			Phenol, 2-methoxy-	85892	00090-05-1	77
			Phenol, 2-methoxy-	85892	00090-05-1	74
23	22.519	0.49	D:\MassHunter\Library\NIST14.L			
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
24	22.736	0.83	D:\MassHunter\Library\NIST14.L			
			Naphthalene	12178	00091-20-3	85
			Naphthalene	12178	00091-20-3	85
			Naphthalene	12178	00091-20-3	85
25	22.834	1.50	D:\MassHunter\Library\NIST14.L			
			1H-Indene,1-methylene-	22223	02471-84-3	88
			1H-Indene,1-methylene-	22223	02471-84-3	88
			1H-Indene,1-methylene-	22223	02471-84-3	88
26	23.653	3.09	D:\MassHunter\Library\NIST14.L			
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	75
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	75
27	23.721	1.01	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
28	24.882	1.57	D:\MassHunter\Library\NIST14.L			
			1,2-dihydroxybenzene	81220	00120-80-9	67
			1,2-dihydroxybenzene	81220	00120-80-9	63
			Heneicosane	155887	000629-94-7	96
29	27.554	2.68	D:\MassHunter\Library\NIST14.L			
			Naphthalene,2-methyl-	12543	00091-57-6	65
			Naphthalene,2-methyl-	12543	00091-57-6	62
			Naphthalene,2-methyl-	12543	00091-57-6	61
30	27.881	1.92	D:\MassHunter\Library\NIST14.L			
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	73
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75

31	28.331	0.19	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-4-vinylphenol	85233	7786-61-0	70
			2-Methoxy-4-vinylphenol	85233	7786-61-0	71
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
32	53.119	0.50	D:\MassHunter\Library\NIST14.L			
			n-Hexadecanoic acid	72134	0057-10-3	43
			n-Hexadecanoic acid	72134	0057-10-3	43
			Carbonic acid octadecyl prop-1-en -2-yl ester	209053	1000383-11-5	91
33	59.323	1.32	D:\MassHunter\Library\NIST14.L			
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
34	61.794	0.77	D:\MassHunter\Library\NIST14.L			
			Nerolidol	85685	000142-50-7	43
			Nerolidol	85685	000142-50-7	43
			Nerolidol	85685	000142-50-7	43
35	61.853	0.73	D:\MassHunter\Library\NIST14.L			
			2-Methyl-3-oxetane	85794	1000144-10-2	44
			2-Methyl-3-oxetane	85794	1000144-10-2	44
			Carbonic acid eicosyl vinyl ester	219345	1000382-54-3	41
36	61.920	0.55	D:\MassHunter\Library\NIST14.L			
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	42
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	42
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	40
37	61.953	0.92	D:\MassHunter\Library\NIST14.L			
			1-Methylene-cyclohexane	85817	1000144-10-6	53
			1-Methylene-cyclohexane	85817	1000144-10-6	53
			1-Methylene-cyclohexane	85817	1000144-10-6	53
38	62.180	0.73	D:\MassHunter\Library\NIST14.L			
			2,6,10-Dodecatrien-1-ol, (Z,E)-	85761	003790-71-4	28
			2,6,10-Dodecatrien-1-ol, (Z,E)-	85761	003790-71-4	27
			2,6,10-Dodecatrien-1-ol, (Z,E)-	85761	003790-71-4	25
39	62.381	0.24	D:\MassHunter\Library\NIST14.L			
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	25
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	25
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	25
40	62.53	0.40	D:\MassHunter\Library\NIST14.L			
			Cyclopropanecarboxylic acid	82450	0501-19-9	43
			Cyclopropanecarboxylic acid	82450	0501-19-9	43
			Cyclopropanecarboxylic acid	82450	0501-19-9	43
41	62.649	0.52	D:\MassHunter\Library\NIST14.L			
			2-Oxabicyclo[4.4.0]	72553	122723-58-4	39
			2-Oxabicyclo[4.4.0]	72553	122723-58-4	37
			2-Oxabicyclo[4.4.0]	72553	122723-58-4	35
42	62.83	1.36	D:\MassHunter\Library\NIST14.L			
			Bicyclo[3.1.1]heptan-3-one	72668	1000163-96-5	47
			Bicyclo[3.1.1]heptan-3-one	72668	1000163-96-5	47

			Bicyclo[3.1.1]heptan-3-one	72668	1000163-96-5	47
43	63.07	0.64	D:\MassHunter\Library\NIST4.L			
			Cyclopropanecarboxylic acid	111703	1000282-78-3	37
			Cyclopropanecarboxylic acid	111703	1000282-78-3	35
			Cyclopropanecarboxylic acid	111703	1000282-78-3	33
44	63.08	0.27	D:\MassHunter\Library\NIST14.L			
			Podocarpa-6,13-diene, 13-isopropyl-	85788	5939-62-8	41
			Podocarpa-6,13-diene, 13-isopropyl-	85788	5939-62-8	40
			Podocarpa-6,13-diene, 13-isopropyl-	85788	5939-62-8	37
45	63.40	0.47	D:\MassHunter\Library\NIST14.L			
			(1-Bromo-pentyl)-cyclopropane	56420	088106-30-3	30
			(1-Bromo-pentyl)-cyclopropane	56420	088106-30-3	30
			(1-Bromo-pentyl)-cyclopropane	56420	088106-30-3	30
46	63.69	0.38	D:\MassHunter\Library\NIST14.L			
			1,3,3-Trimethy -cyclohexene	85818	1000144-10-7	43
			1,3,4-Trimethy -cyclohexene	85818	1000164-10-7	43
			1,3,3-Trimethy -cyclohexene	85818	1000144-10-7	41
47	63.749	0.72	D:\MassHunter\Library\NIST14.L			
			1-Methylene-cyclohexane	82316	1000144-10-6	38
			1-Methylene-cyclohexane	82316	1000144-10-6	38
			1-Methylene-cyclohexane	82316	1000144-10-6	38
48	64.29	0.37	D:\MassHunter\Library\NIST14.L			
			2,6,10-Dodecatrien-1-ol (Z,E)-	85762	003790-71-4	42
			2,6,10-Dodecatrien-1-ol (Z,E)-	85762	003790-71-4	42
			2,6,10-Dodecatrien-1-ol (Z,E)-	85762	003790-71-4	40
49	64.52	0.39	D:\MassHunter\Library\NIST14.L			
			1-Formyl-2-dimethyl-2-cis-cyclohexane	82311	000144-10-0	52
			1-Formyl-2-dimethyl-2-cis-cyclohexane	82311	000144-10-0	50
			1-Formyl-3-dimethyl-3-cis-cyclohexane	82311	000144-10-0	50
50	64.90	0.29	D:\MassHunter\Library\NIST14.L			
			Cyclohexane-4-ethyl- trans-	72753	054934-94-0	37
			Cyclohexane-4-ethyl- trans-	72753	054934-94-0	35
			Cyclohexane-4-ethyl- trans-	72753	054934-94-0	33


Abundance
TIC: S5.D\data.ms
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
6.882
6.982
6.931
6.295
23.653
4.892
14.16.453
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
Time-->

MULTI-USER SC. RES. LAB. ABUZ Library Search Report

Data Path : D:\MassHunter\GCMS\1\data\Sulaiman chem 2652019\
Data File : S6.D
Acq On : 27 May 2019 20:25
Operator : Multi-User Science Reasearch Laboratory
Sample : Sample 1 H
Misc :
ALS Vial : 12 Sample Multiplier: 1

Search Libraries: D:\MassHunter\Library\NIST14.L Minimum Quality: 0

Unknown Spectrum: Apex

Integration Events: RTE Integrator - rteint.p

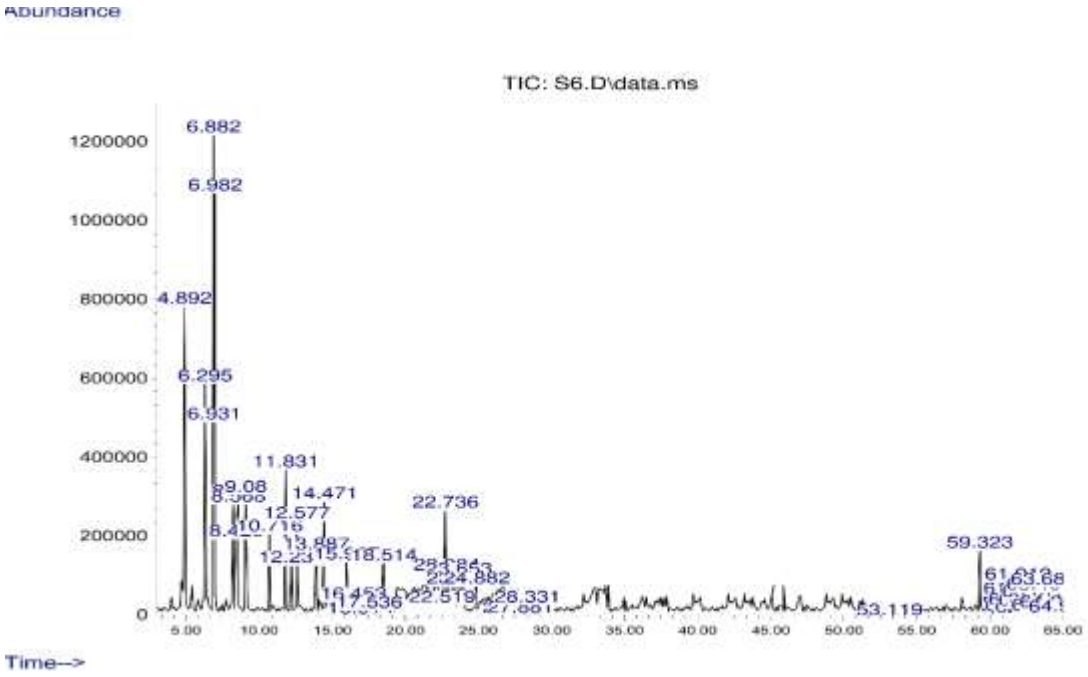
Pk#	RT	Area%	Library/ID	Ref#	CAS#	Qual
1	4.892	9.04	D:\MassHunter\Library\NIST14.L			
			Toluene	9475	000108-88-3	97
			Toluene	9475	000108-88-3	97
			Toluene	9475	000108-88-3	95
2	5.171	2.39	D:\MassHunter\Library\NIST14.L			
			1,3-Dimethyl-1-cyclohexene	6090	002808-76-6	97
			1,4-Hexadiene, 2,3-dimethyl-	6101	018669-52-8	93
			Cyclopentene, 1,2,3-trimethyl-	6112	000473-91-6	91
3	6.295	1.28	D:\MassHunter\Library\NIST14.L			
			Ethylbenzene	5172	000100-41-4	94
			Ethylbenzene	5172	000100-41-4	94
			Benzene, 1,3-dimethyl-	5187	000108-38-3	95
4	6.882	12.51	D:\MassHunter\Library\NIST14.L			
			p-Xylene	5160	000106-42-3	91
			Benzene, 1,3-dimethyl-	5189	000108-38-3	97
			p-Xylene	5160	000106-42-3	91
5	6.931	3.13	D:\MassHunter\Library\NIST14.L			
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
6	6.982	8.93	D:\MassHunter\Library\NIST14.L			
			o-Xylene	5166	000095-47-6	97
			o-Xylene	5166	000095-47-6	97
			o-Xylene	5166	000095-47-6	97
7	8.25	3.17	D:\MassHunter\Library\NIST14.L			
			Benzene,propyl-	9580	000103-65-1	90
			Benzene,propyl-	9580	000103-65-1	90
			Benzene, 1,3-dimethyl-	5189	000108-38-3	89
8	8.426	2.16	D:\MassHunter\Library\NIST14.L			
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95

			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
9	8.568	3.04	D:\MassHunter\Library\NIST14.L			
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97
			Benzene,1,2,4-trimethyl-	9592	000537-73-8	97
10	9.08	1.28	D:\MassHunter\Library\NIST14.L			
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
11	10.095	2.29	D:\MassHunter\Library\NIST14.L			
			Indene	8563	000095-13-6	93
			Indene	8563	000095-13-6	93
			Indene	8563	000095-13-6	93
12	10.263	3.27	D:\MassHunter\Library\NIST14.L			
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
13	10.716	1.96	D:\MassHunter\Library\NIST14.L			
			o-Cymene	15144	000527-84-4	97
			Benzene, 2-ethyl-1,4-dimethyl-	15225	001758-88-9	90
			o-Cymene	15144	000527-84-4	90
14	11.831	3.91	D:\MassHunter\Library\NIST14.L			
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
15	12.234	1.50	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	96
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
16	12.577	2.62	D:\MassHunter\Library\NIST14.L			
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	91
17	13.887	1.83	D:\MassHunter\Library\NIST14.L			
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
			1H Indene,4,7-dimethyl-	20943	006974-97-6	91
18	14.471	3.12	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			Naphthalene, 1,2,3,4-tetrahydro-	14400	000119-64-2	92
19	15.967	1.58	D:\MassHunter\Library\NIST14.L			
			Naphthalene,2-ethyl-	29399	000939-27-5	91

			Naphthalene,2-ethyl-	29399	000939-27-5	91
			Naphthalene,2,6-dimethyl-	29422	000581-42-0	90
20	16.453	0.57	D:\MassHunter\Library\NIST14.L			
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	72
21	16.914	0.20	D:\MassHunter\Library\NIST14.L			
			2-Cyclopenten-1-one,	74560	000080-71-7	74
			2-Cyclopenten-1-one,	74560	000080-71-7	74
			2-Cyclopenten-1-one,	74560	000080-71-7	72
22	17.536	0.35	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
			Naphthalene,1,4,4-trimethyl-	40033	0002241-42-2	93
23	18.514	1.55	D:\MassHunter\Library\NIST14.L			
			Phenol, 2-methoxy-	85892	00090-05-1	77
			Phenol, 2-methoxy-	85892	00090-05-1	77
			Phenol, 2-methoxy-	85892	00090-05-1	77
24	22.519	0.49	D:\MassHunter\Library\NIST14.L			
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
25	22.736	2.90	D:\MassHunter\Library\NIST14.L			
			Naphthalene	12178	00091-20-3	85
			Naphthalene	12178	00091-20-3	85
			Cyclotetradecane	61851	00295-17-0	83
26	22.834	1.30	D:\MassHunter\Library\NIST14.L			
			1H-Indene,1-methylene-	22223	02471-84-3	88
			1H-Indene,1-methylene-	22223	02471-84-3	88
			1H-Indene,1-methylene-	22223	02471-84-3	85
27	23.653	0.96	D:\MassHunter\Library\NIST14.L			
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	70
27	23.721	0.97	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
28	24.882	0.40	D:\MassHunter\Library\NIST14.L			
			1,2-dihydroxybenzene	81220	00120-80-9	67
			1,2-dihydroxybenzene	81220	00120-80-9	67
			Carbonic acid,decyl hexadecyl ester	249495	1000383-16-5	43
29	27.554	2.24	D:\MassHunter\Library\NIST14.L			
			Naphthalene,2-methyl-	12543	00091-57-6	65

			Naphthalene,2-methyl-	12543	00091-57-6	65
			Naphthalene,2-methyl-	12543	00091-57-6	65
30	27.881	0.13	D:\MassHunter\Library\NIST14.L			
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75
			Naphthalene,2-methyl-	12543	00091-57-6	75
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	73
31	28.331	0.49	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
32	53.119	0.16	D:\MassHunter\Library\NIST14.L			
			n-Hexadecanoic acid	72134	0057-10-3	43
			n-Hexadecanoic acid	72134	0057-10-3	43
			Carbonic acid,hexadecyl prop-1-en	184482	1000382-90-3	90
			-2-yl ester			
33	59.323	1.87	D:\MassHunter\Library\NIST14.L			
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
34	61.794	0.46	D:\MassHunter\Library\NIST14.L			
			Nerolidol	85685	000142-50-7	43
			Nerolidol	85685	000142-50-7	43
			Nerolidol	85685	000142-50-7	41
35	61.853	0.71	D:\MassHunter\Library\NIST14.L			
			2-Methyl-oxetane	85794	1000144-10-2	44
			2-Methyl-oxetane	85794	1000144-10-2	44
			2-Methyl-oxetane	85794	1000144-10-2	44
36	61.920	1.07	D:\MassHunter\Library\NIST14.L			
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	45
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	45
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	42
37	61.953	0.27	D:\MassHunter\Library\NIST14.L			
			1-Methylene-cyclohexane	85817	1000144-10-6	53
			1-Methylene-cyclohexane	85817	1000144-10-6	50
			1-Methylene-cyclohexane	85817	1000144-10-6	50
38	62.180	0.43	D:\MassHunter\Library\NIST14.L			
			2,6,10-Dodecatrien-1-ol (Z,E)-	85761	003790-71-4	28
			2,6,10-Dodecatrien-1-ol (Z,E)-	85761	003790-71-4	28
			2,6,10-Dodecatrien-1-ol (Z,E)-	85761	003790-71-4	25
39	62.381	0.09	D:\MassHunter\Library\NIST14.L			
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	25
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	25
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	23
40	62.53	0.23	D:\MassHunter\Library\NIST14.L			
			Cyclopropanecarboxylic acid	82450	00501-19-9	43

			Cyclopropanecarboxylic acid	82450	00501-19-9	43
			Cyclopropanecarboxylic acid	82450	00501-19-9	44
41	62.649	0.24	D:\MassHunter\Library\NIST14.L			
			2-Oxabicyclo[4.4.0]	72553	122723-58-4	38
			2-Oxabicyclo[4.4.0]	72553	122723-58-4	38
			2-Oxabicyclo[4.4.0]	72553	122723-58-4	38
42	62.83	0.40	D:\MassHunter\Library\NIST14.L			
			Bicyclo[3.1.1]heptan-3-one	72668	1000163-96-5	47
			Bicyclo[3.1.1]heptan-3-one	72668	1000163-96-5	47
			Bicyclo[3.1.1]heptan-3-one	72668	1000163-96-5	47
43	63.07	0.50	D:\MassHunter\Library\NIST4.L			
			Cyclopropanecarboxylic acid	111703	1000282-78-3	37
			Cyclopropanecarboxylic acid	111703	1000282-78-3	37
			Cyclopropanecarboxylic acid	111703	1000282-78-3	37
44	63.08	0.63	D:\MassHunter\Library\NIST14.L			
			Podocarpa-6,13-diene	85788	5939-62-8	42
			Podocarpa-6,13-diene	85788	5939-62-8	42
			Podocarpa-6,13-diene	85788	5939-62-8	42
45	63.40	0.81	D:\MassHunter\Library\NIST14.L			
			(1-Bromo-pentyl)-cyclopropane	56420	088106-30-3	30
			(1-Bromo-pentyl)-cyclopropane	56420	088106-30-3	30
			(1-Bromo-pentyl)-cyclopropane	56420	088106-30-3	30
46	63.69	0.94	D:\MassHunter\Library\NIST14.L			
			1,3,3-cyclohexene	85818	1000144-10-7	43
			1,3,3- cyclohexene	85818	1000144-10-7	43
			1,3,3- cyclohexene	85818	1000144-10-7	43
47	63.749	0.28	D:\MassHunter\Library\NIST14.L			
			1-Methylene-cyclohexane		1000144-10-6	37
			1-Methylene-cyclohexane		1000144-10-6	33
			1-Methylene-cyclohexane		1000144-10-6	35
48	64.29	0.35	D:\MassHunter\Library\NIST14.L			
			2,6,10-Dodecatrien-1-ol (Z,E)-	85762	003790-71-4	42
			2,6,10-Dodecatrien-1-ol (Z,E)-	85762	003790-71-4	42
			2,6,10-Dodecatrien-1-ol (Z,E)-	85762	003790-71-4	42
49	64.52	0.53	D:\MassHunter\Library\NIST14.L			
			1-Formyl-2-cyclohexane		1000144-10-0	50
			1-Formyl-2-cyclohexane		1000144-10-0	50
			1-Formyl-2-cyclohexane		1000144-10-0	50
50	64.90	0.25	D:\MassHunter\Library\NIST14.L			
			Cyclohexane-4-ethyl-, trans-	72753	054934-94-0	35
			Cyclohexane-4-ethyl-, trans-	72753	054934-94-0	35
			Cyclohexane-4-ethyl-, trans-	72753	054934-94-0	35


Abundance
TIC: S6.D\data.ms
1200000
1000000
800000
600000
400000
200000
0
6.882
6.982
4.892
6.295
6.931
11.831
14.471
12.577
22.736
59.323
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
Time-->

MULTI-USER SC. RES. LAB. ABUZ Library Search Report

Data Path : D:\MassHunter\GCMS\1\data\Sulaiman chem 2652019\
Data File : S7.D
Acq On : 27 May 2019 20:25
Operator : Multi-User Science Reasearch Laboratory
Sample : Sample 1.5H
Misc :
ALS Vial : 12 Sample Multiplier: 1

Search Libraries: D:\MassHunter\Library\NIST14.L Minimum Quality: 0

Unknown Spectrum: Apex
Integration Events: RTE Integrator - rteint.p

Pk#	RT	Area%	Library/ID	Ref#	CAS#	Qual
1	4.892	9.06	D:\MassHunter\Library\NIST14.L			
			Toluene	9475	000108-88-3	97
			Toluene	9475	000108-88-3	95
			Toluene	9475	000108-88-3	97
2	6.295	4.10	D:\MassHunter\Library\NIST14.L			
			Ethylbenzene	5172	000100-41-4	94
			Ethylbenzene	5172	000100-41-4	94
			Ethylbenzene	5172	000100-41-4	94
3	6.882	22.51	D:\MassHunter\Library\NIST14.L			
			p-Xylene	5160	000106-42-3	91
			p-Xylene	5160	000106-42-3	91
			o-Xylene	5160	000095-47-6	97
4	6.931	2.13	D:\MassHunter\Library\NIST14.L			
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
			Benzene,1,2-dimethyl-	5186	000098-38-3	95
5	6.982	10.94	D:\MassHunter\Library\NIST14.L			
			o-Xylene	5166	000095-47-6	97
			o-Xylene	5166	000095-47-6	97
			p-Xylene	5160	000106-42-3	91
6	8.25	0.17	D:\MassHunter\Library\NIST14.L			
			Benzene,propyl-	9580	000103-65-1	90
			Benzene,propyl-	9580	000103-65-1	90
			Benzene,propyl-	9580	000103-65-1	90
7	8.426	1.16	D:\MassHunter\Library\NIST14.L			
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
8	8.568	1.14	D:\MassHunter\Library\NIST14.L			
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97
			Benzene,1-ethyl-2-methyl-	9603	000611-14-8	93

9	9.08	2.28	D:\MassHunter\Library\NIST14.L			
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
			Benzene, 1-ethyl-2-methyl-	9606	000095-63-6	91
10	10.095	0.09	D:\MassHunter\Library\NIST14.L			
			Indene	8563	000095-13-6	93
			Indene	8563	000095-13-6	93
			Benzene, 2-propenyl-	9131	000300-57-2	83
11	10.263	0.27	D:\MassHunter\Library\NIST14.L			
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
12	10.716	0.06	D:\MassHunter\Library\NIST14.L			
			o-Cymene	15144	000527-84-4	97
			o-Cymene	15144	000527-84-4	95
			p-Cymene	15143	000099-87-4	97
13	11.831	1.91	D:\MassHunter\Library\NIST14.L			
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	92
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
14	12.234	0.04	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
15	12.577	2.12	D:\MassHunter\Library\NIST14.L			
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
16	13.887	0.83	D:\MassHunter\Library\NIST14.L			
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
17	14.471	1.86	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			Naphthalene	12197	000091-20-3	95
18	15.967	0.08	D:\MassHunter\Library\NIST14.L			
			Naphthalene,2-ethyl-	29399	000939-27-5	91
			Naphthalene,2-ethyl-	29399	000939-27-5	91
			Naphthalene,2-ethyl-	29399	000939-27-5	90
19	16.453	0.05	D:\MassHunter\Library\NIST14.L			
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	71
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	69

20	16.914	0.06	D:\MassHunter\Library\NIST14.L			
			2-Cyclopenten-1-one,	74560	000080-71-7	74
			2-Cyclopenten-1-one,	74560	000080-71-7	74
			2-Cyclopenten-1-one,	74560	000080-71-7	74
21	17.536	0.07	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
			Naphthalene,2-methyl-	19725	0000091-57-6	90
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
22	18.514	0.04	D:\MassHunter\Library\NIST14.L			
			Phenol, 2-methoxy-	85892	00090-05-1	77
			Phenol, 2-methoxy-	85892	00090-05-1	77
			Hexadecane	89843	000544-76-3	92
23	22.519	0.02	D:\MassHunter\Library\NIST14.L			
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
			Phenol,3,5-dimethyl-	85685	000108-68-9	80
24	22.736	0.53	D:\MassHunter\Library\NIST14.L			
			Naphthalene	12178	00091-20-3	85
			Naphthalene	12178	00091-20-3	85
			Naphthalene	12178	00091-20-3	82
25	22.834	0.07	D:\MassHunter\Library\NIST14.L			
			1H-Indene,1-methylene-	22223	02471-84-3	88
			1H-Indene,1-methylene-	22223	02471-84-3	88
			1H-Indene,1-methylene-	22223	02471-84-3	81
26	23.653	0.81	D:\MassHunter\Library\NIST14.L			
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
			Naphthalene	12178	00091-20-3	
27	23.721	0.37	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
			2-Methoxy-5-methylphenol	85703	1195-09-1	71
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
28	24.882	0.08	D:\MassHunter\Library\NIST14.L			
			1,2-dihydroxybenzene	81220	00120-80-9	67
			1,2-dihydroxybenzene	81220	00120-80-9	67
			1,2-dihydroxybenzene	81220	00120-80-9	65
29	27.554	0.92	D:\MassHunter\Library\NIST14. L			
			Naphthalene,2-methyl-	12543	00091-57-6	65
			Naphthalene,2-methyl-	12543	00091-57-6	65
			Naphthalene,2-methyl-	12543	00091-57-6	63
30	27.881	0.61	D:\MassHunter\Library\NIST14.L			
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	72
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	71

31	28.331	0.02	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
			2-Methoxy-4-vinylphenol	85233	7786-61-0	71
			2-Methoxy-4-vinylphenol	85233	7786-61-0	70
32	53.119	1.38	D:\MassHunter\Library\NIST14.L			
			n-Hexadecanoic acid	72134	0057-10-3	42
			n-Hexadecanoic acid	72134	0057-10-3	41
			n-Hexadecanoic acid	72134	0057-10-3	43
33	59.323	0.43	D:\MassHunter\Library\NIST14.L			
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	33
34	61.794	1.25	D:\MassHunter\Library\NIST14.L			
			Nerolidol	85685	000142-50-7	43
			Nerolidol	85685	000142-50-7	43
			Nerolidol	85685	000142-50-7	43
35	61.853	1.78	D:\MassHunter\Library\NIST14.L			
			2-Methyl oxetane	85794	1000144-10-2	44
			2-Methyl oxetane	85794	1000144-10-2	41
			2-Methyl oxetane	85794	1000144-10-2	40
36	61.920	0.75	D:\MassHunter\Library\NIST14.L			
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	42
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	42
			3-Penten-1-ol, 3-methyl-	3941	062201-35-3	40
37	61.953	0.74	D:\MassHunter\Library\NIST14.L			
			1-Methylene-cyclohexane	85817	1000144-10-6	53
			1-Methylene-cyclohexane	85817	1000144-10-6	53
			1-Methylene-cyclohexane	85817	1000144-10-6	50
38	62.180	1.58	D:\MassHunter\Library\NIST14.L			
			2,6,10-Dodecatrien-1-ol (Z,E)-	85761	003790-71-4	28
			2,6,10-Dodecatrien-1-ol (Z,E)-	85761	003790-71-4	23
			2,6,10-Dodecatrien-1-ol (Z,E)-	85761	003790-71-4	28
39	62.381	1.55	D:\MassHunter\Library\NIST14.L			
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	25
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	23
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	22
40	62.53	0.23	D:\MassHunter\Library\NIST14.L			
			Cyclopropanecarboxylic acid	82450	0501-19-9	43
			Cyclopropanecarboxylic acid	82450	0501-19-9	43
			Cyclopropanecarboxylic acid	82450	0501-19-9	40
41	62.649	0.24	D:\MassHunter\Library\NIST14.L			
			2-Oxabicyclo[4.4.0]	72553	122723-58-4	38
			2-Oxabicyclo[4.4.0]	72553	122723-58-4	35
			2-Oxabicyclo[4.4.0]	72553	122723-58-4	34
42	62.83	0.90	D:\MassHunter\Library\NIST14.L			

			Bicyclo[3.1.1]heptan-3-one	72668	1000163-96-5	47
			Bicyclo[3.1.1]heptan-3-one	72668	1000163-96-5	45
			Bicyclo[3.1.1]heptan-3-one	72668	1000163-96-5	43
43	63.07	1.50	D:\MassHunter\Library\NIST4.L			
			Cyclopropanecarboxylic acid	111703	1000282-78-3	37
			Cyclopropanecarboxylic acid	111703	1000282-78-3	37
			Cyclopropanecarboxylic acid	111703	1000282-78-3	37
44	63.08	0.33	D:\MassHunter\Library\NIST14.L			
			Podocarpa-6,13-diene, 13-isopropyl-	85788	5939-62-8	46
			Podocarpa-6,13-diene, 13-isopropyl-	85788	5939-62-8	42
			Podocarpa-6,13-diene, 13-isopropyl-	85788	5939-62-8	42
45	63.40	0.81	D:\MassHunter\Library\NIST14.L			
			(1-Bromo-pentyl)-cyclopropane	56420	088106-30-3	30
			(1-Bromo-pentyl)-cyclopropane	56420	088106-30-3	30
			(1-Bromo-pentyl)-cyclopropane	56420	088106-30-3	27
46	63.69	0.94	D:\MassHunter\Library\NIST14.L			
			1,3,3-Trimethyl-cyclohexene	85818	1000144-10-7	43
			1,3,3-Trimethyl-cyclohexene	85818	1000144-10-7	43
			1,3,3-Trimethyl-cyclohexene	85818	1000144-10-7	41
47	63.749	1.28	D:\MassHunter\Library\NIST14.L			
			1-Methylene-cyclohexane		1000144-10-6	38
			1-Methylene-cyclohexane		1000144-10-6	38
			1-Methylene--cyclohexane		1000144-10-6	35
48	64.29	0.59	D:\MassHunter\Library\NIST14.L			
			2,6,10-Dodecatrien-1-ol (Z,E)-	85762	003790-71-4	42
			2,6,10-Dodecatrien-1-ol (Z,E)-	85762	003790-71-4	42
			2,6,10-Dodecatrien-1-ol (Z,E)-	85762	003790-71-4	32
49	64.52	0.53	D:\MassHunter\Library\NIST14.L			
			1-Formyl-2-cyclohexane		1000144-10-0	50
			1-Formyl-2-cyclohexane		1000144-10-0	40
			1-Formyl-2-cyclohexane		1000144-10-0	47
50	64.90	0.13	D:\MassHunter\Library\NIST14.L			
			Cyclohexane-4-ethyl- trans-	72753	054934-94-0	35
			Cyclohexane-4-ethyl-trans-	72753	054934-94-0	35
			Cyclohexane-4-ethyl- trans-	72753	054934-94-0	33


Abundance
TIC: S7.D\data.ms
2400000
2200000
2000000
1800000
1600000
1400000
1200000
1000000
800000
600000
400000
200000
0
6.882
6.982
4.892
6.295
6.931
223.653
63.74
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
Time-->

MULTI-USER SC. RES. LAB. ABUZ Library Search Report

Data Path : D:\MassHunter\GCMS\1\data\Sulaiman Chem 2652019\
Data File : S8.D
Acq On : 27 May 2019 20:25
Operator : Multi-User Science Reasearch Laboratory
Sample : Sample 2H
Misc :
ALS Vial : 12 Sample Multiplier: 1

Search Libraries: D:\MassHunter\Library\NIST14.L Minimum Quality: 0

Unknown Spectrum: Apex
Integration Events: RTE Integrator - rteint.p

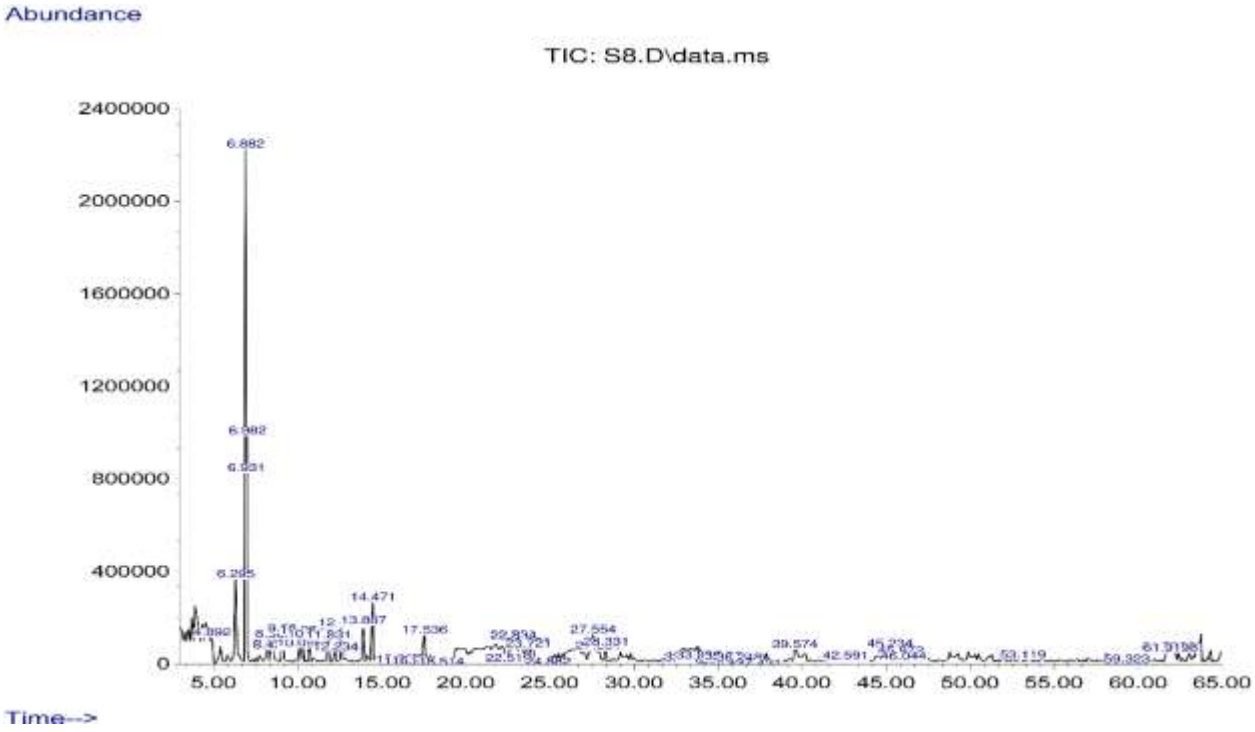
Pk#	RT	Area%	Library/ID	Ref#	CAS#	Qual
1	4.892	9.12	D:\MassHunter\Library\NIST14.L			
			Toluene	9475	000108-88-3	97
			Toluene	9475	000108-88-3	97
			Toluene	9475	000108-88-3	97
2	6.295	3.92	D:\MassHunter\Library\NIST14.L			
			Ethylbenzene	5172	000100-41-4	94
			Ethylbenzene	5172	000100-41-4	94
			Benzene,1,3-dimethyl-	8713	000108-38-3	95
3	6.882	19.10	D:\MassHunter\Library\NIST14.L			
			p-Xylene	5160	000106-42-3	91
			p-Xylene	5160	000106-42-3	91
			o-Xylene	5160	000106-42-3	91
4	6.93	4.51	D:\MassHunter\Library\NIST14.L			
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
5	6.982	9.06	D:\MassHunter\Library\NIST14.L			
			o-Xylene	5166	000095-47-6	97
			o-Xylene	5166	000095-47-6	97
			o-Xylene	5166	000095-47-6	97
6	8.25	0.45	D:\MassHunter\Library\NIST14.L			
			Benzene,propyl-	9580	000103-65-1	90
			Benzene,propyl-	9580	000103-65-1	90
			Benzene,propyl-	9580	000103-65-1	90
7	8.426	1.23	D:\MassHunter\Library\NIST14.L			
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
8	8.568	1.23	D:\MassHunter\Library\NIST14.L			
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97

9	9.08	1.57	D:\MassHunter\Library\NIST14.L			
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
10	10.095	0.94	D:\MassHunter\Library\NIST14.L			
			Indene	8563	000095-13-6	93
			Indene	8563	000095-13-6	93
			Indene	8563	000095-13-6	93
11	10.263	1.50	D:\MassHunter\Library\NIST14.L			
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
12	10.716	1.33	D:\MassHunter\Library\NIST14.L			
			o-Cymene	15144	000527-84-4	97
			o-Cymene	15144	000527-84-4	97
			o-Cymene	15144	000527-84-4	97
13	11.831	1.28	D:\MassHunter\Library\NIST14.L			
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
14	12.234	0.77	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
15	12.577	2.81	D:\MassHunter\Library\NIST14.L			
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
16	13.887	1.93	D:\MassHunter\Library\NIST14.L			
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
17	14.471	0.93	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
18	15.967	0.24	D:\MassHunter\Library\NIST14.L			
			Naphthalene,2-ethyl-	29399	000939-27-5	91
			Naphthalene,2-ethyl-	29399	000939-27-5	91
			Naphthalene,2-ethyl-	29399	000939-27-5	91
19	16.453	0.17	D:\MassHunter\Library\NIST14.L			
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74

20	16.914	0.19	D:\MassHunter\Library\NIST14.L			
			2-Cyclopenten-1-one,	74560	000080-71-7	74
			2-Cyclopenten-1-one,	74560	000080-71-7	74
			2-Cyclopenten-1-one,	74560	000080-71-7	74
21	17.536	0.51	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
22	18.514	0.14	D:\MassHunter\Library\NIST14.L			
			Phenol, 2-methoxy-	85892	00090-05-1	77
			Phenol, 2-methoxy-	85892	00090-05-1	77
			Phenol, 2-methoxy-	85892	00090-05-1	77
23	22.519	0.28	D:\MassHunter\Library\NIST14.L			
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
24	22.736	0.29	D:\MassHunter\Library\NIST14.L			
			Naphthalene	12178	00091-20-3	85
			Naphthalene	12178	00091-20-3	85
			Naphthalene	12178	00091-20-3	85
25	22.834	1.27	D:\MassHunter\Library\NIST14.L			
			1H-Indene,1-methylene-	22223	02471-84-	3 88
			1H-Indene,1-methylene-	22223	02471-84-	3 88
			1H-Indene,1-methylene-	22223	02471-84-	3 88
26	23.653	0.95	D:\MassHunter\Library\NIST14.L			
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
			Napthalene	83224	00093-51-6	73
27	23.721	0.91	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
28	24.882	0.14	D:\MassHunter\Library\NIST14.L			
			1,2-dihydroxybenzene	81220	00120-80-9	67
			1,2-dihydroxybenzene	81220	00120-80-9	67
			2-Methoxy-4-vinylphenol	81220	00120-80-9	67
29	27.554	1.52	D:\MassHunter\Library\NIST14.L			
			Naphthalene,2-methyl-	12543	00091-57-6	65
			Naphthalene,2-methyl-	12543	00091-57-6	65
			Naphthalene,2-methyl-	12543	00091-57-6	65
30	27.881	0.82	D:\MassHunter\Library\NIST14.L			
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75

31	28.331	1.00	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
32	33.142	0.32	D:\MassHunter\Library\NIST14.L			
			Supraene	65623	7683-64-9	55
			Supraene	65623	7683-64-9	55
			Supraene	65623	7683-64-9	55
33	33.832	0.41	D:\MassHunter\Library\NIST14.L			
			Benzaldehyde,3-hydroxy-4-methoxy-	123232	0621-59-0	54
			Benzaldehyde,3-hydroxy-4-methoxy-	123232	0621-59-0	54
			Benzaldehyde,3-hydroxy-4-methoxy-	123232	0621-59-0	54
34	34.972	0.05	D:\MassHunter\Library\NIST14.L			
			Trans-Isoeugenol	39840	5932-68-3	43
			Trans-Isoeugenol	39840	5932-68-3	43
			Trans-Isoeugenol	39840	5932-68-3	43
35	35.07	0.23	D:\MassHunter\Library\NIST14.L			
			Eugenol	39240	1000282-78-3	33
			Eugenol	39241	1000282-78-3	33
			Eugenol	39243	1000282-78-3	33
36	35.551	0.37	D:\MassHunter\Library\NIST14.L			
			Phenol,2-methoxy-4-(1-propenyl)-	85720	0097-54-1	28
			Phenol,2-methoxy-4-(1-propenyl)-	85720	0097-54-1	28
			Phenol,2-methoxy-4-(1-propenyl)-	85720	0097-54-1	28
37	36.013	0.12	D:\MassHunter\Library\NIST14.L			
			Benzenepropanol,4-hydroxy-3-methoxy	3910	2305-13-7	53
			Benzenepropanol,4-hydroxy-3-methoxy	3910	2305-13-7	53
			Benzenepropanol,4-hydroxy-3-methoxy	3910	2305-13-7	53
38	36.248	1.03	D:\MassHunter\Library\NIST14.L			
			Ethanone,1-(3-hydroxy-4-methoxyphenyl	74232	6100-74-9	50
			Ethanone,1-(3-hydroxy-4-methoxyphenyl)	74232	6100-74-9	50
			Ethanone,1-(3-hydroxy-4-methoxyphenyl)	74232	6100-74-9	50
39	36.821	0.04	D:\MassHunter\Library\NIST14.L			
			2,4-Di-tert-butylphenol	82340	0096-76-4	25
			2,4-Di-tert-butylphenol	82340	0096-76-4	25
			2,4-Di-tert-butylphenol	82340	0096-76-4	25
40	37.421	0.04	D:\MassHunter\Library\NIST14.L			
			3-Allyl-6-methoxyphenol	82450	0501-19-9	43
			3-Allyl-6-methoxyphenol	82450	0501-19-9	43
			3-Allyl-6-methoxyphenol	82450	0501-19-9	43
41	39.574	0.88	D:\MassHunter\Library\NIST14.L			
			4-(1-Hydroxyallyl)-2-methoxyphenol	82370	112465-50-6	38
			4-(1-Hydroxyallyl)-2-methoxyphenol	82370	112465-50-6	38
			4-(1-Hydroxyallyl)-2-methoxyphenol	82370	112465-50-6	38

42	42.591	0.39	D:\MassHunter\Library\NIST14.L			
			Apocynin	15621	0498-02-2	47
			Apocynin	15621	0498-02-2	47
			Apocynin	15621	0498-02-2	47
43	45.234	0.91	D:\MassHunter\Library\NIST4.L			
			4-Hydroxy-2-methoxycinnamaldehyde	13236	127321-19-1	37
			4-Hydroxy-2-methoxycinnamaldehyde	13236	127321-19-1	37
			4-Hydroxy-2-methoxycinnamaldehyde	13236	127321-19-1	37
44	45.872	0.60	D:\MassHunter\Library\NIST14.L			
			(E)-2-methoxyphenol	83400	32811-40-8	42
			(E)-2-methoxyphenol	83400	32811-40-8	42
			(E)-2-methoxyphenol	83400	32811-40-8	42
45	46.044	0.37	D:\MassHunter\Library\NIST14.L			
			Coniferyl aldehyde	77201	0458-36-6	50
			Coniferyl aldehyde	77201	0458-36-6	50
			Coniferyl aldehyde	77201	0458-36-6	50
46	53.119	0.43	D:\MassHunter\Library\NIST14.L			
			n-Hexadecanoic acid	72134	0057-10-3	43
			n-Hexadecanoic acid	72134	0057-10-3	43
			n-Hexadecanoic acid	72134	0057-10-3	43
47	59.323	0.24	D:\MassHunter\Library\NIST14.L			
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
48	61.793	0.78	D:\MassHunter\Library\NIST14.L			
			Nerolidol	85685	000142-50-7	42
			Nerolidol	85685	000142-50-7	42
			Nerolidol	85685	000142-50-7	42
49	61.852	0.74	D:\MassHunter\Library\NIST14.L			
			2-Methyl-oxetane	85794	1000144-10-2	50
			2-Methyl-oxetane	85794	1000144-10-2	50
			2-Methyl-oxetane	85794	1000144-10-2	50
50	61.919	0.73	D:\MassHunter\Library\NIST14.L			
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	35
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	35
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	35


Abundance
TIC: S8.D\data.ms
2400000
2000000
1600000
1200000
800000
400000
0
6.882
6.982
6.931
6.295
14.471
17.536
27.554
29.574
45.234
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
Time-->

MULTI-USER SC. RES. LAB. ABUZ Library Search Report

Data Path : D:\MassHunter\GCMS\1\data\Suaiman Chem 2652019\
Data File : S9.D
Acq On : 27 May 2019 20:25
Operator : Multi-User Science Reasearch Laboratory
Sample : Sample 3H
Misc :
ALS Vial : 12 Sample Multiplier: 1

Search Libraries : D:\MassHunter\Library\NIST14.L Minimum Quality: 0

Unknown Spectrum : Apex
Integration Events: RTE Integrator - rteint.p

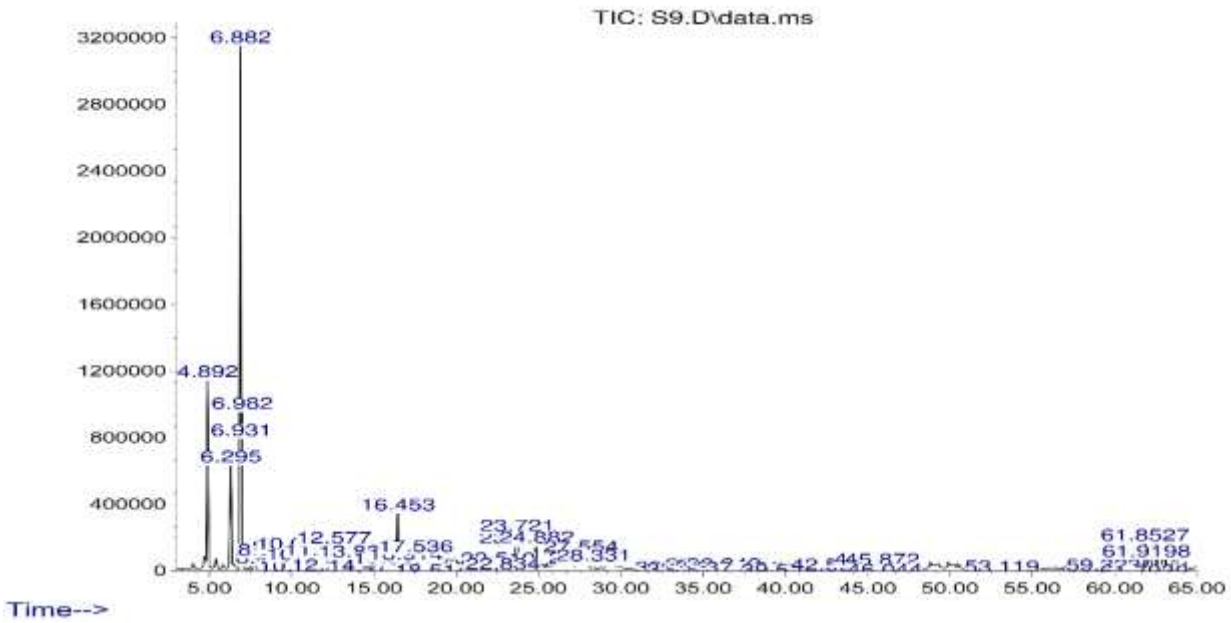
Pk#	RT	Area%	Library/ID	Ref#	CAS#	Qual
1	4.892	9.77	D:\MassHunter\Library\NIST14.L			
			Toluene	9475	000108-88-3	97
			Toluene	9475	000108-88-3	93
			Toluene	9475	000108-88-3	95
2	6.295	5.21	D:\MassHunter\Library\NIST14.L			
			Ethylbenzene	5172	000100-41-4	94
			Ethylbenzene	5172	000100-41-4	94
			Benzene, 1,3-dimethyl-	5187	000108-38-3	92
3	6.882	20.13	D:\MassHunter\Library\NIST14.L			
			p-Xylene	5160	000106-42-3	91
			p-Xylene	5163	000106-42-3	91
			o-Xylene	5168	000108-38-3	90
4	6.931	8.51	D:\MassHunter\Library\NIST14.L			
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
5	6.982	10.12	D:\MassHunter\Library\NIST14.L			
			o-Xylene	5166	000095-47-6	97
			o-Xylene	5166	000095-47-6	97
			o-Xylene	5166	000095-47-6	97
6	8.25	0.97	D:\MassHunter\Library\NIST14.L			
			Benzene,propyl-	9580	000103-65-1	90
			Benzene,propyl-	9580	000103-65-1	90
			Benzene,propyl-	9580	000103-65-1	90
7	8.426	0.85	D:\MassHunter\Library\NIST14.L			
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
8	8.568	1.33	D:\MassHunter\Library\NIST14.L			
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97

9	9.08	1.83	D:\MassHunter\Library\NIST14.L			
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
			Benzene, 1,3-dimethyl-	9599	000526-73-8	92
10	10.095	1.70	D:\MassHunter\Library\NIST14.L			
			Indene	8563	000095-13-6	93
			Indene	8563	000095-13-6	93
			Indene	8563	000095-13-6	93
11	10.263	0.37	D:\MassHunter\Library\NIST14.L			
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
12	10.716	1.05	D:\MassHunter\Library\NIST14.L			
			o-Cymene	15144	000527-84-4	97
			o-Cymene	15144	000527-84-4	97
			o-Cymene	15144	000527-84-4	97
13	11.831	1.32	D:\MassHunter\Library\NIST14.L			
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
14	12.234	0.41	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
			Naphthalene, 2-methyl-	19725	000091-57-6	92
15	12.577	1.06	D:\MassHunter\Library\NIST14.L			
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	95
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
16	13.887	0.24	D:\MassHunter\Library\NIST14.L			
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
17	14.471	0.37	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
18	15.967	0.82	D:\MassHunter\Library\NIST14.L			
			Naphthalene,2-ethyl-	29399	000939-27-5	91
			Naphthalene,2-ethyl-	29399	000939-27-5	91
			Naphthalene,2-ethyl-	29399	000939-27-5	91
19	16.453	0.031	D:\MassHunter\Library\NIST14.L			
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74

20	16.914	0.04	D:\MassHunter\Library\NIST14.L			
			2-Cyclopenten-1-one,	74560	000080-71-7	74
			2-Cyclopenten-1-one,	74560	000080-71-7	74
			Naphthalene, 2,6-dimethyl-	29422	000581-42-0	72
21	17.536	0.88	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
22	18.514	0.98	D:\MassHunter\Library\NIST14.L			
			Phenol, 2-methoxy-	85892	00090-05-1	77
			Phenol, 2-methoxy-	85892	00090-05-1	77
			Phenol, 2-methoxy-	85892	00090-05-1	77
23	22.519	0.08	D:\MassHunter\Library\NIST14.L			
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
24	22.736	0.91	D:\MassHunter\Library\NIST14.L			
			Naphthalene	12178	00091-20-3	85
			Naphthalene	12178	00091-20-3	85
			Naphthalene	12178	00091-20-3	85
25	22.834	1.61	D:\MassHunter\Library\NIST14.L			
			1H-Indene,1-methylene-	22223	02471-84-3	88
			1H-Indene,1-methylene-	22223	02471-84-3	88
			1H-Indene,1-methylene-	22223	02471-84-3	88
26	23.653	0.96	D:\MassHunter\Library\NIST14.L			
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
27	23.721	0.91	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
28	24.882	0.14	D:\MassHunter\Library\NIST14.L			
			1,2-dihydroxybenzene	81220	00120-80-9	67
			1,2-dihydroxybenzene	81220	00120-80-9	67
			1,2-dihydroxybenzene	81220	00120-80-9	67
29	27.554	0.57	D:\MassHunter\Library\NIST14.L			
			Naphthalene,2-methyl-	12543	00091-57-6	65
			Naphthalene,2-methyl-	12543	00091-57-6	65
			Naphthalene,2-methyl-	12543	00091-57-6	65
30	27.881	0.35	D:\MassHunter\Library\NIST14.L			
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75

31	28.331	0.81	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
32	33.142	0.55	D:\MassHunter\Library\NIST14.L			
			Supraene	65623	7683-64-9	55
			Supraene	65623	7683-64-9	55
			Supraene	65623	7683-64-9	55
33	33.832	0.48	D:\MassHunter\Library\NIST14.L			
			Benzaldehyde,3-hydroxy-4-methoxy-	123232	0621-59-0	54
			Benzaldehyde,3-hydroxy-4-methoxy-	123232	0621-59-0	54
			Benzaldehyde,3-hydroxy-4-methoxy-	123232	0621-59-0	54
34	34.972	0.41	D:\MassHunter\Library\NIST14.L			
			Trans-Isoeugenol	39840	5932-68-3	43
			Trans-Isoeugenol	39840	5932-68-3	43
			Trans-Isoeugenol	39840	5932-68-3	43
35	35.07	0.33	D:\MassHunter\Library\NIST14.L			
			Eugenol	39240	1000282-78-3	33
			Eugenol	39240	1000282-78-3	33
			Eugenol	39240	1000282-78-3	33
36	35.551	0.38	D:\MassHunter\Library\NIST14.L			
			Phenol,2-methoxy-4-(1-propenyl)-	85720	0097-54-1	28
			Phenol,2-methoxy-4-(1-propenyl)-	85720	0097-54-1	28
			Phenol,2-methoxy-4-(1-propenyl)-	85720	0097-54-1	28
37	36.013	0.38	D:\MassHunter\Library\NIST14.L			
			Benzenepropanol,4-hydroxy-3-methoxy	3910	2305-13-7	53
			Benzenepropanol,4-hydroxy-3-methoxy	3910	2305-13-7	53
			Benzenepropanol,4-hydroxy-3-methoxy	3910	2305-13-7	53
38	36.248	0.49	D:\MassHunter\Library\NIST14.L			
			Ethanone,1-(3-hydroxy-4-methoxyphenyl	74232	6100-74-9	50
			Ethanone,1-(3-hydroxy-4-methoxyphenyl	74232	6100-74-9	50
			Ethanone,1-(3-hydroxy-4-methoxyphenyl	74232	6100-74-9	50
39	36.821	0.04	D:\MassHunter\Library\NIST14.L			
			2,4-Di-tert-butylphenol	82340	0096-76-4	25
			2,4-Di-tert-butylphenol	82340	0096-76-4	25
			2,4-Di-tert-butylphenol	82340	0096-76-4	25
40	37.421	0.05	D:\MassHunter\Library\NIST14.L			
			3-Allyl-6-methoxyphenol	82450	0501-19-9	43
			3-Allyl-6-methoxyphenol	82450	0501-19-9	43
			3-Allyl-6-methoxyphenol	82450	0501-19-9	43
41	39.574	0.88	D:\MassHunter\Library\NIST14.L			
			4-(1-Hydroxyallyl)-2-methoxyphenol	82370	112465-50-6	38
			4-(1-Hydroxyallyl)-2-methoxyphenol	82370	112465-50-6	38
			4-(1-Hydroxyallyl)-2-methoxyphenol	82370	112465-50-6	38

42	42.591	0.39	D:\MassHunter\Library\NIST14.L			
			Apocynin	15621	0498-02-2	47
			Apocynin	15621	0498-02-2	47
			Apocynin	15621	0498-02-2	47
43	45.234	0.31	D:\MassHunter\Library\NIST4.L			
			4-Hydroxy-2-methoxycinnamaldehyde	13236	127321-19-1	37
			4-Hydroxy-2-methoxycinnamaldehyde	13236	127321-19-1	37
			4-Hydroxy-2-methoxycinnamaldehyde	13236	127321-19-1	37
44	45.872	0.60	D:\MassHunter\Library\NIST14.L			
			(E)-4-methoxyphenol	83400	32811-40-8	42
			(E)-4-methoxyphenol	83400	32811-40-8	42
			(E)-4-methoxyphenol	83400	32811-40-8	42
45	46.044	0.37	D:\MassHunter\Library\NIST14.L			
			Coniferyl aldehyde	77201	0458-36-6	50
			Coniferyl aldehyde	77201	0458-36-6	50
			Coniferyl aldehyde	77201	0458-36-6	50
46	53.119	0.43	D:\MassHunter\Library\NIST14.L			
			n-Hexadecanoic acid	72134	0057-10-3	43
			n-Hexadecanoic acid	72134	0057-10-3	43
			n-Hexadecanoic acid	72134	0057-10-3	43
47	59.323	0.24	D:\MassHunter\Library\NIST14.L			
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
48	61.793	0.21	D:\MassHunter\Library\NIST14.L			
			Nerolidol	85685	000142-50-7	42
			Nerolidol	85685	000142-50-7	42
			Nerolidol	85685	000142-50-7	42
49	61.852	0.24	D:\MassHunter\Library\NIST14.L			
			2-Methyl-oxetane	85794	1000144-10-2	50
			2-Methyl-oxetane	85794	1000144-10-2	50
			2-Methyl-oxetane	85794	1000144-10-2	50
50	61.919	0.14	D:\MassHunter\Library\NIST14.L			
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	35
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	35
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	35


Abundance
TIC: S9.D\data.ms
3200000
2800000
2400000
2000000
1600000
1200000
800000
400000
0
6.882
4.892
6.982
6.931
6.295
16.453
12.577
17.536
23.721
61.8527
61.9198
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
Time-->

MULTI-USER SC. RES. LAB. ABUZ Library Search Report

Data Path : D:\MassHunter\GCMS\1\data\Sulaiman chem 2652019\
Data File : S10.D
Acq On : 27 May 2019 20:25
Operator : Multi-User Science Reasearch Laboratory
Sample : Sample 1.5 Parent
Misc :
ALS Vial : 12 Sample Multiplier: 1

Search Libraries: D:\MassHunter\Library\NIST14.L Minimum Quality: 0

Unknown Spectrum: Apex
Integration Events: RTE Integrator - rteint.p

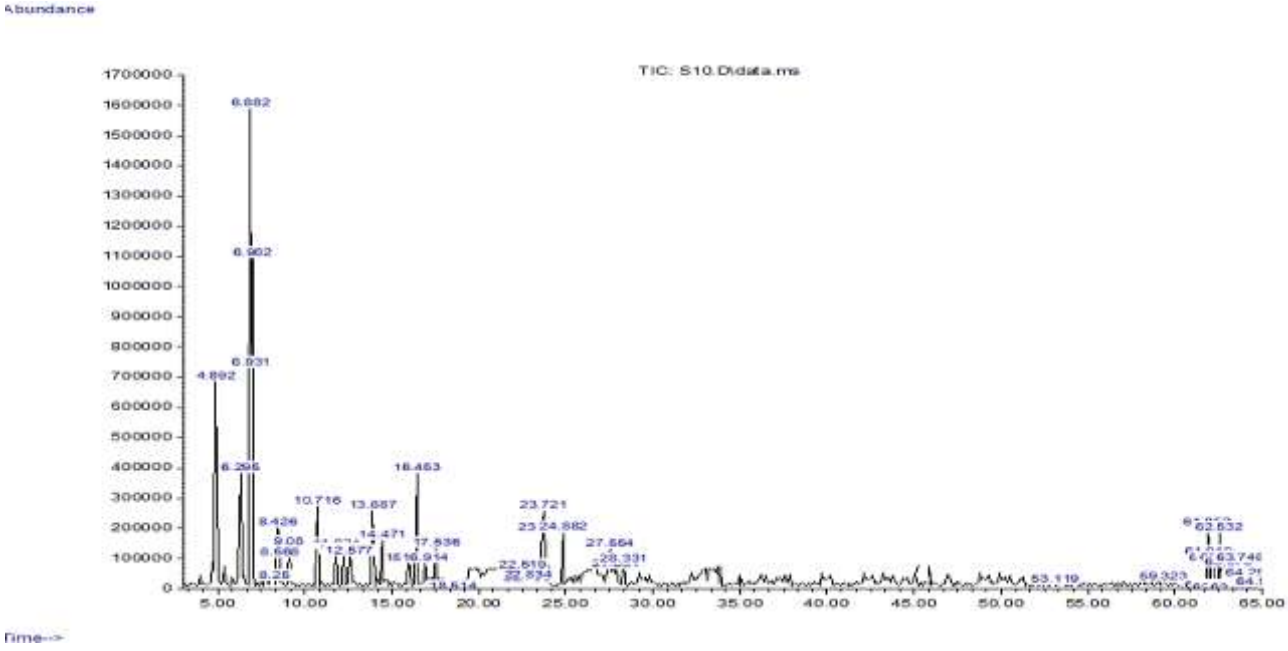
Pk#	RT	Area%	Library/ID	Ref#	CAS#	Qual
1	4.892	7.09	D:\MassHunter\Library\NIST14.L			
			Toluene	9475	000108-88-3	97
			Toluene	9475	000108-88-3	97
			Toluene	9475	000108-88-3	97
2	6.295	4.02	D:\MassHunter\Library\NIST14.L			
			Ethylbenzene	5172	000100-41-4	94
			Ethylbenzene	5172	000100-41-4	94
			Ethylbenzene	5172	000100-41-4	94
3	6.882	13.51	D:\MassHunter\Library\NIST14.L			
			p-Xylene	5160	000106-42-3	91
			p-Xylene	5160	000106-42-3	91
			o-Xylene	5169	000108-38-3	90
4	6.931	7.51	D:\MassHunter\Library\NIST14.L			
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
5	6.982	8.93	D:\MassHunter\Library\NIST14.L			
			o-Xylene	5166	000095-47-6	97
			o-Xylene	5166	000095-47-6	97
			o-Xylene	5166	000095-47-6	97
6	8.25	0.46	D:\MassHunter\Library\NIST14.L			
			Benzene,propyl-	9580	000103-65-1	90
			Benzene,propyl-	9580	000103-65-1	90
			Benzene,propyl-	9580	000103-65-1	90
7	8.426	1.23	D:\MassHunter\Library\NIST14.L			
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
			Benzene,1-ethyl-4-methyl-	9614	000642-10-4	92
8	8.568	1.23	D:\MassHunter\Library\NIST14.L			
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97
9	9.08	1.56	D:\MassHunter\Library\NIST14.L			

			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
10	10.095	0.94	D:\MassHunter\Library\NIST14.L			
			Indene	8563	000095-13-6	93
			Indene	8563	000095-13-6	93
			Indene	8563	000095-13-6	90
11	10.263	1.50	D:\MassHunter\Library\NIST14.L			
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	82
12	10.716	0.33	D:\MassHunter\Library\NIST14.L			
			o-Cymene	15144	000527-84-4	97
			o-Cymene	15144	000527-84-4	97
			p-Cymene	15076	000549-64-4	93
13	11.831	1.28	D:\MassHunter\Library\NIST14.L			
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
14	12.234	0.78	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	91
15	12.577	1.81	D:\MassHunter\Library\NIST14.L			
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	92
16	13.887	0.03	D:\MassHunter\Library\NIST14.L			
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
			1H Indene,4,7-dimethyl-	20943	006974-97-6	90
17	14.471	2.53	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
18	15.967	O.06	D:\MassHunter\Library\NIST14.L			
			Naphthalene,2-ethyl-	29399	000939-27-5	91
			Naphthalene,2-ethyl-	29399	000939-27-5	91
			Naphthalene,2-ethyl-	29399	000939-27-5	91
19	16.453	0.53	D:\MassHunter\Library\NIST14.L			
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
20	16.914	0.09	D:\MassHunter\Library\NIST14.L			
			2-Cyclopenten-1-one,	74560	000080-71-7	74

			2-Cyclopenten-1-one,	74560	000080-71-7	74
			2-Cyclopenten-1-one,	74560	000080-71-7	74
21	17.536	0.80	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
22	18.514	0.35	D:\MassHunter\Library\NIST14.L			
			Phenol, 2-methoxy-	85892	00090-05-1	77
			Phenol, 2-methoxy-	85892	00090-05-1	77
			Phenol, 2-methoxy-	85892	00090-05-1	77
23	22.519	0.49	D:\MassHunter\Library\NIST14.L			
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
24	22.736	1.84	D:\MassHunter\Library\NIST14.L			
			Naphthalene	12178	00091-20-3	85
			Naphthalene	12178	00091-20-3	85
			Naphthalene	12178	00091-20-3	85
25	22.834	0.79	D:\MassHunter\Library\NIST14.L			
			1H-Indene,1-methylene-	22223	02471-84-3	88
			1H-Indene,1-methylene-	22223	02471-84-3	88
			1H-Indene,1-methylene-	22223	02471-84-3	88
26	23.653	1.81	D:\MassHunter\Library\NIST14.L			
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
27	23.721	0.35	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
28	24.882	0.22	D:\MassHunter\Library\NIST14.L			
			1,2-dihydroxybenzene	81220	00120-80-9	67
			1,2-dihydroxybenzene	81222	00120-80-9	67
			1,2-dihydroxybenzene	81225	00120-80-9	65
29	27.554	0.52	D:\MassHunter\Library\NIST14.L			
			Naphthalene,2-methyl-	12543	00091-57-6	65
			Naphthalene,2-methyl-	12543	00091-57-6	65
			Naphthalene,2-methyl-	12543	00091-57-6	65
30	27.881	0.83	D:\MassHunter\Library\NIST14.L			
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75
31	28.331	0.02	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73

			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
32	53.119	0.32	D:\MassHunter\Library\NIST14.L			
			n-Hexadecanoic acid	72134	0057-10-3	43
			n-Hexadecanoic acid	72134	0057-10-3	43
			n-Hexadecanoic acid	72134	0057-10-3	43
33	59.323	0.41	D:\MassHunter\Library\NIST14.L			
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
34	61.794	0.06	D:\MassHunter\Library\NIST14.L			
			Nerolidol	85685	000142-50-7	43
			Nerolidol	85685	000142-50-7	43
			Nerolidol	85685	000142-50-7	43
35	61.853	3.21	D:\MassHunter\Library\NIST14.L			
			2-Methyl-oxetane	85794	1000144-10-2	44
			2-Methyl-oxetane	85794	1000144-10-2	44
			2-Methyl-oxetane	85794	1000144-10-2	44
36	61.920	2.25	D:\MassHunter\Library\NIST14.L			
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	42
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	42
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	42
37	61.953	0.12	D:\MassHunter\Library\NIST14.L			
			1-Methylene-cyclohexane	85817	1000144-10-6	53
			1-Methylenecyclohexane	85817	1000144-10-6	53
			1-Methylene-cyclohexane	85817	1000144-10-6	53
38	62.180	2.03	D:\MassHunter\Library\NIST14.L			
			2,6,10-Dodecatrien-1-ol (Z,E)-	85761	003790-71-4	28
			2,6,10-Dodecatrien-1-ol (Z,E)-	85761	003790-71-4	28
			2,6,10-Dodecatrien-1-ol (Z,E)-	85761	003790-71-4	28
39	62.38	2.04	D:\MassHunter\Library\NIST14.L			
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	25
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	25
			6,11-Dimethyl-2,6,10-dodecatrien-1-ol	72632	1000196-53-3	25
40	62.53	2.05	D:\MassHunter\Library\NIST14.L			
			Cyclopropanecarboxylic acid	82450	0501-19-9	43
			Cyclopropanecarboxylic acid	82450	0501-19-9	43
			Cyclopropanecarboxylic acid	82450	0501-19-9	43
41	62.649	3.02	D:\MassHunter\Library\NIST14.L			
			2-Oxabicyclo[4.4.0]	72553	122723-58-4	38
			2-Oxabicyclo[4.4.0]	72553	122723-58-4	38
			2-Oxabicyclo[4.4.0]	72553	122723-58-4	38
42	62.83	2.04	D:\MassHunter\Library\NIST14.L			

			Bicyclo[3.1.1]heptan-3-one	72668	1000163-96-5	47
			Bicyclo[3.1.1]heptan-3-one	72668	1000163-96-5	47
			Bicyclo[3.1.1]heptan-3-one	72668	1000163-96-5	47
43	63.07	0.11	D:\MassHunter\Library\NIST4.L			
			Cyclopropanecarboxylic acid	111703	1000282-78-3	37
			Cyclopropanecarboxylic acid	111703	1000282-78-3	37
			Cyclopropanecarboxylic acid	111703	1000282-78-3	37
44	63.08	0.90	D:\MassHunter\Library\NIST14.L			
			Podocarpa-6,13-diene, 13-isopropyl-	85788	5939-62-8	42
			Podocarpa-6,13-diene, 13-isopropyl-	85788	5939-62-8	42
			Podocarpa-6,13-diene, 13-isopropyl-	85788	5939-62-8	42
45	63.40	3.03	D:\MassHunter\Library\NIST14.L			
			(1-Bromo-pentyl)-cyclopropane	56420	088106-30-3	30
			(1-Bromo-pentyl)-cyclopropane	56420	088106-30-3	30
			(1-Bromo-pentyl)-cyclopropane	56420	088106-30-3	30
46	63.69	1.08	D:\MassHunter\Library\NIST14.L			
			1,3,3-Trimethyl-2-cyclohexene	85818	1000144-10-7	43
			1,3,3-Trimethyl-2-cyclohexene	85818	1000144-10-7	43
			1,3,3-Trimethyl-2-cyclohexene	85818	1000144-10-7	43
47	63.749	1.04	D:\MassHunter\Library\NIST14.L			
			1-Methylene-cyclohexane	10001	44-10-6	38
			1-Methylene-cyclohexane	10001	44-10-6	38
			1-Methylene-2-cyclohexane	10001	44-10-6	38
48	64.29	0.54	D:\MassHunter\Library\NIST14.L			
			2,6,10-Dodecatrien-1-ol (Z,E)-	85762	003790-71-4	42
			2,6,10-Dodecatrien-1-ol (Z,E)-	85762	003790-71-4	42
			2,6,10-Dodecatrien-1-ol (Z,E)-	85762	003790-71-4	42
49	64.52	0.20	D:\MassHunter\Library\NIST14.L			
			1-Formyl-2-cyclohexane	10001	44-10-0	50
			1-Formyl-2-cyclohexane	10001	44-10-0	50
			1-Formyl-2-cyclohexane	10001	44-10-0	50
50	64.90	0.74	D:\MassHunter\Library\NIST14.L			
			Cyclhexanetrans-	72753	054934-94-0	35
			Cyclohexanetrans-	72753	054934-94-0	35
			Cyclohexanetrans-	72753	054934-94-0	35


Abundance
TIC: S10.D\data.ms
1700000
1600000
1500000
1400000
1300000
1200000
1100000
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
6.882
6.902
6.931
4.892
6.295
10.716
13.687
8.429
14.471
16.463
17.838
23.721
23.882
27.564
28.331
53.119
59.323
62.632
63.746
64.21
64.1
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
Time-->

MULTI-USER SC. RES. LAB. ABUZ Library Search Report

Data Path : D:\MassHunter\GCMS\1\data\Sulaiman Chem 2652019\
Data File : S11.D
Acq On : 27 May 2019 20:25
Operator : Multi-User Science Reasearch Laboratory
Sample : Sample M
Misc :
ALS Vial : 12 Sample Multiplier: 1

Search Libraries: D:\MassHunter\Library\NIST14.L Minimum Quality: 0

Unknown Spectrum: Apex
Integration Events: RTE Integrator - rteint.p

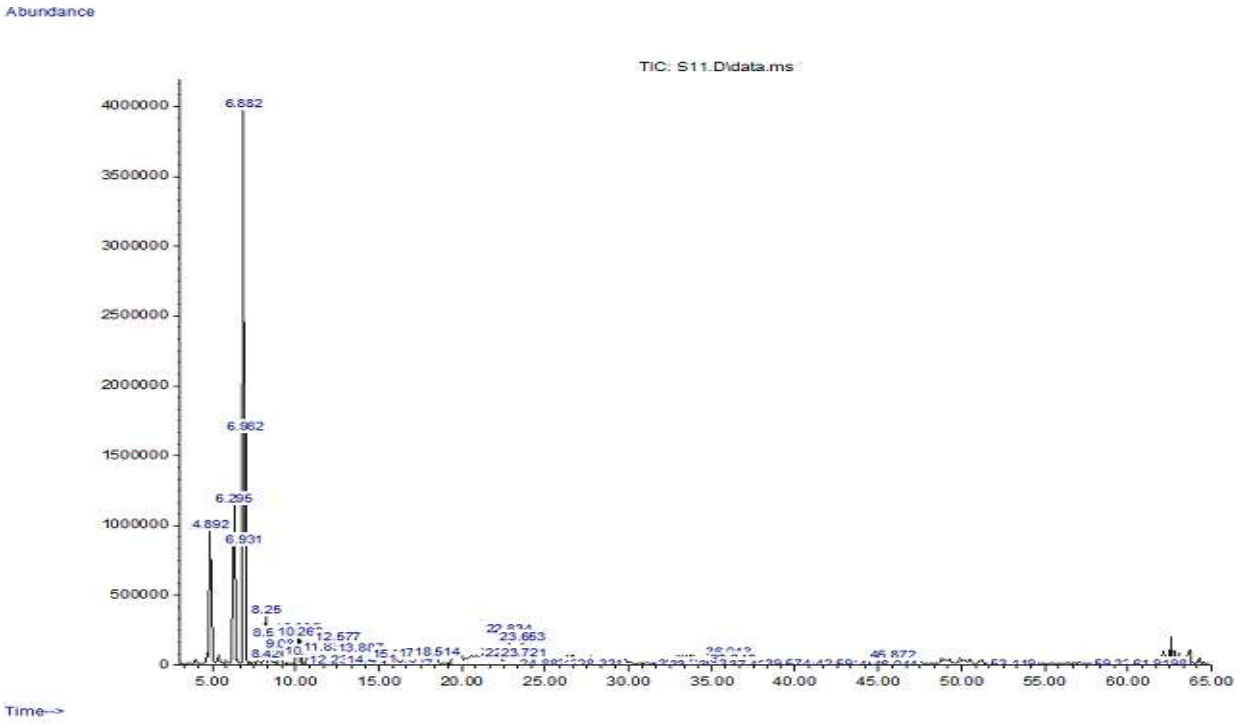
Pk#	RT	Area%	Library/ID	Ref#	CAS#	Qual
1	4.892	9.03	D:\MassHunter\Library\NIST14.L			
			Toluene	9475	000108-88-3	97
			Toluene	9475	000108-88-3	97
			Toluene	9475	000108-88-3	97
2	6.295	4.42	D:\MassHunter\Library\NIST14.L			
			Ethylbenzene	5172	000100-41-4	94
			Ethylbenzene	5172	000100-41-4	94
			Ethylbenzene	5172	000100-41-4	94
3	6.882	27.21	D:\MassHunter\Library\NIST14.L			
			p-Xylene	5160	000106-42-3	91
			p-Xylene	5160	000106-42-3	91
			p-Xylene	5160	000106-42-3	91
4	6.931	9.00	D:\MassHunter\Library\NIST14.L			
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
			Benzene,1,3-dimethyl-	5186	000108-38-3	95
5	6.982	14.62	D:\MassHunter\Library\NIST14.L			
			o-Xylene	5166	000095-47-6	97
			o-Xylene	5166	000095-47-6	97
			o-Xylene	5166	000095-47-6	97
6	8.25	0.97	D:\MassHunter\Library\NIST14.L			
			Benzene,propyl-	9580	000103-65-1	90
			Benzene,propyl-	9580	000103-65-1	90
			Benzene,propyl-	9580	000103-65-1	90
7	8.426	0.05	D:\MassHunter\Library\NIST14.L			
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
			Benzene,1-ethyl-3-methyl-	9600	000620-14-4	95
8	8.568	0.33	D:\MassHunter\Library\NIST14.L			
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97

			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97
			Benzene,1,2,3-trimethyl-	9599	000526-73-8	97
9	9.08	0.90	D:\MassHunter\Library\NIST14.L			
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
			Benzene,1,2,4-trimethyl-	9601	000095-63-6	95
10	10.095	0.18	D:\MassHunter\Library\NIST14.L			
			Indene	8563	000095-13-6	93
			Indene	8563	000095-13-6	93
			Indene	8563	000095-13-6	93
11	10.263	0.96	D:\MassHunter\Library\NIST14.L			
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
			Benzene,1-methyl-4-propyl-	15193	001074-55-1	84
12	10.716	0.05	D:\MassHunter\Library\NIST14.L			
			o-Cymene	15144	000527-84-4	97
			o-Cymene	15144	000527-84-4	97
			o-Cymene	15144	000527-84-4	97
13	11.831	0.92	D:\MassHunter\Library\NIST14.L			
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
			1H-Indene,2,3-dihydro-5-methyl-	14392	000874-35-1	93
14	12.234	0.41	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
			Naphthalene,1,2,3,4-tetrahydro-	14388	000119-64-2	94
15	12.577	0.96	D:\MassHunter\Library\NIST14.L			
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
			Benzene,(1,2-dimethyl-1-propenyl)	22219	000769-57-3	94
16	13.887	0.24	D:\MassHunter\Library\NIST14.L			
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
			1H Indene,4,7-dimethyl-	20943	006974-97-6	93
17	14.471	0.34	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
			Naphthalene,1,7-dimethyl-	12197	000575-37-1	94
18	15.967	0.82	D:\MassHunter\Library\NIST14.L			
			Naphthalene,2-ethyl-	29399	000939-27-5	91
			Naphthalene,2-ethyl-	29399	000939-27-5	91
			Naphthalene,2-ethyl-	29399	000939-27-5	91
19	16.453	0.03	D:\MassHunter\Library\NIST14.L			
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74

			3-Methylcyclopentane-1,2-dione	74550	1000411-55-2	74
20	16.914	0.44	D:\MassHunter\Library\NIST14.L			
			2-Cyclopenten-1-one,	74560	000080-71-7	74
			2-Cyclopenten-1-one,	74560	000080-71-7	74
			2-Cyclopenten-1-one,	74560	000080-71-7	74
21	17.536	0.08	D:\MassHunter\Library\NIST14.L			
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
			Naphthalene,1,4,6-trimethyl-	40026	0002131-42-2	93
22	18.514	0.08	D:\MassHunter\Library\NIST14.L			
			Phenol, 2-methoxy-	85892	00090-05-1	77
			Phenol, 2-methoxy-	85892	00090-05-1	77
			Phenol, 2-methoxy-	85892	00090-05-1	77
23	22.519	0.10	D:\MassHunter\Library\NIST14.L			
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
			Phenol,3,5-dimethyl-	85685	000108-68-9	83
24	22.736	0.92	D:\MassHunter\Library\NIST14.L			
			Naphthalene	12178	00091-20-3	85
			Naphthalene	12178	00091-20-3	85
			Naphthalene	12178	00091-20-3	85
25	22.834	0.06	D:\MassHunter\Library\NIST14.L			
			1H-Indene,1-methylene-	22223	02471-84-3	88
			1H-Indene,1-methylene-	22223	02471-84-3	88
			1H-Indene,1-methylene-	22223	02471-84-3	88
26	23.653	0.10	D:\MassHunter\Library\NIST14.L			
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
			2-methoxy-4-methyl-Phenol	83224	00093-51-6	73
27	23.721	0.01	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
			2-Methoxy-5-methylphenol	85703	1195-09-1	72
28	24.882	0.27	D:\MassHunter\Library\NIST14.L			
			1,2-dihydroxybenzene	81220	00120-80-9	67
			1,2-dihydroxybenzene	81220	00120-80-9	67
			1,2-dihydroxybenzene	81220	00120-80-9	67
29	27.554	0.06	D:\MassHunter\Library\NIST14.L			
			Naphthalene,2-methyl-	12543	00091-57-6	65
			Naphthalene,2-methyl-	12543	00091-57-6	65
			Naphthalene,2-methyl-	12543	00091-57-6	65
30	27.881	0.09	D:\MassHunter\Library\NIST14.L			
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75
			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75

			Phenol, 4-ethyl-2-methoxy-	85340	2785-89-9	75
31	28.331	0.06	D:\MassHunter\Library\NIST14.L			
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
			2-Methoxy-4-vinylphenol	85233	7786-61-0	73
32	33.142	1.08	D:\MassHunter\Library\NIST14.L			
			Supraene	65623	7683-64-9	55
			Supraene	65623	7683-64-9	55
			Supraene	65623	7683-64-9	55
33	33.832	1.02	D:\MassHunter\Library\NIST14.L			
			Benzaldehyde,3-hydroxy-4-methoxy-	123232	0621-59-0	54
			Benzaldehyde,3-hydroxy-4-methoxy-	123232	0621-59-0	54
			Benzaldehyde,3-hydroxy-4-methoxy-	123232	0621-59-0	54
34	34.972	0.06	D:\MassHunter\Library\NIST14.L			
			Trans-Isoeugenol	39840	5932-68-3	43
			Trans-Isoeugenol	39840	5932-68-3	43
			Trans-Isoeugenol	39840	5932-68-3	43
35	35.07	0.09	D:\MassHunter\Library\NIST14.L			
			Eugenol	39240	1000282-78-3	33
			Eugenol	39240	1000282-78-3	33
			Eugenol	39240	1000282-78-3	33
36	35.551	0.02	D:\MassHunter\Library\NIST14.L			
			Phenol,2-methoxy-4-(1-propenyl)-	85720	0097-54-1	28
			Phenol,2-methoxy-4-(1-propenyl)-	85720	0097-54-1	28
			Phenol,2-methoxy-4-(1-propenyl)-	85720	0097-54-1	28
37	36.013	0.09	D:\MassHunter\Library\NIST14.L			
			Benzenepropanol,4-hydroxy-3-methoxy	3910	2305-13-7	53
			Benzenepropanol,4-hydroxy-3-methoxy	3910	2305-13-7	53
			Benzenepropanol,4-hydroxy-3-methoxy	3910	2305-13-7	53
38	36.248	2.91	D:\MassHunter\Library\NIST14.L			
			Ethanone,1-(3-hydroxy-4-methoxyphenyl)	74232	6100-74-9	50
			Ethanone,1-(3-hydroxy-4-methoxyphenyl)	74232	6100-74-9	50
			Ethanone,1-(3-hydroxy-4-methoxyphenyl)	74232	6100-74-9	50
39	36.821	1.07	D:\MassHunter\Library\NIST14.L			
			2,4-Di-tert-butylphenol	82340	0096-76-4	25
			2,4-Di-tert-butylphenol	82340	0096-76-4	25
			2,4-Di-tert-butylphenol	82340	0096-76-4	25
40	37.421	0.06	D:\MassHunter\Library\NIST14.L			
			3-Allyl-6-methoxyphenol	82450	0501-19-9	43
			3-Allyl-6-methoxyphenol	82450	0501-19-9	43
			3-Allyl-6-methoxyphenol	82450	0501-19-9	43
41	39.574	0.09	D:\MassHunter\Library\NIST14.L			
			4-(1-Hydroxyallyl)-2-methoxyphenol	82370	112465-50-6	38
			4-(1-Hydroxyallyl)-2-methoxyphenol	82370	112465-50-6	38

			4-(1-Hydroxyallyl)-2-methoxyphenol	82370	112465-50-6	38
42	42.591	0.09	D:\MassHunter\Library\NIST14.L			
			Apocynin	15621	0498-02-2	47
			Apocynin	15621	0498-02-2	47
			Apocynin	15621	0498-02-2	47
43	45.234	2.06	D:\MassHunter\Library\NIST4.L			
			4-Hydroxy-2-methoxycinnamaldehyde	13236	127321-19-1	37
			4-Hydroxy-2-methoxycinnamaldehyde	13236	127321-19-1	37
			4-Hydroxy-2-methoxycinnamaldehyde	13236	127321-19-1	37
44	45.872	1.70	D:\MassHunter\Library\NIST14.L			
			(E)-4-(3-Hydroxyprop-1-en-1-yl-2-methoxyphenol	83400	32811-40-8	42
			(E)-4-(3-Hydroxyprop-1-en-1-yl-2-methoxyphenol	83400	32811-40-8	42
			(E)-4-(3-Hydroxyprop-1-en-1-yl-2-methoxyphenol	83400	32811-40-8	42
45	46.044	1.06	D:\MassHunter\Library\NIST14.L			
			Coniferyl aldehyde	77201	0458-36-6	50
			Coniferyl aldehyde	77201	0458-36-6	50
			Coniferyl aldehyde	77201	0458-36-6	50
46	53.119	1.10	D:\MassHunter\Library\NIST14.L			
			n-Hexadecanoic acid	72134	0057-10-3	43
			n-Hexadecanoic acid	72134	0057-10-3	43
			n-Hexadecanoic acid	72134	0057-10-3	43
47	59.323	0.06	D:\MassHunter\Library\NIST14.L			
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
			Phenol,4,4'-(1-methylethylidene)bis-	84552	0080-05-7	38
48	61.793	0.08	D:\MassHunter\Library\NIST14.L			
			Nerolidol	85685	000142-50-7	42
			Nerolidol	85685	000142-50-7	42
			Nerolidol	85685	000142-50-7	42
49	61.852	0.02	D:\MassHunter\Library\NIST14.L			
			2-Methyloxetane	85794	1000144-10-2	50
			2-Methyloxetane	85794	1000144-10-2	50
			2-Methyloxetane	85794	1000144-10-2	50
50	61.919	0.06	D:\MassHunter\Library\NIST14.L			
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	35
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	35
			3-Penten-1-ol, 2-methyl-	3939	062238-37-3	35


Abundance
TIC: S11.D\data.ms
4000000
3500000
3000000
2500000
2000000
1500000
1000000
500000
0
6.882
6.982
6.295
4.892
6.931
8.25
8.5
10.261
12.577
23.663
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
45.00
50.00
55.00
60.00
65.00
Time-->