BEHAVIOR OF MIXTURES OF HEAVY OIL STOCKS AND WAXES

A Thesis
Submitted to the College of Engineering of
Nahrain University in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
in
Chemical Engineering

by
SARMAD KAMAL FAKHRALDEEN
(B. Sc. in Chemical Engineering 2004)

Thul - Hijjah 1428
December 2007

Certification

I certify that this thesis entitled **“Behavior of Mixtures of Heavy Oil Stocks and Waxes”** was prepared by **Sarmad kamal Fakhraldeen** under my supervision at Nahrain University, College of Engineering in partial fulfillments of the requirements for the degree of Master of Science in Chemical Engineering.

Signature:
Name: **Dr. Basim O. Hasan**
(Supervisor)
Date: / /

Signature:
Name: **Prof. Dr. Qasim J. M. Slaiman**
(Head of Department)
Date: / /

Certificate

We certify, as an examining committee, that we have read this thesis entitled "**Behavior of Mixtures of Heavy Oil Stocks and Waxes**", examined the student **Sarmad kamal Fakhraldeen** in its content and found it meets the standard of thesis for the degree of Master of Science in Chemical Engineering.

Signature:
Name: **Dr. Basim O. Hasan**
(Supervisor)
Date: / /

Signature: M-A-R. Mahommed
Name: **Ass. Prof. Dr. Muhanned A. R. Mohammed**
(Member)
Date: / /

Signature: Dr. Ammar S. Abbas
Name: **Dr. Ammar S. Abbas**
(Member)
Date: / /

Signature: J. Shanshool
Name: **Prof. Dr. Jaber Shanshool**
(Chairman)
Date: 16 / 3 / 2008

Approval of the College of Engineering

Signature: M. J. Jweeg
Name: **Prof. Dr. Muhsin J. Jweeg**
(Acting Dean)
Date: 3 / 4 /2008

Abstract

Experimental work is carried out to study behavior of mixture of mixing of two types of waxes (paraffin and microcrystalline) and different types of heavy oil (base stock 40, base stock 60, base stock 150, furfural extract 60 and furfural extract 150).

The experimental work included the determination of important properties of mixture which are drop point, penetration, and copper corrosion. Also the experimental work included the investigation of the effect of wax weight percentage, wax type and heavy oil type on these properties of mixture.

Various types of mixtures were used containing different percentages of waxes and heavy oil. The results revealed that the wax weight percentage and oil type have considerable effect on the drop point, penetration and copper corrosion of mixtures. It is found that increasing wax weight percentage leads to increase in the drop point for all types of mixture. The penetration and copper corrosion are found to decrease with the increase in wax weight percentage.

Generally the microcrystalline wax exhibits higher drop point than the paraffin wax. Also the microcrystalline wax gives lower penetration and copper corrosion than paraffin wax in all heavy oil types.

The value of drop point of different types of mixtures increases in the following manner for same type of wax and wax weight percentage: base stock oil 40, base stock oil 60**,** furfural extract oil 60, base stock oil 150 and furfural extract oil 150, The value of penetration of mixtures and increases in the following manner for same type of wax and wax weight percentage: furfural extract oil 150, base stock oil 150**,** furfural extract oil 60, base stock oil 60 and base stock oil 40. As the drop point increases the penetration decreases and the copper corrosion decreases.

According to this work, the drop point of mixture (F_6) which is composed of 30% microcrystalline wax and 70 % furfural extract oil 150 is higher than the drop point of other types of mixtures, while its penetration and copper corrosion is lower than other mixtures, that indicate leading to conclusion that this type of mixture is better than other types in prepare the special type of greases (waxy greases) in study in may work.

List of contents

Contents Page

Abstract I

List of contents III

Notations VI

List of Tables VII

List of Figure VIII

Chapter One – Introduction 1

Chapter Two – Review of literature and Theoretical Background

2.1 Base oil 3

2.1.1 Introduction of Base Oil 3

2.1.2 Chemical and Physical Properties of Base Oil 4

2.1.3 Product of Base Oil 5

2.1.4 Lube Oil Processing 6

2.1.4 Used of Base Oil 8

2.2 Lubricating Oil 8

2.3 Furfural Extract 10

2.3.1 Properties of Furfural Extract Oil 10

2.3.2 Productions of Furfural Extract Oil 11

2.3.3 Uses of Furfural Extract Oil 11

2.3.4 Safety of Furfural Extract Oil 12

2.4 Waxes 12

2.4.1 History of Waxes 12

2.4.2 Composition of Waxes 12

2.5 Paraffin Wax 14
2.5.1 Definition of Paraffin Wax 14
2.5.2 Chemical Compositions of Paraffin Wax 15
2.5.3 Physical Properties of Paraffin Wax 15
2.5.4 Chemical Properties of Paraffin Wax 17
2.5.5 Uses of Paraffin Wax 18
2.6 Microcrystalline Wax 18
2.6.1 Definition of Microcrystalline Wax 18
2.6.2 Chemical Compositions of Microcrystalline Wax 19
2.6.3 Physical Properties of Microcrystalline Wax 20
2.6.4 Chemical Properties of Microcrystalline Wax 20
2.6.5 Industries and Applications of Microcrystalline Wax 21
2.7 Grease (lubricant) 22
2.7.1 Properties of Grease 22
2.7.2 Manufacturing the Lubricants Grease 24
2.7.3 Manufacturing the EP Lubricants Grease 24
2.7.4 Uses of Grease 25
2.7.5 Types of Grease 25
2.7.6 Drop Point of Grease 26
2.7.7 Penetration of Grease 27
2.7.8 Copper Corrosion of Grease 28

Chapter Three - Experimental Work

3.1 Material used 29
3.1.1 Oils 29
3.1.2 Waxes 30
3.2 Procedure of Mixture 30

3.3 The Laboratory Experiments 33

3.3.1 Drop Point ASTM D-566 33

3.3.1.1System Description to Measure the Drop Point Experiments 33

3.3.1.2 The Procedure of Testing the Drop Point 33

3.3.2 Penetration ASTM D-217 34

3.3.2.1System Description to Measure the Penetration Experiments 34

3.3.2.2 The Procedure of Penetration Experiments 35

3.3.3 Copper Corrosion ASTM D-617 37

3.3.3.1 Description of Copper Corrosion Experiments 37

3.3.3.2 The Procedure of Copper Corrosion Experimental 38

Chapter Fore – Results and Discussions

4.1 Results 40

4.2 Discussions of Experimental Drop Point 44

4.3 Discussions of Experimental Penetration 59

4.4 Discussions of Experimental Copper corrosion 74

Chapter Five - Conclusions and Recommendations

5.1 Conclusion 79

5.2 Recommendation 80

References 81

Notations

Symbols

W	Weight (g)
V	Volume (m^3)
M	Viscosity (cp)
T	Temperature
Wt.M.	Molecular weight (mol/g)
WPM	Weight percentage of mixture
CMC	Carboxymethyl cellulose
EP	Extreme pressure
D.P.	Drop point (°C)
NLGI	National Lubricate Greases Institute
ASTM	American Standard Test Method
F.T.	Fischer-Tropsch
IGI	The International Group Inc.
API	American Petroleum Institute

List of Tables

Table	Title	page
2.1	Wax components	13
2.2	NLGI Mixture Classifications	22
2.3	Comparison of Microcrystalline and Paraffin Waxes	28
3.1	physical and chemical properties of base stock oils	29
3.2	physical and chemical properties of furfural extract oils.	29
3.3	physical and chemical properties of waxes	30
3.4	Types of samples weight percentage used in the experiments	31
4.1	Experimental result of base stock oil (40) for paraffin wax	40
4.2	Experimental result of base stock oil (40) for microcrystalline wax	40
4.3	Experimental result of base stock oil (60) for paraffin wax	41
4.4	Experimental result of base stock oil (60) for microcrystalline wax	41
4.5	Experimental result of base stock oil (150) for paraffin wax	41
4.6	Experimental result of base stock oil (150) for microcrystalline wax	42
4.7	Experimental result of furfural extract oil (60) for paraffin wax	42
4.8	Experimental result of furfural extract oil (60) for microcrystalline wax	43
4.9	Experimental result of furfural extract oil (150) for paraffin wax	43
4.10	Experimental result of furfural extract oil (150) for microcrystalline wax	44

List of Figures

Figure	Title	page
2.1	Types of paraffin wax	16
3.1	Experimental Apparatus of making of mixture	32
3.2	Instrument for drop point measurement	33
3.3	Procedure for drop point measurement	34
3.4	Apparatus hammer used for penetration measurements	35
3.5	Instrument for Penetration measurement	36
3.6	Instrument for copper corrosion measurement	38
4.1	Effect of wax WPM on drop point for base stock oil 40	45
4.2	Effect of wax WPM on drop point for base stock oil 150	45
4.3	Effect of wax WPM on drop point for base stock oil 150	46
4.4	Effect of wax WPM on drop point for furfural extract oil 150	47
4.5	Effect of wax WPM on drop point for furfural extract oil 150	47
4.6	Effect of wax WPM on drop point for paraffin wax	48
4.7	Effect of wax WPM on drop point for microcrystalline wax	49
4.8	Effect of wax WPM on drop point for paraffin wax	49
4.9	Effect of wax WPM on drop point for microcrystalline wax	50
4.10	Effect of wax WPM on drop point for paraffin wax	51
4.11	Effect of wax WPM on drop point for microcrystalline wax	51
4.12	Effect of wax WPM on drop point for paraffin wax	52
4.13	Effect of wax WPM on drop point for microcrystalline wax	53
4.14	Effect of wax WPM on drop point for paraffin wax	53
4.15	Effect of wax WPM on drop point for microcrystalline wax	54
4.16	Effect of wax WPM on drop point for paraffin wax	55
4.17	Effect of wax WPM on drop point for microcrystalline wax	55

4.18 Effect of wax WPM on drop point for paraffin wax 56
4.19 Effect of wax WPM on drop point for microcrystalline wax 57
4.20 Effect of wax WPM on drop point for paraffin wax 57
4.21 Effect of wax WPM on drop point for microcrystalline wax 58
4.22 Effect of wax WPM on the penetration for base stock oil 40 60
4.23 Effect of wax WPM on the penetration for base stock oil 60 60
4.24 Effect of wax WPM on the penetration for base stock oil 150 61
4.25 Effect of wax WPM on the penetration for furfural extract oil 60 62
4.26 Effect of wax WPM on the penetration for furfural extract oil 150 62
4.27 Effect of wax WPM on drop point for paraffin wax 63
4.28 Effect of wax WPM on drop point for microcrystalline wax 64
4.29 Effect of wax WPM on drop point for paraffin wax 64
4.30 Effect of wax WPM on drop point for microcrystalline wax 65
4.31 Effect of wax WPM on drop point for paraffin wax 66
4.32 Effect of wax WPM on drop point for microcrystalline wax 66
4.33 Effect of wax WPM on drop point for paraffin wax 67
4.34 Effect of wax WPM on drop point for microcrystalline wax 68
4.35 Effect of wax WPM on drop point for paraffin wax 68
4.36 Effect of wax WPM on drop point for microcrystalline wax 69
4.37 Effect of wax WPM on drop point for paraffin wax 70
4.38 Effect of wax WPM on drop point for microcrystalline wax 70
4.39 Effect of wax WPM on drop point for paraffin wax 71
4.40 Effect of wax WPM on drop point for microcrystalline wax 72
4.41 Effect of wax WPM on drop point for paraffin wax 72
4.42 Effect of wax WPM on drop point for microcrystalline wax 73

Chapter One

Introduction

Lube base stocks (of petroleum origin) continue to constitute a major part of today's lubricant. These are complex mixtures of paraffinic, aromatics and naphthenic hydrocarbon type molecules, ranging in carbon number from 14 to 40+. They constitute a very important segment of the hydrocarbon industry. Manufacture of these base stocks in the past two decades or so underwent evolutionary changes due to a number of reasons. The variety of crude oils that need to be processed considerably increased, coupled with the introduction of new and improved refining processes [1, 2].

Naphthenic base oils have lower pour points and better solvency characteristics, compared to paraffinic base oils which makes them, particularly useful in formulating low temperature, hydraulic oils, refrigeration oils, rubber process oils, metal working oils, as well as cylinder lubricants for large engines and greases [3].

The waxy materials present in the high boiling fractions of mineral oils are now considered to be crystalline throughout but under certain conditions may behave like a colloid. The waxes extend throughout the entire boiling range of the lubricating base stocks oil. Attempts to separate wax from oil by fractionation have met with no success [4].

Grease is one which is used rather loosely to include a great variety of products, which rang in consistency from fluid oils to comparatively hard materials, many of which are not in a strict sense of the word true greases but may be a mere mixture or solution of various ingredients such as bitumen, petroleum jelly, mineral oil to give special lubricating greases properties [5].

Waxy grease is a special type of greases are compound from mixed waxes (paraffin and microcrystalline) with base stock oils and additive some materials such as anticorrosion and this waxy greases such as greases GOE-54P [5].

The aim of the present work is to study the behavior of the mixtures of base oil stock and furfural extract oil and paraffinic wax and microcrystalline wax. The effect of Wt. % on the drop point, penetration and copper corrosion should be studied to selected any types of mixture which can be used to prepare a special type of greases called "waxy greases" which is used to protect the metal from corrosion in temperature range 40 – 60 °C and penetration 212- 243 mm.

Chapter Two

Review of literature and Theoretical Background

2.1 Base Oil

2.1.1 Introduction of Base Oil

The large number of natural lubricating and specialty oils sold today are produced by blending a small number of lubricating oil base stocks and additives. The lube oil base stocks are prepared from selected crude oils by distillation and special processing to meet the desired qualifications. The additives are chemicals used to give the base stocks desirable characteristics which they lack or to enhance and improve existing properties [6].

Base oils are the primary hydrocarbon components of industrial lubricants including engine oils, transmission fluids, hydraulic fluids, gear oils, metalworking oils, greases, heat transfer oils, general-purpose oils, and machine oils. The more intensively refined base oils (reduced levels of undesirable components) are used as food machinery lubricants, pharmaceutical white oils, laxatives, body lotions, cosmetics, direct food additives, and in a number of food-contact applications [7].

The materials in this category are complex petroleum mixtures composed primarily of saturated hydrocarbons with carbon numbers ranging from C15 to C50. At ambient temperatures lubricating base oils are liquids of varying viscosities, with negligible vapor pressures. Base oils are produced by first distilling crude oil at atmospheric pressure to remove lighter components (e.g. gasoline and distillate fuel components), leaving a residue (residuum) that contains base oil precursors. This atmospheric residuum is then distilled under vacuum to yield a range of distillate fractions (unrefined distillate base oils) and a vacuum residuum. Removal of the asphalt components of the vacuum residuum results in unrefined residual base oils. These distillate and residual base oil fractions may then undergo a series of extractive or transforming processes that improve the base oils' performance characteristics and reduce or eliminate undesirable components [8].

Lube base stock oils are conventionally prepared by refining distillate fractions or the residuum prepared by vacuum distilling a suitable crude oil from which the lighter portion has been removed by distillation in an atmospheric tower. Thus, the charge to the vacuum tower is commonly referred to as an atmospheric resid or reduced crude, and the residuum from the vacuum tower is distinguished from the starting material by referring to it as the vacuum resid [9].

The quality of the lube base stock oil prepared by the sequence of operations outlined above depends on the particular crude chosen as well as the severity of treatment for each of the treatment steps. Additionally, the yield of a high quality lube base stock oil also depends on these factors and, as a rule, the higher the quality sought, the less the yield. In general, naphthenic crudes are favored because less loss is encountered, particularly in the dewaxing step. In many cases, however, waxy crudes are more readily available, and it would be desirable to provide a process for preparing very high quality lube base stock in good yields from such waxy crude oils [12].

2.1.2 Chemical and Physical Properties of Base Oil

A lubricating oil base stock, Inter Neutral type, boiling range 282°C - 562°C, was fractionated into three boiling ranges of 282°C -456°C, 456°C -

492°C, and 492°C -562°C. The waxes were isolated from the parent base stock and its fractions by solvent dewaxing. Hydrocarbon-type constituents, i.e., saturates, naphthenic aromatics, and polar aromatics, were separated by elution chromatography and were characterized for their physical properties. The viscosity-temperature behavior of the base stock sample and its various fractions and components, i.e., dewaxed oil, extracted waxes, saturates, naphthenic aromatics, and polar aromatics, was determined and correlated with the composition. It was found that the concentration, nature, and type of hydrocarbon components present greatly influenced the physical properties as well as the viscosity-temperature behaviors [15].

Base stocks differ widely in molecular composition, physical and chemical properties due to the crude source and processing steps used in their manufacture. These differences in base stock composition, even with similar physical properties can impact the end use performance of finished lubricants [10, 11].

As such lube base stocks are thus considered to be non-fungible products in many end use applications. In 1990 the American Petroleum Institute (API) established a base oil classification system to help marketers to minimize re-testing costs when blending licensed engine oils with base oils from different manufacturing sources [11].

2.1.3 Product of Base Oil

The instant invention is directed to a method for producing a lubricating base stock having a preselected oxidative stability comprising the steps of: (a) separating, into a plurality of fractions based on molecular shape, a hydroisomerized hydrocarbon wax, (b) collecting the fractions of step (a) which have the preselected oxidative stability for use as a lubricating base stock, wherein the fractions to be collected are determined by measuring the oxidative stability of each of said fractions of said plurality of fractions to determine which fractions have said preselected oxidative stability. The invention is also directed to improve lubricating base oil and a formulated lubricating composition using said lubricating base oil [19].

Lube base stock oil of low pour point and excellent stability is produced from a waxy crude oil fraction by solvent refining, catalytic dewaxing over a zeolite catalyst in the nature of zeolite ZSM-5 and hydro treating under specified conditions [12].

Lubricating oil compositions having substantially reduced pour points are prepared by incorporating an effective pour depressant amount of an oil-soluble copolymer of ethylene and a vinyl ester of a lower saturated monobasic aliphatic carboxylic acid in a paraffinic, waxy-type, residual lubricating oil base stock. The copolymers, in which the lower saturated monobasic carboxylic component of the ester has from 2 to 6 carbon atoms, have molecular weights of about 16,000 to about 31,000 and which contain about 17 to about 42 weight percent of the vinyl ester, can be added to the lubricating base stock in the form of an emulsion, as a hydrocarbon solution or in any other convenient manner [13].

2.1.4 Lube oil processing

The first step in processing of lubricating oils is the separation on the crude oil distillation units of the individual fractions according to viscosity and boiling range specifications. The heavier lube oil raw stocks are included in the vacuum fractionating tower bottoms with the asphaltenes, resins, and other undesirable materials.

The raw lube oil fractions from most crude oils contain components which have undesirable characteristics for finished lubricating oils. These must be removed or reconstituted by processes such as liquid-liquid extraction, crystallization, selective hydrocracking, and / or hydrogenation. The undesirable characteristics include high pour points, large viscosity changes with temperature (low VI), poor oxygen stability, poor color, high cloud points, high organic acidity, and high carbon- and sludge-foming tendencies [14].

The processes used to change these characteristics are:

1. Reduce carbon- and sludge-forming tendencies
   Solvent deasphalting
2. Improve viscosity index
   Solvent extraction
   Hydrocracking
3. Lower cloud and pour points
   Solvent dewaxing
   Selective hydrocracking
4. Improve color and oxygen stability
   Hydrotreating
5. Lower organic acidity
   Hydrotreating[14].

2.1.5 Use of Base Oil

Base oils are commonly used for the production of lubricants, such as lubricating oils for automotives, industrial lubricants and lubricating greases. They are also used as process oils, white oils and metal working oils. Finished lubricants consist of two general parts, lubricating base oils and additives. Base oils are the major constituents in finished lubricants and they contribute significantly to the properties of the finished lubricant. In general, a few base oils are used to manufacture a wide variety of finished lubricants by varying the mixtures of individual base oils and individual additives [15].

2.2 Lubricating Oil

The residual fractionation of atmospheric and vacuum distillation produces lubricating oils and waxes. The primary objective of the various lubricating oil refinery processes is to remove asphalts, sulfonated aromatics, and paraffin and isoparaffin waxes from residual fractions. Reduced crude from the vacuum unit is deasphalted and combined with straight-run lubricating oil feedstock, preheated, and solvent-extracted (usually with phenol or furfural) to produce raffinate. The manufacture of low-cold test lubricating oils is accomplished by vacuum distillation in the presence of a small amount of causticsoda, or soda ash, acid treatment and soda ash neutralization of each of the several lube fractions, and percolation clay treatment. The most viscous oils must be diluted with naphtha or the lightest lube fraction before treating [16].

The dewaxed raffinate is blended with other distillate fractions and further treated for viscosity index, color, stability, carbon residue, sulfur, additive response, and oxidation stability in extremely selective extraction processes using solvents (furfural, phenol, etc.). In a typical phenol unit, the raffinate is mixed with phenol in the treating section at temperatures below 400° F. Phenol is then separated from the treated oil and recycled. The treated lube-oil base stocks are then mixed and/or compounded with additives to meet the required physical and chemical characteristics of motor oils, industrial lubricants, and metal working oils [17].

A lubricating oil base stock containing less than 0.03% sulfur, greater than or equal to 90% saturates and having a viscosity index of at least 80, which lubricating oil base stock is prepared from a lube oil feedstock containing at least 0.1% sulfur by a process comprising[18].

Mineral lubricant base oils (e.g., neutral oils) can be added to asphalt composition to improve low temperature properties at low addition rates (e.g., oil 1-5%). Rerefined oils (boiling above about 177.degree. C.) have the same properties as virgin mineral lubricant base oils, but most rerefined oils are too dark in color to be used as lube oil base stocks. Their use in asphalt would be ideal as color is not a problem and they are much cheaper in cost than virgin base oils. This can permit disposing of rerefined motor oil. The resulting asphalt compositions exhibit important improvements in low temperature properties, resistance to thermal cracking and expanded useful temperature range [19].

Lubricating oil can oxidize, so can the base oil in grease. When the grease oxidizes, it usually darkens; there is a build-up of acidic oxidation products, just as in other lubrications. These products can have a destructive effect on the thickener, causing softening, oil bleeding, and leakage. Because grease does not conduct heat easily, serious oxidation can begin at a hot point and spread slowly through the grease. This produces carbonization and progressive hardening or crust formation. The effects of oxidation are more harmful in grease than in oil [19].

2.3 Furfural Extract

The chemical compound furfural is an industrial chemical derived from a variety of agricultural byproducts, including corncobs, oat and wheat bran, and sawdust. The name furfural comes from the Latin word furfur, meaning bran, referring to its usual source [20].

Furfural is an aromatic aldehyde, with the ring structure shown at right. Its chemical formula is $C_5H_4O_2$. In its pure state, it is a colorless oily liquid with the odor of almonds, but upon exposure to air it quickly becomes yellow [20].

2.3.1 Properties of Furfural Extract Oil

Furfural's physical properties are summarized in the table at right. Furfural dissolves readily in most polar organic solvents, but is only slightly soluble in either water or alkanes.

Chemically, furfural participates in the same kinds of reactions as other aldehydes and other aromatic compounds. The aromatic stability of furfural is not as great as in benzene, and furfural participates in hydrogenation and other addition reactions more readily than many other aromatics.

When heated above 250 °C, furfural decomposes into furan and carbon monoxide, sometimes explosively, when heated in the presence of acids; furfural irreversibly solidifies into a hard thermosetting resin [21].

2.3.2Productions of Furfural Extract Oil

Many plant materials contain the polysaccharide hemicelluloses, a polymer of sugars containing five carbon atoms each. When heated with sulfuric acid, hemicelluloses undergo hydrolysis to yield these sugars, principally xylose. Under the same conditions of heat and acid, xylose and other five carbon sugars undergo dehydration, losing three water molecules to become furfural:

$$C_5H_{10}O_5 \rightarrow C_5H_4O_2 + 3\ H_2O$$

For crop residue feedstock's, about 10% of the mass of the original plant matter can be recovered as furfural. Furfural and water evaporate together from the reaction mixture, and separate upon condensation.

Global total capacity of production is about 450,000 ton. China is the biggest supplier of this product and they have about a half of global capacity. In the laboratory, synthesis of furfural from corn cobs takes place by reflux with concentrated sulfuric acid [20, 22].

2.3.3 Uses of Furfural Extract Oil

Furfural is used as a solvent in petrochemical refining to extract dienes (which are used to make synthetic rubber) from other hydrocarbons, Furfural, as well as its derivative furfuryl alcohol, can be used either by themselves or in together with phenol, acetone, or urea to make solid resins. Such resins are used in making fiberglass, some aircraft components, and automotive brakes.

Furfural is also used as a chemical intermediate in the production of the solvents furan and tetrahydrofuran. Hydroxymethylfurfural has been identified in a wide variety of heat processed foods [23].

2.3.4 Safety of Furfural Extract Oil

When ingested or inhaled, furfural can cause symptoms similar to those of intoxication, including euphoria, headache, dizziness, nausea, and eventual unconsciousness and death due to respiratory failure. Contact with furfural irritates the skin and respiratory tract and can cause the lungs to fill with fluid.

Chronic skin exposure can lead to a skin allergy to the substance, as well as an unusual susceptibility to sunburn. In toxicity studies, furfural has led to tumors, mutations, and liver and kidney damage in animals [22, 24].

2.4 Waxes

2.4.1 History of Waxes

Wax research was established as a scientific discipline in 1823. It became part of the new research area of soaps, oils, fats, and waxes. The real breakthrough of wax as an important raw material, in terms of quantity, occurred at the beginning of the Industrial Revolution. Ozocerite (fossil wax) was mined and refined to give ceresin, Montan wax was obtained from Eocene lignite, and paraffin waxes were obtained from crude petroleum [25].

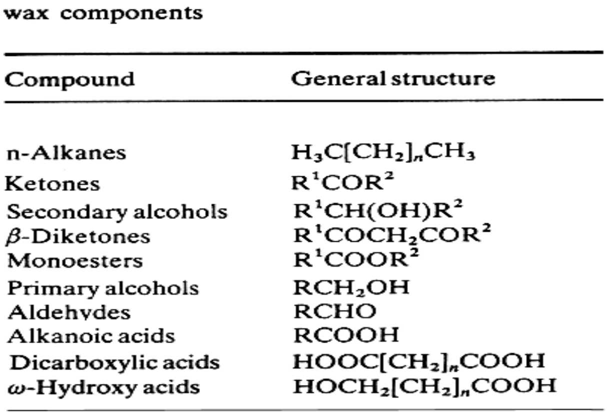
2.4.2 Compositions of Waxes

Typically wax is complex mixtures. Being oligomers or polymers in many cases, the components differ in their molar mass, molar mass distribution, or in the degree of side-chain branching. Functional groups such as carboxyl, alcohol, and ester, keto, and amide groups can be detected in waxes, sometimes several different groups [25, 26].

Raffinate from the extraction unit contains a considerable amount of wax that must be removed by solvent extraction and crystallization. The raffinate is mixed with a solvent (propane) and precooled in heat exchangers. The crystallization temperature is attained by the evaporation of propane in the chiller and filter feed tanks. The wax is continuously removed by filters and cold solvent-washed to recover retained oil. The solvent is recovered from the oil by flashing and steam stripping. The wax is then heated with hot solvent, chilled, filtered, and given a final wash to remove all oil [28].

The various materials named waxes do not form a chemically homogeneous group. All waxes are water-resistant materials made up of various substances including hydrocarbons (normal or branched alkanes and alkenes), ketones, diketones, primary and secondary alcohols, baldheads, sterol esters, alkanoic acids, terpenes (squalene) and monoesters (wax esters)in table 2.3, all with long or very long carbon chains (from 12 up to about 38 carbon atoms) and solid in a large range of temperature (fusion point between 60 and 100°C) [26, 27].

Table 2.1: wax components [26].



wax components

Compound	General structure
n-Alkanes	$H_3C[CH_2]_nCH_3$
Ketones	R^1COR^2
Secondary alcohols	$R^1CH(OH)R^2$
β-Diketones	$R^1COCH_2COR^2$
Monoesters	R^1COOR^2
Primary alcohols	RCH_2OH
Aldehydes	$RCHO$
Alkanoic acids	$RCOOH$
Dicarboxylic acids	$HOOC[CH_2]_nCOOH$
ω-Hydroxy acids	$HOCH_2[CH_2]_nCOOH$

Wax is an organic, plastic-like substance that is solid at ambient temperature and becomes liquid when melted. Because wax is plastic in nature, it usually deforms under pressure without the application of heat.

The general features of wax:

1) Solid at ambient temperature
2) Thermoplastic in nature
3) Combustible
4) Liquid at 110 °F to 200 °F
5) Insoluble in water

Waxes can be further categorized by origin as follows:

1. Natural Waxes –
2. Animal Waxes – Beeswax, Lanolin, Tallow
3. Vegetable Waxes – Carnauba, Candelilla, Soy
4. Mineral Waxes
5. Fossil or Earth – Ceresin, Montan
6. Petroleum – Paraffin, Microcrystalline
7. Synthetic (man-made)
8. Ethylenic polymers such as polyethylene & polyol ether-esters
9. Chlorinated naphthalene's
10. Hydrocarbon type, such as Fischer-Tropsch [26, 29].

2.5 Paraffin Wax

2.5.1 Definition of Paraffin Wax

Paraffin is a common name for a group of alkane hydrocarbons with the general formula C_nH_{2n+2}, where n is greater than about 20, discovered by Carl Reichenbach. It is distinct from the fuel known in Britain as paraffin oil or just paraffin, which is called kerosene in American English. Usage of the term varies in other countries, leading to confusion about which substance is being referred to. The solid forms of paraffin are called paraffin wax. Paraffin is also a technical name for an alkane in general, but in most cases it refers specifically to a linear or normal alkane — whereas branched, or isoalkanes are also called isoparaffins. The name is derived from the Latin parum affinis with the meaning here of "lacking affinity", or "lacking reactivity") [30].

Paraffin waxes are obtained from light and middle lubricating oil cuts of vacuum distillation. Paraffin waxes also include waxes from heavy lubricating oil distillates, which are intermediates between microcrystalline and microcrystalline waxes with regard to structure and composition (intermediate waxes) [30].

2.5.2 Chemical Compositions of Paraffin Wax

Paraffin waxes consist predominantly of mixtures of straight-chain alkanes in a typical distribution of the homologous series whose molar masses depend on the boiling range of the lubricating oil distillate from which they are obtained. Long-chain, weakly branched isoalkanes are present in a much lower proportion, along with a very small fraction of monocyclic alkanes [25].

2.5.3 Physical Properties of Paraffin Wax

Paraffin waxes are insoluble in water and sparingly soluble in low molar mass aliphatic alcohols and ethers. They are more soluble in ketones, chlorohydrocarbons, petroleum spirit, solvent naphtha, benzene, toluene, xylene, and higher aromatics, especially at elevated temperature. The solubility decreases markedly with increasing molar mass (higher melting point) of the waxes [25, 31].

Paraffin Wax is a natural product derived from the molecular components of decayed vegetable and animal material. Paraffin wax consists of a complex mixture of hydrocarbons with the following general properties.

1) Non-reactive
2) Non-toxic
3) Good water barrier
4) Clean-burning fuel
5) Colorless [32].

Paraffin waxes are characterized by a clearly defined crystal structure and have the tendency to be hard and brittle. The melt point of paraffin waxes generally falls between 48.89 and 71.11°C.

Individual test methods are determined by molecular size & structure, chemical composition and oil content. Paraffin wax consists mostly of straight chain hydrocarbons with 80 to 90% normal paraffin content and the balance consists of branched paraffin's (iso-paraffin) and cycloparaffins figure 2.1[32].

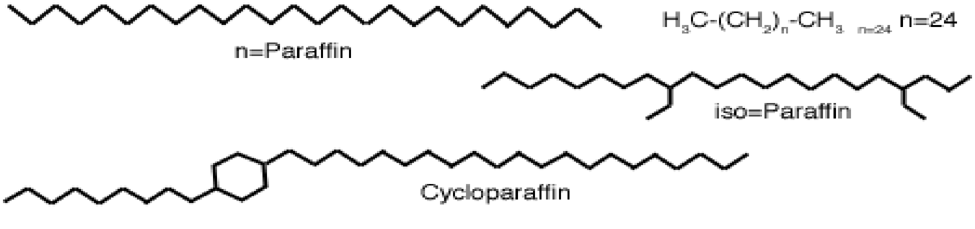


Figure 2.1: Types of paraffin wax

Typical test methods that can be measured and controlled include melt point, congealing point, penetration, hardness, oil content, viscosity and color.

However, these physical properties alone do not completely define the suitability of a wax for a particular application. The functional properties of wax should be considered as well. These include the translucency & opaqueness of the wax, solid appearance such as dry, waxy, mottled, and shiny and flexibility, etc. It is the combination of physical and functional properties that ultimately determine if a particular wax is right for a given application [32, 33].

Division into Product Classes:

Depending on the degree of refining, paraffin waxes are divided into the following product classes:

1. Crude waxes, also known as slack waxes
2. Slack wax raffinates (scale waxes)
3. Deoiled slack waxes
4. Soft waxes
5. Semi-refined waxes
6. Filtered (decolorized) waxes
7. Fully refined waxes [25].

2.5.4 Chemical Properties of Paraffin Wax

Paraffin waxes are extremely unreactive under normal conditions. Oxidation reactions occur only at elevated temperatures (e.g., on storage and processing above 100 °C), particularly in the presence of oxygen and catalytically active metals. These reactions can be recognized from the burnt odor produced and the yellow to brown coloration of the waxes. Nevertheless, under certain thermally and catalytically controlled conditions, these waxes can undergo chemical reactions such as chlorination, oxidation, dehydrogenation, and cracking, of which chlorination and cracking are important in industry [25, 32].

2.5.5 Uses of Paraffin Wax

1) Candle making
2) Coatings for waxed paper or cloth.
3) Food-grade paraffin wax
4) A key component in wax used for investment casting.
5) As anti-caking, moisture repellent, and dustbinding coatings for fertilizers.
6) Preparing specimens for histology.
7) In dermatology, as an emollient (moisturiser).
8) The primary component of glide wax, used on skis and snowboards.
9) For use on handrails and cement ledges to dramatically reduce friction for rolling, otherwise known as aggressive in-line skating.
10) The paraffin test is used in forensics to detect nitrates and nitrites on the hand of a shooting suspect.
11) Paraffin waxes are utilized in numerous electrical applications as a result of their insulating capabilities [25, 34].

2.6 Microcrystalline wax

2.6.1 Definition of Microcrystalline Wax

Microcrystalline wax is a refined mixture of solid, saturated aliphatic hydrocarbons, and produced by de-oiling certain fractions from the petroleum refining process. Microcrystalline waxes differ from refined paraffin wax in that the molecular structure is more branched and the hydrocarbon chains are longer (higher molecular weight). As a result the crystal structure of microcrystalline wax is much finer than paraffin wax, and this directly impacts many of the physical properties. Microcrystalline waxes are tougher, more flexible and generally higher in melting point than paraffin wax. The fine crystal structure also enables microcrystalline wax to bind solvents or oil, and thus prevent the sweating-out of compositions [35].

Microcrystalline waxes originate from vacuum residues and from the sediments of paraffin crude oil (settling waxes). Waxes that are liquid at room temperature are mostly contained in diesel oil or gas oil fractions and can be isolated from them [25].

Microcrystalline waxes when produced by wax refiners are typically produced to meet a number of ASTM specifications. These include congeal point (ASTM D938), needle penetration (D1321), color (ASTM D6045), and viscosity (ASTM D445). Microcrystalline waxes can generally be put into two categories: "laminating" grades and "hardening" grades. The laminating grades typically have a melt point of 60 °C - 115 °C and needle penetration of 25mm. or above. The hardening grades will range from about 79.44°C - 128.89 °C, and have a needle penetration of 25mm. or below. Color in both grades can range from brown to white, depending on the degree of processing done at the refinery level [35].

2.6.2 Chemical Compositions of Microcrystalline Wax

Like paraffin waxes, microcrystalline waxes consist of a mixture of saturated hydrocarbons that are predominantly solid at room temperature, such as n- and isoalkanes, naphthenes, and alkyl- and naphthenes-substituted aromatics. Unlike paraffin waxes, isoparaffins and naphthenic compounds predominate here. The microcrystalline structure can be explained by the presence of strongly branched isoparaffins and naphthenes, which inhibit crystallization [25].

2.6.3 Physical Properties of Microcrystalline wax

Microcrystalline waxes are insoluble in water and most organic solvents at room temperature. They are moderately to readily soluble in solvents such as chlorohydrocarbons, benzene, toluene, xylene, solvent naphtha, and turpentine oil, especially at elevated temperature. Solubility decreases markedly as molar mass increases. Solvents and oils are retained very strongly by microcrystalline waxes and therefore evaporate very slowly. The quality of some consumer products, such as petroleum jellies or floor and shoe polish, is determined by this retention capacity of micro waxes [25].

Division into Product Classes:

Depending on the degree of refining, microwaxes are divided into the following classes:

1. Bright stock slack waxes (petrolatum)
2. Plastic microwaxes
3. Hard micro waxes [25].

2.6.4 Chemical Properties of Microcrystalline Wax

Microcrystalline waxes are more reactive than paraffin waxes because of the higher concentration of complex branched hydrocarbons with tertiary and quaternary carbon atoms. These C–C bonds are not very thermally stable (i.e. the waxes darken and resinify) on prolonged heating. In addition, they form black tar like substances on contact with aggressive chemicals such as concentrated sulfuric acid or antimony pent chloride [36].

The reaction of micro waxes with oxygen at elevated temperature and in the presence of catalytically acting heavy-metal soaps is used for the production of oxidized microwaxes.

2.6.5 Industries and Applications of Microcrystalline Wax

Microcrystalline Wax is often used in industries such as the tire and rubber, candles, adhesives, corrugated board, cosmetics, castings, and a host of others. Refineries may also utlize blending faciluties to combine paraffin and microcrystalline waxes. This type of activity is prevalent especially for industries such as tire and rubber [36].

Microcrystalline waxes are excellent materials to use when modifying the crystalline properties of paraffin wax. The microcrystalline wax has a significant effect on the branching of the carbon chains that are the backbone of paraffin wax. This is useful when some desired functional changes in the paraffin are needed, such as flexibility, higher melt point, and increased opacity [35].

1) Microcrystalline waxes are used as a desensitizer in the manufacture of detonating fuses.
2) The waxes are usually provided by specialty businesses that utilize the paraffin and microcrystalline waxes with other materials to make a finished dental wax
3) Paraffin and microcrystalline waxes serve as binders in investment casting “waxes” and assist in the removal of the blend after the mold is produced. Investment casting waxes offer exceptional dimensional stability required in precision castings of metals [35,37].

Table 2.2: Comparison of Microcrystalline and Paraffin Waxes [37].

Paraffin Wax	Microcrystalline Wax
Mainly unbranched alkanes	Mainly branched alkanes
Crystalline	Amorphous
Brittle	Malleable
Translucent	Opaque
Low melting (48 to 70?C)	Higher melting (54 to 95?C)
Glossy	Adhesive
Hard	Soft
White	White to Colored
Odorless	Odorless

2.7 Grease (lubricant)

2.7.1 Properties of Grease

Grease is a lubricant of higher initial viscosity than oil, consisting originally of a calcium, sodium or lithium soap jelly emulsified with mineral oil, true grease consists of oil and other fluid lubricant that is mixed with another thickener substance, a soap, to form a solid. Greases are a type of shear-thinning or pseudo-plastic fluid, which means that the viscosity of the fluid is reduced under shear. After sufficient force to shear the grease has been applied, the viscosity drops and approaches that of the base lubricant, such as the mineral oil. This sudden drop in shear force means that grease is considered a plastic fluid, and the reduction of shear force with time makes it thixotropic. It is often applied using a grease gun, which applies the grease to the part being lubricated under pressure, forcing the solid grease into the spaces in the part [38, 39].

This viscosity selection is confused by the common practice in grease manufacture to blend higher and lower viscosity base oils to achieve the desired viscosity. For a 110 cSt base oil at 40°C, for instance, the lighter oil used in blending might be in the 40 to 75 cSt range, the heavier at 175 to 200°C [40].

Grease is made by blending metallic soaps (salts of long-chained fatty acids) and additives into a lubricating oil medium at temperatures of 400°-600° F. Grease may be either batch-produced or continuously compounded. The characteristics of the grease depend to a great extent on the metallic element (calcium, sodium, aluminum, lithium, etc.) in the soap and the additives used.Soaps are the most common emulsifying agent used, and the type of soap depends on the conditions in which the grease is to be used. Different soaps provide differ levels of temperature resistance (relating to both viscosity and volatility), water resistance, and chemical reactivity. Powder solids may also be used, such as clay, which was used to emulsify early grease and is still used in some inexpensive, low performance grease [41, 42].

An oil and grease resistant formulation comprising: a. polyvinyl alcohol and b. a fatty-acid melamine wax, wherein said polyvinyl alcohol comprises from about 40 to about 90 percent by weight and said fatty-acid melamine wax comprises from about 10 to about 60 percent by weight, based on the total weight of said formulation[29].

2.7.2 Manufacturing the Lubricants Grease

This term is applied primarily to greases, semisolid compositions, and gear oils, even though some of the materials are as mush like liquid oils like soils. Most generally, greases may be grouped into three classes:-

1. Admixtures of mineral oil and solid lubricant. Some of the common solid lubricants are graphite, mica, talc, sulfur and asbestos fiber. These greases are invaluable in the lubrication of ill-fitting machine parts functioning under heavy or intermittent loads. Examples of this type are tractor-roller lubricants for concrete mixers, ditch-digging equipment, and railroad-car unloading devices.
2. Blends of residuum, waxes, uncombined fats, rosin oils and pitches. This group is particularly suited to the lubrication of rock bits, steel cables, water pumps, dredges and chains, and gears operating under water or under exposed weather conditions.
3. Soap-thickened mineral oils. Common thickeners are sodium, calcium, aluminum, and lithium and lead soaps. The soaps of these metals are prepared by saponification of fatty glyceride of either animal or vegetable origin. This group is widely useful because a large variety of different consistency greases can be produced by selecting various metallic soaps, fatty glycerides and mineral oils [43].

2.7.3 Manufacturing the EP Lubricants Grease

There are also three general bases used for manufacturing the EP lubricants now used almost exclusively for differential, transmission, and general gear lubrication.

1. Blends of saponifiable oil containing chemically combined sulfur with suitable lubricating oil or mineral oils to which flowers of sulfur have been added.

2. Blends of a sulfur chloride-treated saponifiable oil base and a lubricating oil of suitable viscosity or chlorine combined directly with chosen mineral-oil fractions.
3. Lubricants containing lead soaps of fatty or naphthenic acids and sulfur. These may contain sulfur that has been added or only the sulfur that is naturally present in the mineral oil [44].

2.7.4 Uses of Grease

Greases are employed when heavy pressures exist, oils drip from the bearings is undesirable, and/or the motions of the contacting surfaces are discontinuous so that it is difficult to maintain a separating lubricant film in the bearing. Grease-lubricated bearings have greater frictional characteristics at the beginning of operation. Under shear, the viscosity drops to give the effect of an oil-lubricated bearing of approximately the same viscosity as the base oil used in the grease. Calcium- and sodium-based greases are the most commonly used; sodium-based greases have higher melting point than calcium-based greases but are not resistant to the action of water. Lithium-based grease has a drip temperature at 190 °C to 220 °C and it resists moisture, hence it is commonly used as lubricant in household products such as garage door openers, grease used for axles are composed of a compound of fatty oils to which is added tar, graphite, or mica to increase the durability of the grease and give it a better surface [29, 45].

2.7.5 Type of Grease

Teflon is added to some grease to improve their lubricating properties. Gear greases consist of rosin oil, thickened with lime and mixed with mineral oil, with some percentage of water. Special-purpose greases contain glycerol and sorbitan esters. They are used, in low-temperature conditions. Some grease is labeled "EP", which indicates "extreme pressure". Under high pressure or shock loading, normal grease can be compressed to the extent that the greased parts come into physical contact, causing friction and wear. "EP" grease contains solid lubricants, usually graphite and/or molybdenum, to provide protection under heavy loadings. The solid lubricants bond to the surface of the metal, and prevent metal-to-metal contact and the resulting friction and wear when the lubricant film gets too thin [40].

Other types of lubricating material that are soft solids or high viscosity liquids at room temperature are often called grease, though they may not exhibit the shear-thinning properties typical of the oil/soap grease. Petroleum jellies, such as Vaseline, are also sometimes called greases, and are commonly used for lubricating food-handling equipment. Silicone grease is an amorphous fumed, silica-thickened, polysiloxane-based compound, which can be used to provide lubrication and corrosion resistance. Since it is not oil-based, it is often used where oil-based lubricants would attack rubber seals. Silicone greases also maintain stability under high temperatures, and are often used, in pure form or mixed with zinc oxide, to join heat sinks to computer CPUs [45, 46].

2.7.6 Drop Point of Grease

Drop point means qualitative ownership from lubrication the grease which gives public sign on the degree of temperature that the mixture passes through the solid half to the liquid status under partial test condition; it is a measurement of heat resistance for any mixture [47].

Grease, when heated above its drop point and then allowed to cool it usually does not fully regain its grease-like consistency, and its performance subsequently will be unsatisfactory. The problem with multi-purpose greases is that at least one of the agents will exceed its drop point thus adversely affecting the soap unification process. Grease has a maximum temperature at which it can safely be used. Therefore, it follows that it must also have a minimum temperature. The minimum temperature is the point where the grease becomes too hard for the bearing, or other greased component, to be used. The base oil of the grease determines the minimum temperature [29].

2.7.7 Penetration of Grease

To stiff grease may not be used into areas requiring lubrication, while grease that is too fluid may leak out. Grease consistency depends on the type and amount of thickener used and the viscosity of its base oil. Grease's consistency is its resistance to deformation by an applied force. The measure of consistency is called penetration. Penetration depends on whether the consistency has been altered by handling or working. ASTM D 217 and D 1403 methods measure penetration of unworked and worked greases [49].

To measure penetration, a cone of given weight is allowed to sink into a grease for 5 seconds at a standard temperature of 25°C). The depth, in tenths of a millimeter, to which the cone sinks into the grease, is the penetration. A penetration of 100 would represent solid grease while one of 450 would be semi fluid. The NLGI has established consistency numbers or grade numbers, ranging from 0000 to 6, corresponding to specified ranges of penetration numbers. Table (2.1); below lists the NLGI grease classifications along with a description of the consistency of each classification [49, 50].

Table 2.3: NLGI Grease Classification [49].

NLGI Grease Classification		
NLGI Number	**ASTM Worked Penetration 0.1 mm at 25°C**	**Consistency**
0000	**445 - 475**	**Semi fluid**
00	**400 - 430**	**Semi fluid**
0	**355 - 385**	**Very soft**
1	**310 - 340**	**Soft**
2	**265 - 295**	**Common grease**
3	**220 - 250**	**Semi hard**
4	**175 - 205**	**Hard**
5	**130 - 160**	**Very hard**
6	**85 - 115**	**Solid**

2.7.8 Copper Corrosion of Grease

According to product type and specification.

Results are reported as a number followed by a letter according to the following scheme:-

1) Slight tarnishes a. light orange, almost the same as a freshly polished strip b. dark orange.

2) moderate tarnish a. claret red b. lavender c. multi colored with lavender blue or silver, or both , overlaid on claret red d. silvery e. brassy or gold.

3) Dark tarnish a. magenta overcast on brassy strip b. multi-colored with red and green showing (peacock), but no gray.

4) Corrosion a. transparent black, dark gray or brown with peacock green barley showing b. graphite or lusterless black c. glossy or jet black.[51]

Chapter three

Experimental Work

3.1 Material used

3.1.1 Oils

The oils used in the experiment are base stock oil and furfural extract oil produced by Al-Dorah refinery. The physical and chemical properties of base stock oil and furfural extract oil are shown in tables 3.1, 3.2.

Table 3.1: physical and chemical properties of base stock oils.

Properties	Base stock oil 40	Base stock oil 60	Base stock oil 150
Viscosity cp	2.8 - 3.2	10 - 12	22 - 29
Color	1.5	3.5-4.5	6.5
Gravity	0.86	0.88	0.908
Pour point °C	- 12	- 14	-15
Flash point °C	175	255	313

Table 3.2: physical and chemical properties of furfural extract oils.

Properties	Furfural extract 60	Furfural extract 150
Viscosity index cp	7 - 9	25 - 28
Color ASTM	6 - 8	dark
Gravity	1.01	0.97
Flash point °C	254	296

3.1.2 Waxes

The waxes used in the experiment are paraffin wax and microcrystalline wax produced by Al-Dorah refinery. The physical and chemical properties of paraffin wax and microcrystalline wax are shown in tables 3.3.

Table 3.3: physical and chemical properties of waxes.

Properties	Paraffin wax	Microcrystalline wax
Oil content %	1.5	5.0
Color ASTM	1-1.5	4.5 - dark
Penetration **0.1 mm at 25°C** melting point **°C**	34 48	18 71

3. 2 Procedure of Mixture

Sensitive balance is placed in a small room free from air current in order to prevent the entry of air which affects the reading of the balance. A beaker containing is placed in the balance. The beaker is weight of 100 g and the mixture weight used in obtaining the result is 100 g. At start the reading of the balance is set to zero and restart the balance to ensure a correct reading.

A sample is taken from each type of waxy substances mix it with one type of oil. These samples are illustrated in Table (3.4):

Table 3.4: Types of samples weight percentage used in the experiments

Sample name	Oil type	Oil weight %	Waxy type	Wax weight %
A1	Base stock 40	90%	paraffin wax	10%
A2	Base stock 40	80%	paraffin wax	20%
A3	Base stock 40	70%	paraffin wax	30%
A4	Base stock 40	90%	Microcrystalline wax	10%
A5	Base stock 40	80%	Microcrystalline wax	20%
A6	Base stock 40	70%	Microcrystalline wax	30%
B1	Base stock 60	90%	paraffin wax	10%
B2	Base stock 60	80%	paraffin wax	20%
B3	Base stock 60	70%	paraffin wax	30%
B4	Base stock 60	90%	Microcrystalline wax	10%
B5	Base stock 60	80%	Microcrystalline wax	20%
B6	Base stock 60	70%	Microcrystalline wax	30%
C1	Base stock 150	90%	paraffin wax	10%
C2	Base stock 150	80%	paraffin wax	20%
C3	Base stock 150	70%	paraffin wax	30%
C4	Base stock 150	90%	Microcrystalline wax	10%
C5	Base stock 150	80%	Microcrystalline wax	20%
C6	Base stock 150	70%	Microcrystalline wax	30%
E1	Furfural extract 60	90%	paraffin wax	10%
E2	Furfural extract 60	80%	paraffin wax	20%
E3	Furfural extract 60	70%	paraffin wax	30%
E4	Furfural extract 60	90%	Microcrystalline wax	10%
E5	Furfural extract 60	80%	Microcrystalline wax	20%
E6	Furfural extract 60	70%	Microcrystalline wax	30%
F1	Furfural extract150	90%	paraffin wax	10%
F2	Furfural extract 150	80%	paraffin wax	20%
F3	Furfural extract 150	70%	paraffin wax	30%
F4	Furfural extract 150	90%	Microcrystalline wax	10%
F5	Furfural extract 150	80%	Microcrystalline wax	20%
F6	Furfural extract 150	70%	Microcrystalline wax	30%

For example, sample C_2 consists 20% paraffin wax and 80% base stock oil 150, the weight of wax is 20 g and the weight of base stock oil 150 is 80 g the total weight of mixture is 100 g. The paraffin wax in the beaker is placed on the sensitive balance measuring the mount of wax with pouring the oil on the paraffin wax in the beaker in order to reach the weight of mixture 100g.

The mixture is heated by putting the beaker on heater, in order to increase the temperature of mixture to become homogenous and the homogeneity is increased by using an electrical heater Figure 3.1.

The temperature of mixture increases and the wax dissolves gradually in the oil till the paraffin wax dissolves completely in base stock oil 150 and in this degree the mixture becomes completely homogenous taking in the consideration that the degree of dissolution of waxes is different according to the type of wax and its wax weight percentage in the mixture from one side and the type of oil and its degree on the other side.

When the mixture becomes homogenous, it is placed in plastic glasses. The mixture is left to cool and the temperature decreases until the mixture becomes semi-solid in the plastic glasses. It is possible to make the necessary tests on the samples.

The following properties of sample are determined:

1. Drop point
2. Penetration
3. Copper corrosion

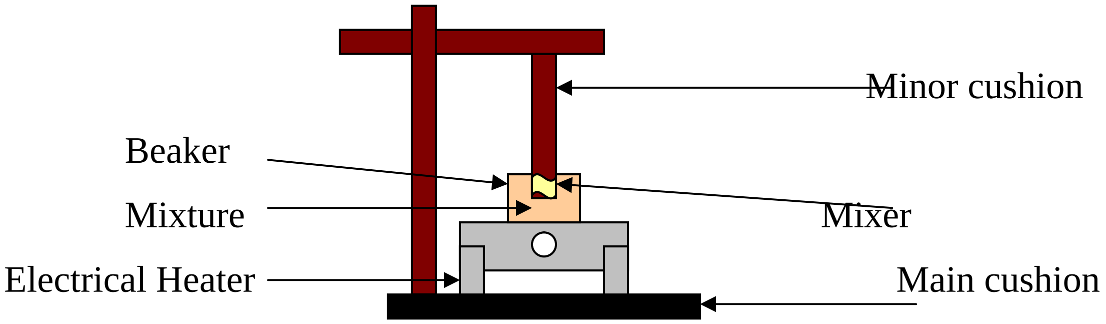


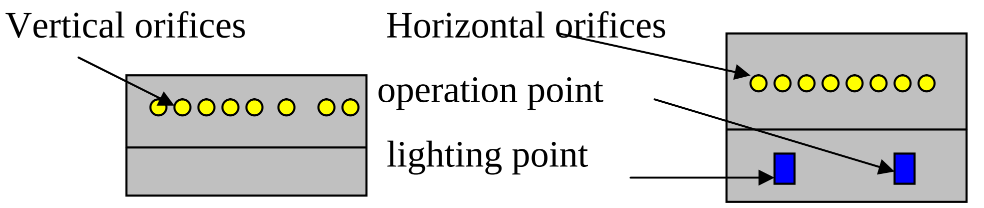
Fig. 3.1 : Experimental Apparatus of making mixture

3.3 The Laboratory Experiments

3.3.1 Drop Point ASTM D-566

3.3.1.1 System Description to Measure the Drop Point Experiments

The instrument was used t measure the drop point of mixture. The instrument used is shown in Fig. 3, 2. The test instrument has a rectangular shape made of iron and it has an electrical heater which contains 8 horizontals orifices it lips to see the descending point which clarity increases the sight existing the electrical lamp inside the instrument 8 vertical orifices above the horizontal orifices in addition to the external supple mentations like the test cup, needle, thermometer, test tube, the instrument is electrical and acquires heat quickly and loses it slowly, and this system is made in U.S.



Top view of instrument

Front view of instrument

Fig. 3.2: Instrument for drop point measurement

3.3.1.2 The Procedure of Testing the Drop Point

At start a small part from any sample which contains the mixture is taken and placed fill the test cup. The test cup is a small conical hallow shape. A needle related with the instrument is used to remove large part from the mixture from test cup with spiral manner where the mixture is staying just on the walls of the test cup in order to keep the dropping point small.

The test cup is placed in the test tube, in manner that doesn't touch the bottom of the tube in order to view the dropping point obviously. The tube is driven to the instrument and the thermometer is inserted inside the tube where in touches the test cup without closing the hole of the test cup by setting the thermometer inside circular wood Fig. 3.3 and running the instrument, waiting to see the point falls which is the drop point.

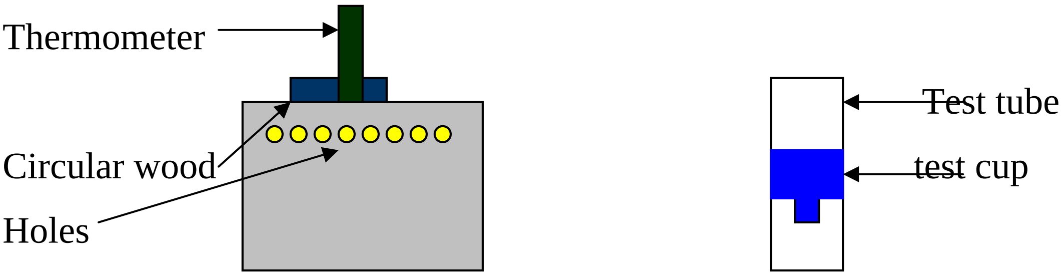


Fig 3.3: Procedure for drop point measurement

3.3.2 Penetration ASTM D 217

3.3.2.1 System Description to Measure the Penetration Experiments

These test methods cover four procedures for measuring the consistency of mixture by the penetration of a cone of specified dimensions, mass, and finish. The penetration is measured in tenths of a millimeter.

The system used for measuring the penetration of the mixture is composed of hummer, special knife; bath, microscope, electric lamp, and this system are made in Japan.

3.3.2.2 The Procedure of Penetration Experiments

Taking a sample of D_2 which composed of mixture of 30% of the microcrystalline wax with 70% furfural extract oil 60 and is placed in a device called hammer Fig. 3.4.

Fig. 3.4: Apparatus hammer used for penetration measurements

This device is set in the hammer cup. The cup is filled completely by using a special knife in order not to remove any bubbles which affect the results that appear as a product of setting the mixture in the hammer cup as layers since the bubbles is formed among them.

Even if the amount of the mixture greater than the volume of the cup, it contains space in the upper side of the hammer executes to take out the extra mixture by compacting the upper and lower side of hammer, then putting the hammer in particular conditions with 25 °C and atmospheric pressure 1 bar for 1 hour in order to make the mixture ready for rapping by 60 rap double and complete, it is universal measurement to raps number.

The hammer cup is placed in the particular place in the penetration instrument which is called penetrometer that measures of amount of penetration per unit time and area.

Penetration instrument Fig. 3.5. is a conical part placed on the hammer cup vertically and tangent to the mixture, its surface is plain and empty from the bubbles. Starting to run the penetrometer which is regulated according to specifications and waiting 15 sec.. When penetration starts, by taking down the conical part on the mixture inside the hammer cup through 5 sec. and calculating the amount of penetration by the equation:-

Amount of real penetration = Amount of apparent penetration in the instrument * 2

Fig. 3.5: Instrument for Penetration measurement

Another additions for penetration instrument like microscope which works to illustrate tangent point between the conical shape and mixture in hammer cup, the electric lamp which gives enough light to see all points specially the tangent point and the operation. Obviously, it is possible tuning the speed and penetration.

After each experiment, the conical part is cleaned from above hollow; consequently, part of mixture enters to the hole of cone through operation. So, before each test, it must reset the instrument by rising the conical part to the upper tip with the instrument and restarting it, the control panel has good specifications, there is a point to rise the conical part with three points has different speeds to take down the conical part in order to be the operation perfectly.

3.3.3 Copper Corrosion ASTM D 617

3.3.3.1 Description of Copper Corrosion Experiments

This test is to assess the relative degree of corrosively of mixture with metals. The Copper Strip Tarnish Test assesses the relative degree of corrosivity of petroleum products, including aviation fuels, automotive gasoline, natural gasoline, solvents, kerosene, diesel fuel, distillate fuel oil, lubricating oil and other products. A polished copper strip is immersed in 30 g of sample at elevated temperature. After the test period, the strip is examined for evidence of corrosion and a classification number from 1-4 is assigned based on a comparison with the ASTM Copper Strip Corrosion Standards. For aviation fuels and natural gasoline the sample tube is placed inside a stainless steel bomb during testing Fig. 3.6 and this system is made in U.S.

Fig. 3.6: Instrument for copper corrosion measurement

3.3.3.2 The Procedure of Copper Corrosion Experimental

When copper starts to corrode, one of the samples which presents the mixture that taken to input it in the test tube which is of weight 100 g in order to sight easily, because of the difficulty to enter the mixture which is in semi-solid status into the tester tube, since the mixture must melt inside the plastic glasses by using the electrical oven, where the heat of the oven is moderate and enough to make the mixture in liquid status without reaching to the heat that leads melt the plastic glasses which mixes with the mixture that effects the results.

A small part of copper ingot moderately is brought which has known dimensions it is resorted to make the surface of ingot by energy paper to smooth the surface of metal, after that the copper ingot is inserted inside the test tube which is set it a mount of the mixture in its liquid-status, so it must the test tube filled with the mixture and the tube be inclined through maturing the ingot in order not to break tube.

The test tube is placed inside the bath which is in standard condition; the tests will be on the ingot by putting the test tube inside the bath for the period 24 hour at 100 °C. In the present work the tube is placed in the bath for 24 hour at 100 °C, in addition the oily bath must be set at 100 °C approximately.

The time is recorded from the test tube is placed in side the bath and waited set for 24 hour completed after ending the period copper ingot is taken out from the tube and cleaned from the hanging mixture to see the effect corrosion inhibitor to keep the surface of metal from the oxidation which leads to the corrosion, it was seen that shape and color copper ingot changes with difference mixture which is put in the test tube.

Chapter Four

Results and Discussions

4.1 Results

The experiments have been repeated ten times, the Drop point, Penetration and copper corrosion have been tested. The results are as below:

The table 4.1 shows the three mixtures (A_1, A_2, A_3) are compound same wax (paraffin wax) and same heavy oils (base stock oil (40)) but different wax weight percentage of mixture.

Table 4.1: Experimental results of base stock oil (40) for paraffin wax

Sample name	Drop Point °C	Penetration mm.	Copper strip corrosion
A_1	42	703	3a
A_2	45	612	3e
A_3	49	565	2d

The table 4.2 shows the three mixtures are compound same wax (micro crystalline wax) and same heavy oils (base stock oil (40)) but different wax weight percentage of mixture. Comparison between table 4.1 and table 4.2 obtain was used same heavy oils but different type of wax.

Table 4.2: Experimental results of base stock oil (40) for microcrystalline wax

Sample name	Drop Point °C	Penetration mm.	Copper strip corrosion
A_4	43	689	3a
A_5	46	603	2e
A6	49.5	554	2d

The table 4.3 shows the three mixtures are compound same wax (paraffin wax) and same heavy oils (base stock oil (60)) but different wax weight percentage of mixture. Comparison between table 4.1 and table 4.3 obtain was used same wax but different type of heavy oils and wax WPM.

Table 4.3: Experimental results of base stock oil (60) for paraffin wax

Sample name	Drop Point °C	Penetration mm.	Copper strip corrosion
B1	48.5	540	2d
B2	50.5	501	2c
B3	53.5	449.6	2b

The table 4.4 shows the three mixtures are compound same wax (micro crystalline wax) and same heavy oils (base stock oil (60)) but different wax weight percentage of mixture. Comparison between mixture A_6 in table 4.2 and mixture B_6 in table 4.4 obtain was used same wax and wax WPM, but different type of heavy oils.

Table 4.4: Experimental results of base stock oil (60) for microcrystalline wax

Sample name	Drop Point °C	Penetration mm.	Copper strip corrosion
B4	49.5	513	2c
B5	52	472	2c
B6	55	409.4	2b

The table 4.5 shows the three mixtures are compound same wax (paraffin wax) and same heavy oils (base stock oil (150)) but different wax weight percentage of mixture. Comparison between table 4.1, table 4.3 and table 4.5 obtain was used same heavy oils, wax and wax WPM, but different degree of heavy oils.

Table 4.5: Experimental result of base stock oil (150) for and paraffin wax

Sample name	Drop Point °C	Penetration mm.	Copper strip corrosion
C1	53	344	2b
C2	54.5	299	2b
C3	56.5	248	2a

The table 4.6 shows the three mixtures are compound same wax (micro crystalline wax) and same heavy oils (base stock oil (150)) but different wax weight percentage of mixture. Comparison between table 4.5 and table 4.6 obtain was used same heavy oils but different type of wax.

Table 4.6: Experimental results of base stock oil (150) for microcrystalline wax

Sample name	Drop Point °C	Penetration mm.	Copper strip corrosion
C4	54	301.2	2b
C5	56	267	2a
C6	58.5	235.8	1b

The table 4.7 shows the three mixtures are compound same wax (paraffin wax) and same heavy oils (furfural extract oil (60)) but different wax weight percentage of mixture. Comparison between table 4.4 and table 4.7 obtain was used same wax, degree of heavy oils and wax WPM, but different type of heavy oils.

Table 4.7: Experimental results of furfural extract oil 60 and paraffin wax

Sample name	Drop Point °C	Penetration mm.	Copper strip corrosion
E1	49	507	2d
E2	51	456	2c
E3	54	389.6	2b

The table 4.8 shows the three mixtures are compound same wax (micro crystalline wax) and same heavy oils (furfural extract oils (60)) but different wax weight percentage of mixture. Comparison between table 4.7 and table 4.8 obtain was used same heavy oils but different type of wax.

Table 4.8: Experimental results of furfural extract oil 60 and microcrystalline wax

Sample name	Drop Point °C	Penetration mm.	Copper strip corrosion
E4	50	467	2c
E5	53	423	2b
E6	56	357	2a

The table 4.9 shows the three mixtures are compound same wax(paraffin wax) and same heavy oils (furfural extract oil (40)) but different wax weight percentage of mixture. Comparison between table 4.7 and table 4.9 obtain was used same heavy oils, wax, wax WPM, but different degree of heavy oil.

Table 4.9: Experimental result of furfural extract oil 150 and paraffin wax

Sample name	Drop Point °C	Penetration mm.	Copper strip corrosion
F1	54.5	312	2a
F2	55.5	287	2a
F3	57.5	236	1b

The table 4.10 shows the three mixtures are compound same wax(micro crystalline wax) and same heavy oils (furfural extract oil (150)) but different wax weight percentage of mixture. Comparison between table 4.4 and table 4.10 obtain was used same wax and wax WPM, but different type of heavy oils and degree of heavy oil.

Table 4.10: Experimental results of furfural extract oil 150 and microcrystalline wax

Sample name	Drop Point °C	Penetration mm.	Copper strip corrosion
F4	55	289	2a
F5	57	240	1b
F6	60	211.4	1a

4.2 Discussions of Experimental Drop Point

The effect of wax WPM and oil types on drop point are investigated and discussed. Result of the experiments it can be concluded that best mixture practically, and using these mixture in corrosion preventing or friction decrease processes. Also from in the experiments of drop point one can note that which mixtures have the ability more than the others to the temperatures with about 40 - 60 °C.

Drop point of mixture is useful as a guiding tool to identify the mixture type safe operating temperatures and the temperature limits for use of mixture.

Obviously, the base oil of the mixture for low-temperature service must be made from oils having a low viscosity at that temperature. The temperature limits for use of mixtures are therefore, determined by drop point, oxidation, and stiffening at low temperatures.

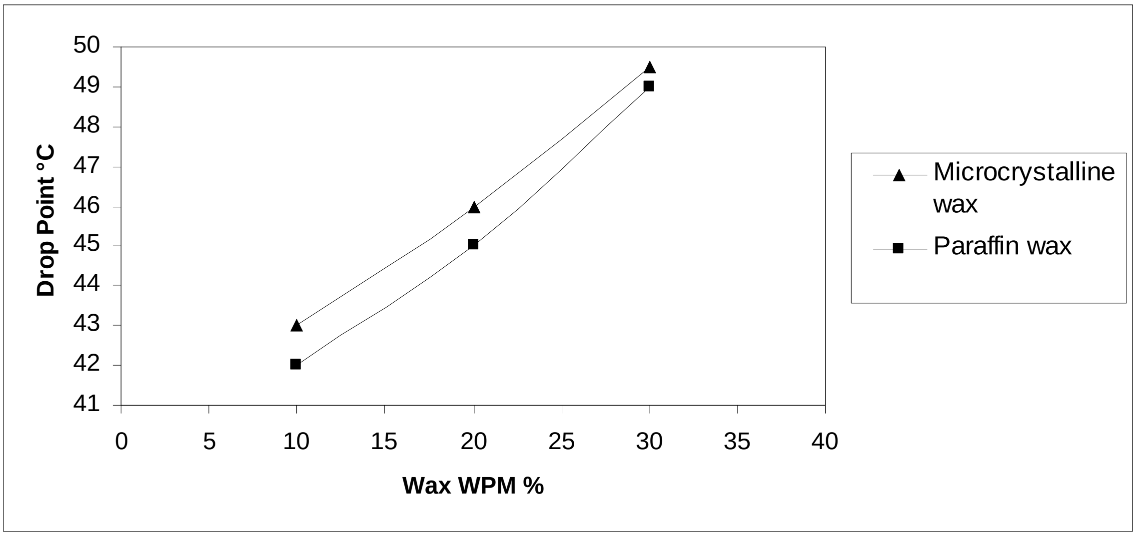


Fig 4.1: Effect of wax WPM on drop point for oil base stock 40

Figure 4.1: shows the variation of drop point with wax WPM for two types of waxes for base stock oil 40. It is clear that as the wax WPM increases the drop point increases for the two types. Also, the microcrystalline wax gives higher values of drop point for mixtures. The drop point increases with the wax WPM because the drop point of the wax is higher than that of the oil base stock. The higher the wax WPM, the higher the drop point will be. In case of microcrystalline wax the drop point is higher than that of paraffin wax, because the M.Wt. of microcrystalline wax is higher than that the M.Wt. of paraffin wax.

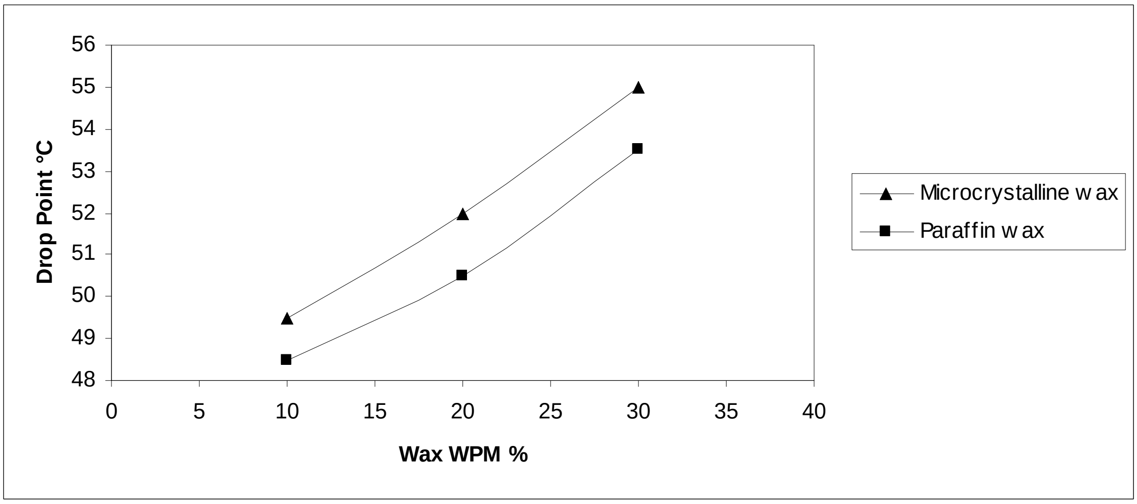


Fig 4.2: Effect of wax WPM on drop point for oil base stock 60

Figure 4.2: illustrates the variation of drop point with wax WPM for two types of waxes for oil base stock 60. This figure shows that the increase in the wax WPM leads to increase the drop point. The drop point in case of microcrystalline wax is higher than the drop point of paraffin wax. The higher the M.Wt, the higher the drop point will be. Although the use of other type of base stocks oil does not affect the behavior of the drop point with wax WPM in Figure 4.1.

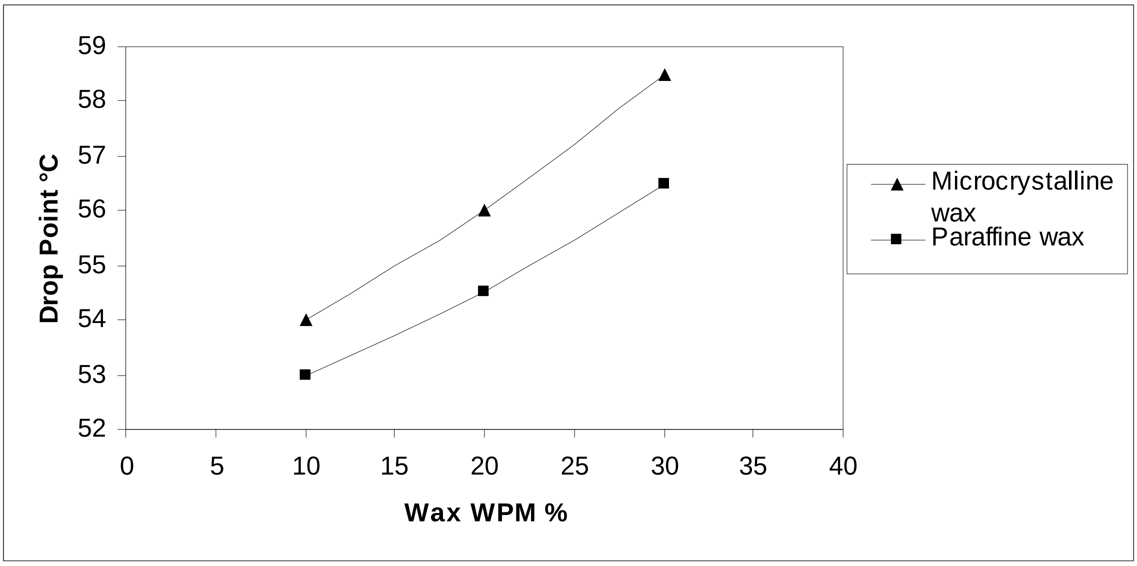


Fig 4.3: Effect of wax WPM on drop point for base stock oil 150

Figure 4.3: reveals the variation of drop point with wax WPM for two types of waxes for oil base stock 150. This figure obviously indicates that when the wax WPM increases, the drop point increases too. It has been found that the mixture that formed from microcrystalline wax and oil base stock 150 have drop point higher than the mixture that formed from paraffin wax and oil base stock 150 and this may be due to microcrystalline wax the M.Wt. higher than the M.Wt. paraffin wax.

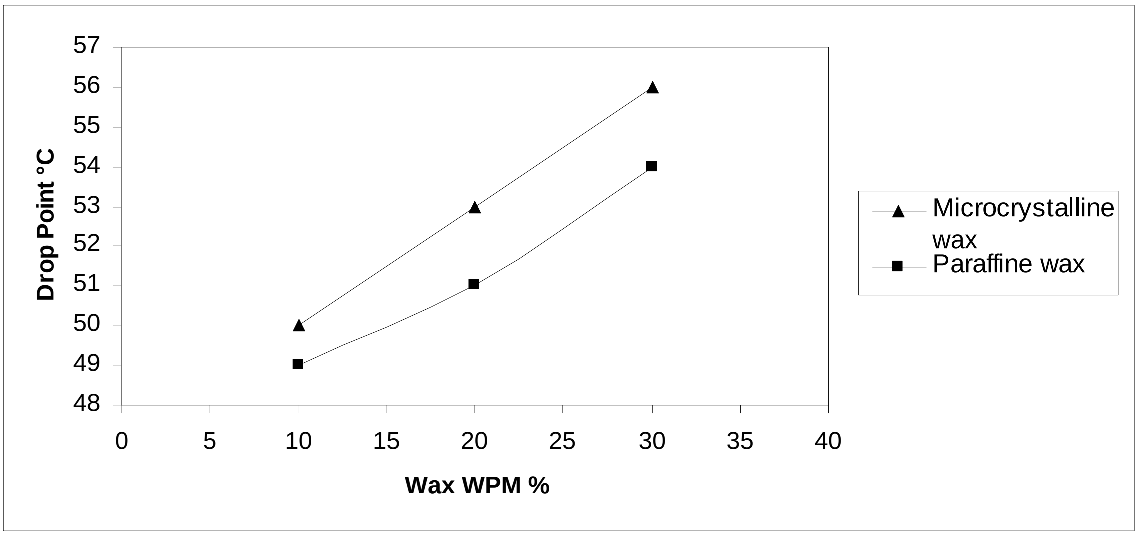


Fig 4.4: Effect of wax WPM on drop point for furfural extract oil 60

Figure 5.4: shows the variation of drop point with wax WPM for two types of waxes for furfural extract oil 60. It is evident that the wax WPM increases, the drop point increases. Also the figure shows that the mixture that composed from microcrystalline wax and furfural extract oil 60 have drop point higher than the mixture that composed from paraffin wax and furfural extract 60. The higher the M.Wt., the higher the drop point will be.

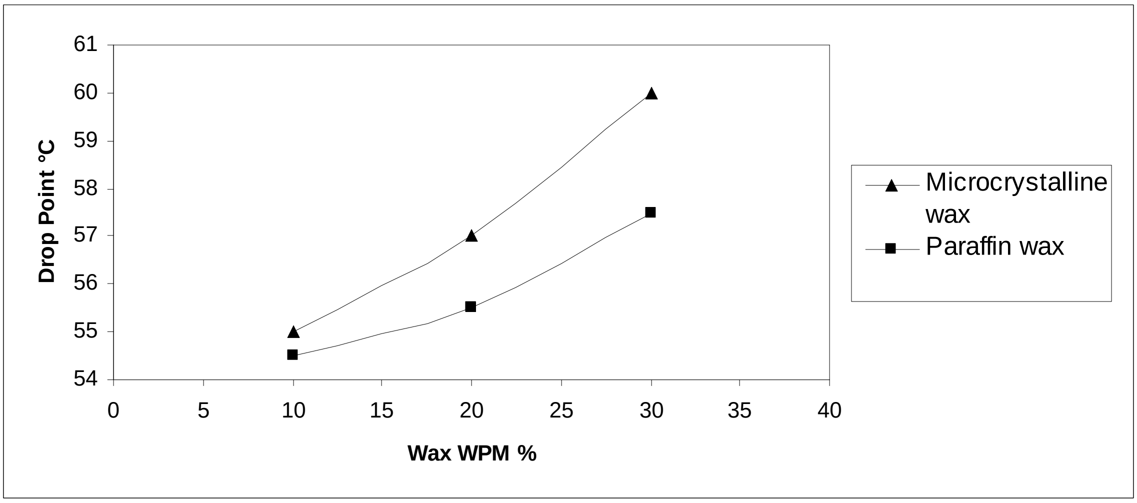


Fig 4.5: Effect of wax WPM on drop point for furfural extract oil 150

Figure 4.5: shows the variation of drop point with wax WPM for two types of waxes for furfural extract oil 150. This figure indicates that as the wax WPM increases, the drop point increases too. The drop point in case of microcrystalline wax is higher than that of paraffin wax. Although the use of other type of furfural extract oil the result of the drop point with wax WPM still the same with results indicated in figure 4.4.

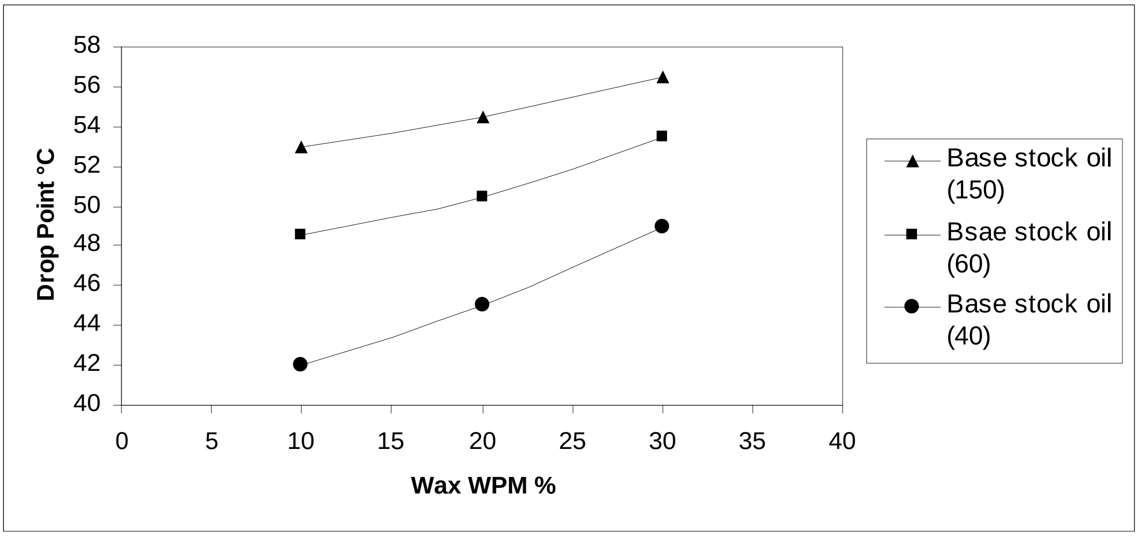


Fig 4.6: Effect of wax WPM on drop point for paraffin wax

Figure 4.6: reveals the effect of base stock oil degree on the drop point in presence of paraffin wax. This figure obviously reveals that the increase in the wax WPM leads to increase the drop point. Also the figure shows that the base stock oil of degree 150 gives higher drop point than that of degree 60 and the drop point of degree 60 is higher than degree 40. This is ascribed to the fact that the higher the degree is the higher the viscosity will be. As the viscosity increases the drop point increase, this may be due to the significant variation in the oils viscosities, such that µ base stock oil 150 > µ base stock oil 60 > µ base stock oil 40, since the M.Wt. of base stock oil 150 > M.Wt. of base stock oil 60 > M.Wt. of base stock oil 40.

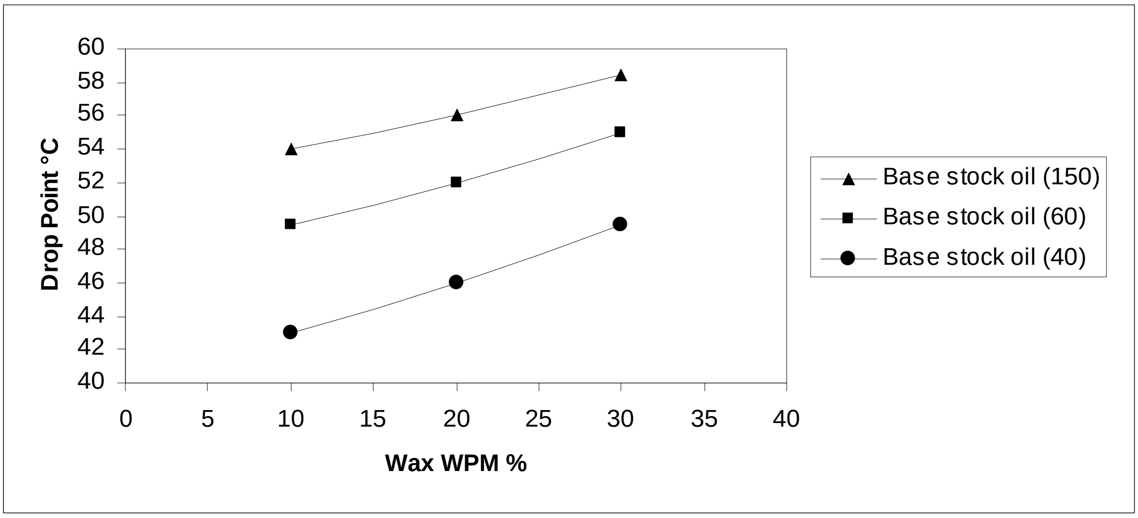


Fig 4.7: Effect of wax WPM on drop point for microcrystalline wax

Figure 4.7: shows the effect of base stock oil degree on the drop point in presence of microcrystalline wax. It is clear that when the wax WPM increases, the drop point increases too. This figure reveals that the base stock oil of degree 150 is gives higher drop point than the degree 60 and the letter is higher than degree 40, this illustrates the mixture that formed from base stock oil 150 and microcrystalline wax is higher drop point than the mixtures that formed from base stock oil 150 and paraffin wax in Figure 4.6.

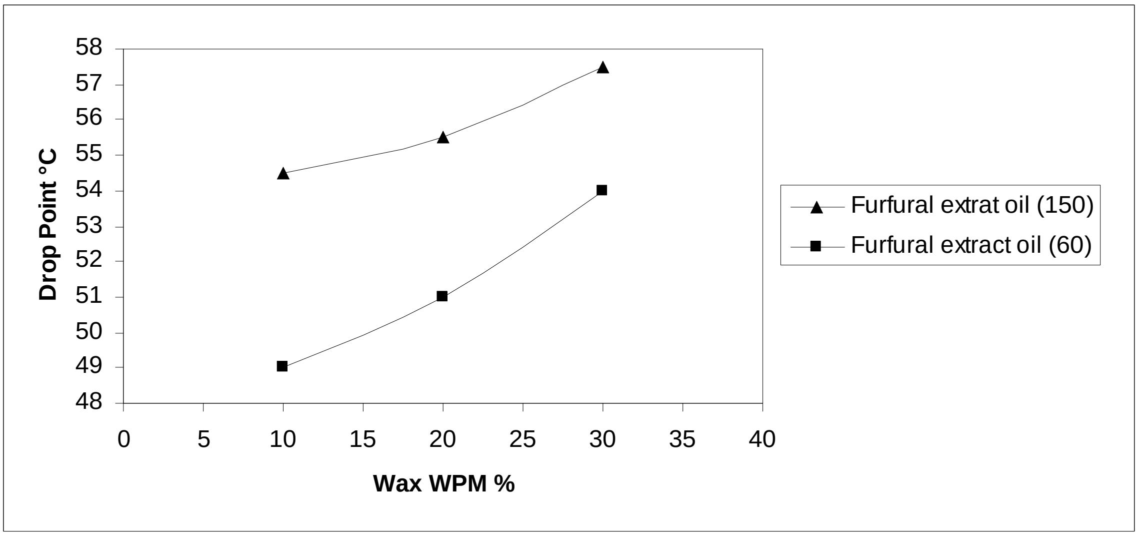


Fig 4.8: Effect of wax WPM on drop point for paraffin wax

Figure 4.8: illustrates the effect of furfural extract oil type on the drop point in presence of paraffin wax. The degree of drop point increases as wax WPM increased, the furfural extract oil 150 causes the drop point to be higher than that of furfural extract oil 60, this may be due the significant variation in the oils viscosity value, such that is µ furfural extract oil 150 > µ furfural extract oil 60 and that is come from that the M.Wt. of furfural extract oil 150 > the M.Wt. of furfural extract oil 60.

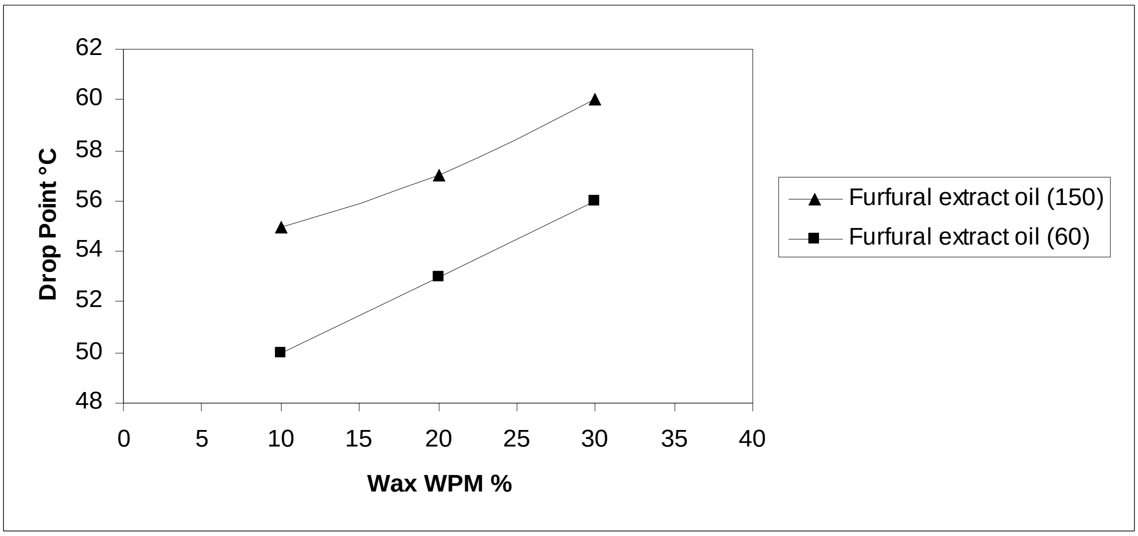


Fig 4.9: Effect of wax WPM on drop point for microcrystalline wax

Figure 4.9: reveals the effect of furfural extract type on the drop point in presence of microcrystalline wax. This figure shows that the drop point of mixture that composed from the furfural extract oil 150 become higher than when the mixture that composed from furfural extract oil 60, this may be due the variation in the oils viscosity such that µ furfural extract oil 150 > µ furfural extract oil 60. The higher the M.Wt, the higher the drop point will be. Although the use of other compound wax (paraffin, microcrystalline) the result of the drop point and wax WPM still the same with the results indicated in Fig. 4.8.

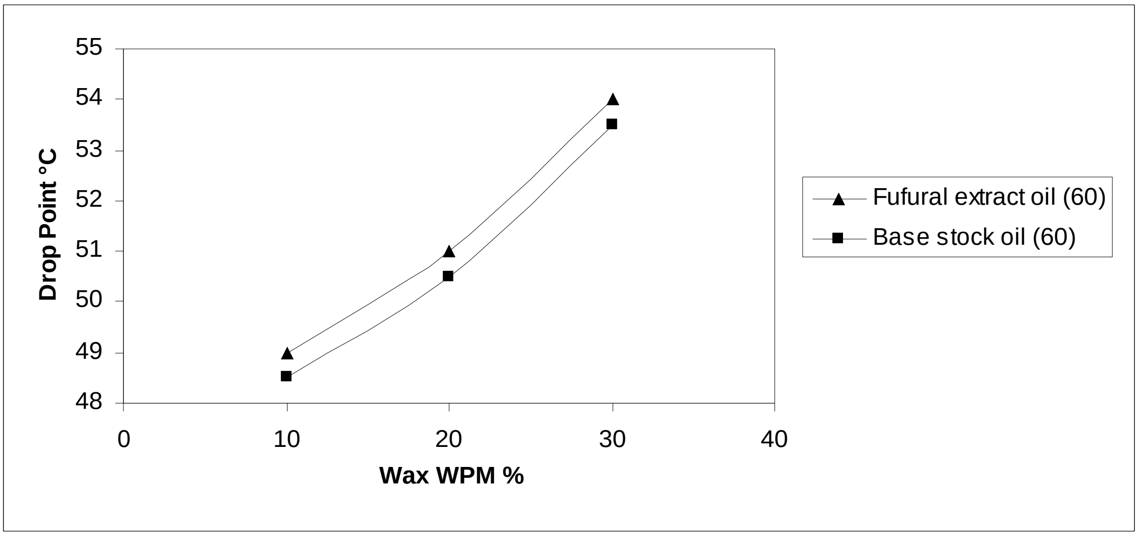


Fig 4.10: Effect of wax WPM on drop point for paraffin wax

Figure 4.10: shows the variation of drop point with wax WPM for two types of oil degree 60 in presence of paraffin wax. This figure obviously indicate that base stock oil 60 and furfural extract oil 60 having almost the same results for the effect of wax WPM on degree of drop point, the drop point of mixture of furfural extract oil 60 is higher than of drop point of mixture of base stock oil 60. which may be due to the close viscosity values, such that μ furfural extract oil 60 > μ base stock oil 60, since the M.Wt. of furfural extract oil 60 is higher than the M.Wt. of base stock oil 60.

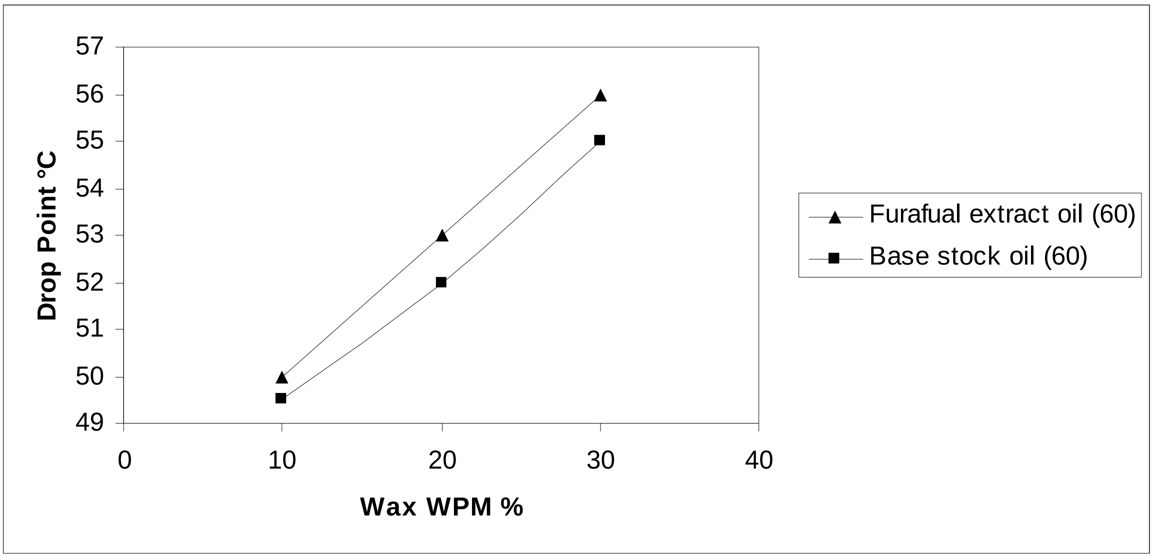


Fig 4.11: Effect of wax WPM on drop point for microcrystalline wax

Figure 4.11: shows the variation of drop point with wax WPM for two types of oil degree 60 in presence of microcrystalline wax. It is evident that as the wax WPM increases the drop point increases for the two oil degree 60 types. Also the furfural extract oil 60 gives higher values of drop point for mixtures, the drop point of mixture of furfural extract oil 60 is higher than of drop point of mixture of base stock oil 60. The higher the M.Wt, the higher the drop point will be.

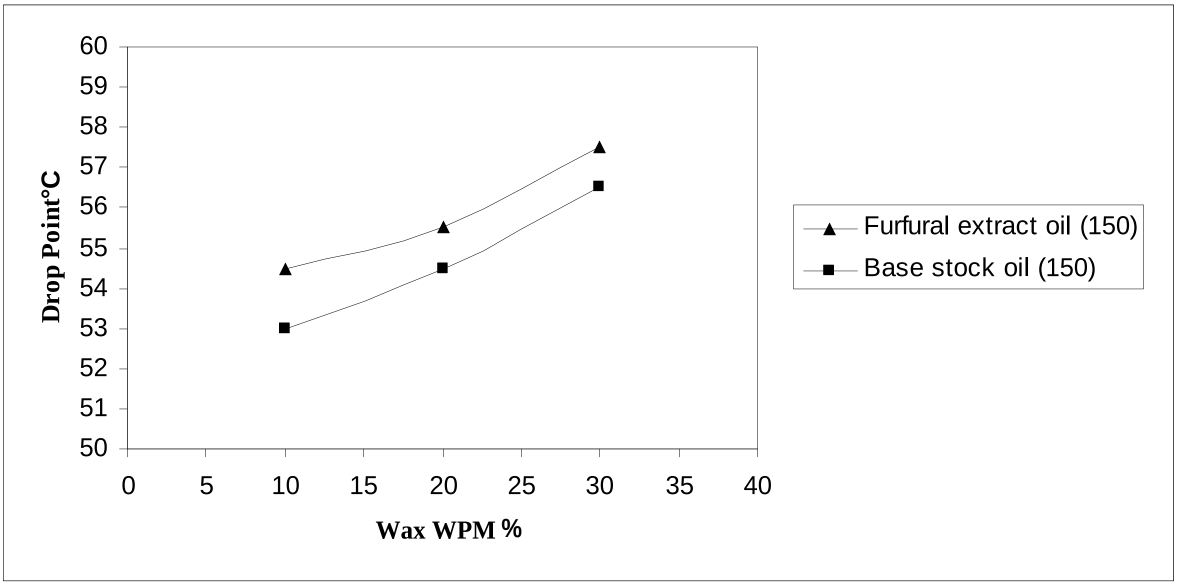


Fig 4.12: Effect of wax WPM on drop point for paraffin wax

Figure 4.12: reveals the variation of drop point with wax WPM for two types of oil degree 150 in presence of paraffin wax. This figure indicates that the wax WPM increases, the drop point increases too. This figure shows that the mixture that composed from the furfural extract oil 150 higher drop point than the mixture that composed from base stock oil 150, this may be due the variation in the oils viscosity values, such that µ furfural extract oil 150 > µ base stock oil 150, because the M.Wt. of furfural extract oil 150 is higher than the M.Wt. of base stock oil 150.

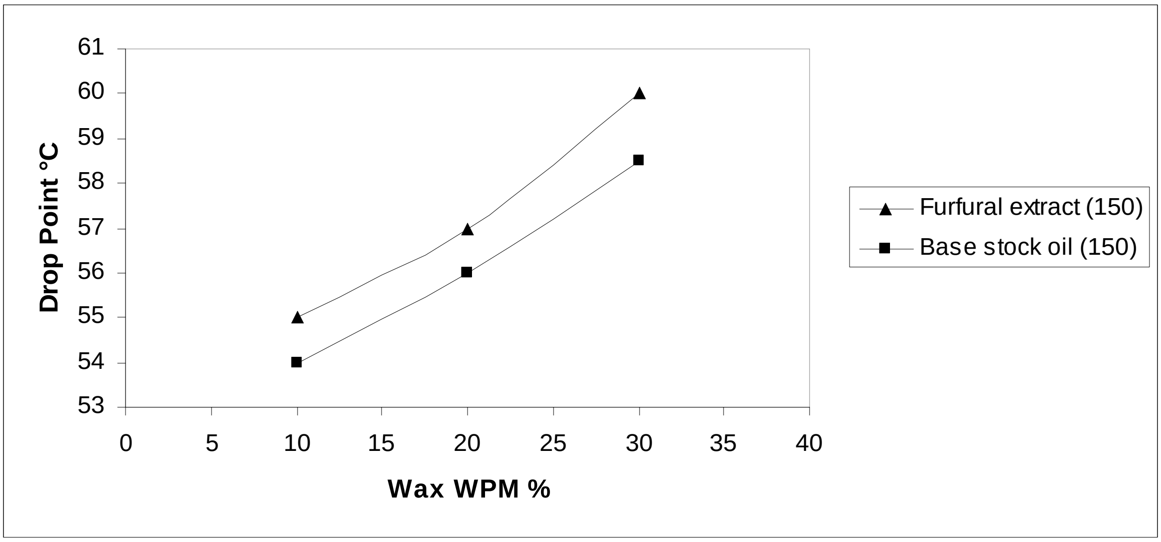


Fig 4.13: Effect of wax WPM on drop point for microcrystalline wax

Figure 4.13: shows the variation of drop point with wax WPM for two types of oil degree 150 in presence of microcrystalline wax. This figure obviously reveals that when wax WPM increase in the drop point increase. The drop point in case use of furfural extracts oil 150 is higher than that use of base stock oil 150. Although the use of other compound wax (paraffin, microcrystalline) the result of the drop point with wax WPM still the same with results indicated in figure 4.12.

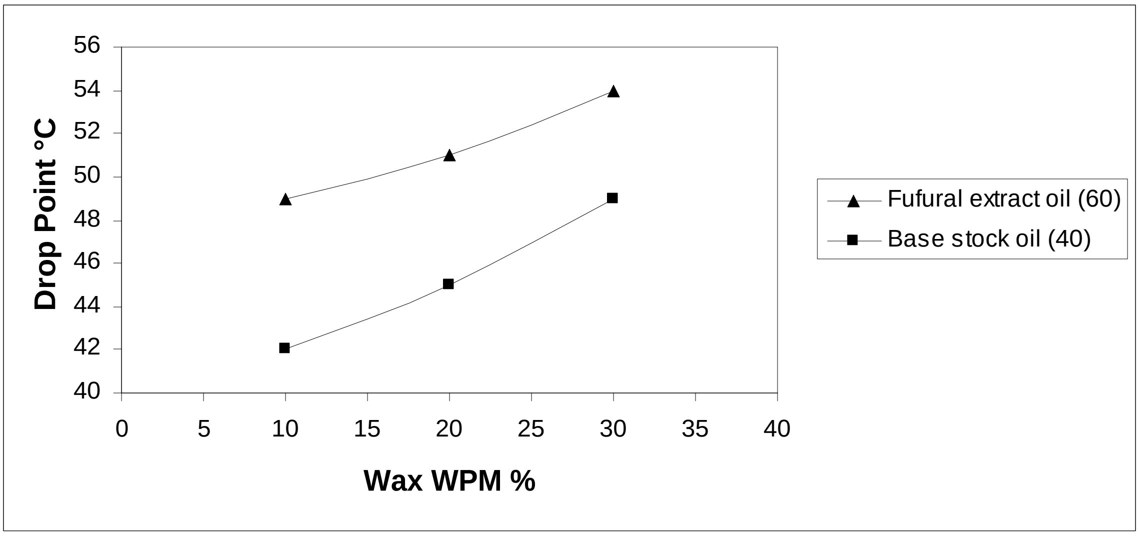


Fig 4.14: Effect of wax WPM on drop point for paraffin wax

Figure 4.14: illustrates the effect of oil type degree on drop point in presence of paraffin wax. It is clear that as the wax WPM increases the drop point increases for the two oil type degree. It illustrates that higher drop point is obtained when furfural extract oil 60 is presented and gives higher values of drop point for mixture of base stock oil 40, this may be due to the variation of oils viscosity values, such that µ furfural extract 60 > µ Base stock oil 40 and that is come from that the M.Wt. of furfural extract oil 60 > the M.Wt. of Base stock oil 40.

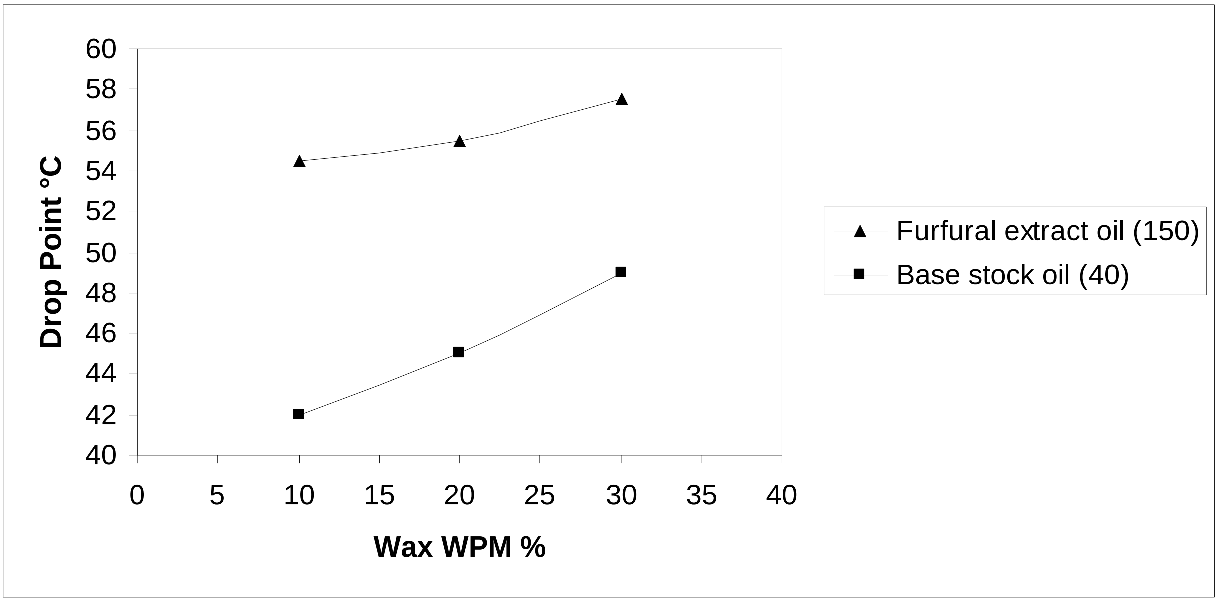


Fig 4.15: Effect of wax WPM on drop point for paraffin wax

Figure 4.15: reveals the effect of oil type degree on drop point in presence the paraffin wax. The figure shows that the increase in the wax WPM leads to increase the drop point. Also the furfural extract oil 150 gives higher values of drop point for mixtures, the drop point of mixture that formed from furfural extract oil 150 more higher than that of drop point of mixture that formed from base stock oil 40, which may be due to the variation of oils viscosity values, such that µ furfural extract oil 150 > µ Base stock oil 40, since the M.Wt. of furfural extract oil 150 is higher than the M.Wt. of Base stock oil 40.

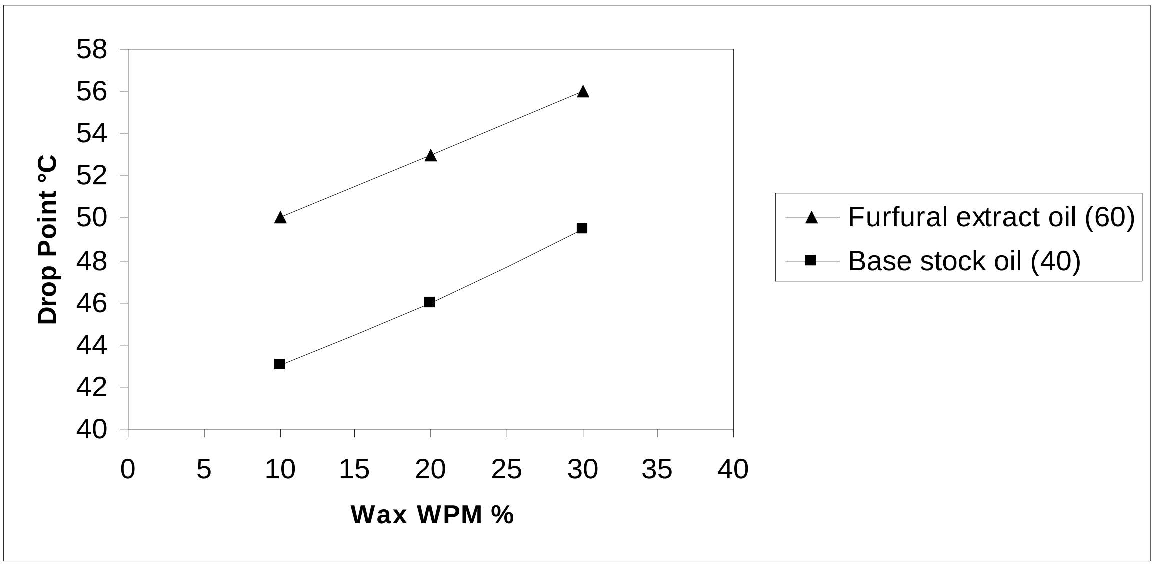


Fig 4.16: Effect of wax WPM on drop point for microcrystalline wax

Figure 4.16: shows the effect of oil type degree on drop point in presence of microcrystalline wax. This figure obviously indicates that when the wax WPM increases, the drop point increases. It has been found that the mixtures that composed from furfural extract oil 60 and microcrystalline wax has a drop point higher than the mixtures that composed from paraffin wax and base stock oil 40. Although the use of other type degree oil does not affect the behavior of the drop point with wax WPM in figure 4.14.

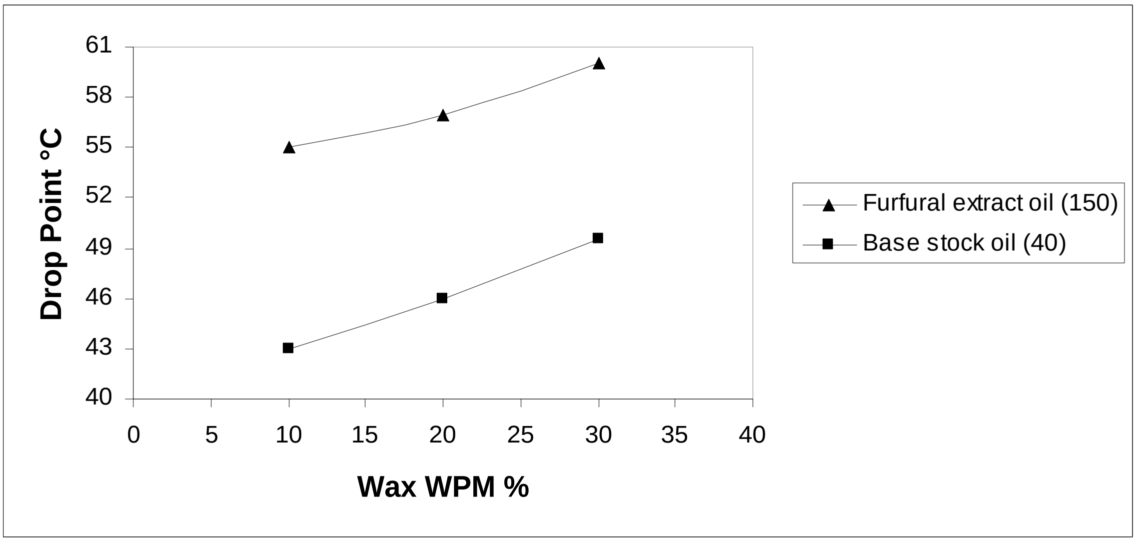


Fig 4.17: Effect of wax WPM on drop point for microcrystalline wax

Figure 4.17: shows the effect of oil type degree on drop point in presence of microcrystalline wax. It is evident that when as the wax WPM increases, the drop point is increases too. Also the figure shows that the mixtures that formed from microcrystalline wax and furfural extract oil 150 has a drop point higher than the mixtures that formed from paraffin wax and base extract oil 40. The higher the M.Wt., the higher the drop point will be. Also the figure shows although in the use of other degree oil types the result for drop point and wax WPM still the same with the result in figure 4.16.

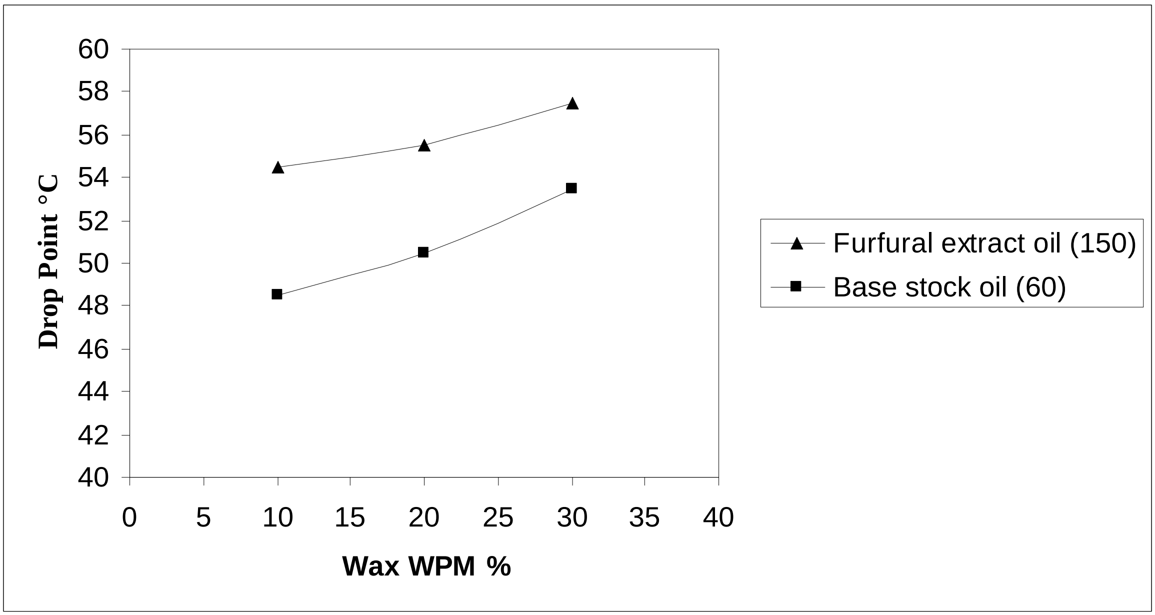


Fig 4.18 Effect of wax WPM on drop point for paraffin wax

Figure 4.18: reveals the effect of oil type degree on drop point in presence of paraffin wax. This figure obviously reveal that the wax WPM increase the drop point. The drop point in case of furfural extract oil 150 is higher than that of base stock oil 60. This is ascribed to the fact the higher the degree is the higher the viscosity will be, this may be due to the variation of viscosity values, such that μ furfural extract oil 150 > μ Base stock oil 60 and that is come from that the M.Wt. of furfural extract oil 150 is higher than the M.Wt. of Base stock oil 60.

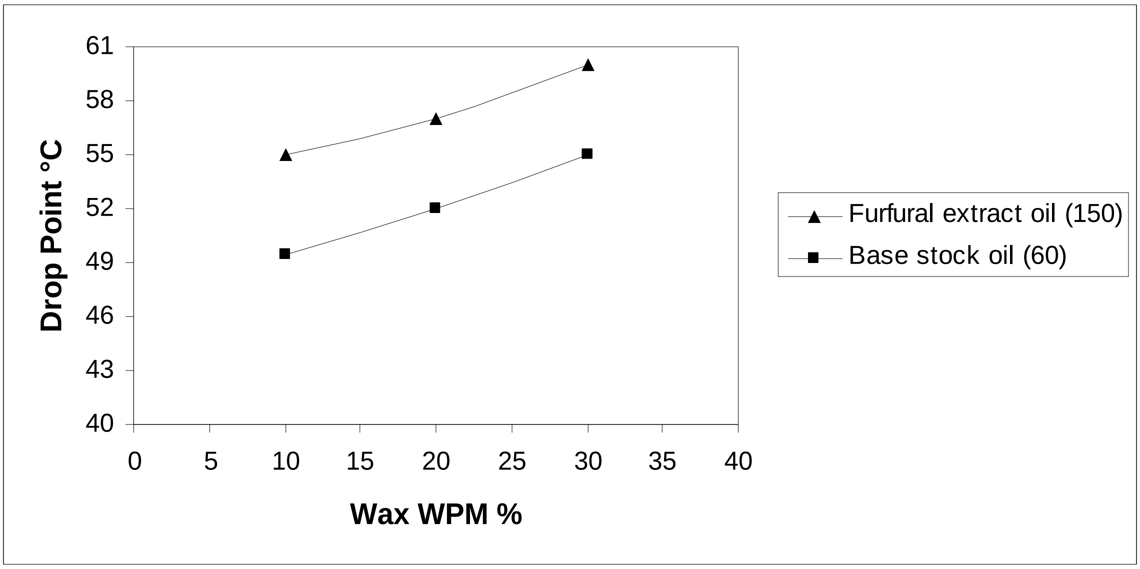


Fig 4.19: Effect of wax WPM on drop point for microcrystalline wax

Figure 4.19: shows the effect of oil type degree on the drop point in presence of microcrystalline wax. This figure indicates that when the wax WPM increases, the drop point increases. It is clear that the mixture formed from furfural extract oil is gives higher drop point than the mixture formed from base stock oil 60. The higher the M.Wt., the higher the drop point will be.

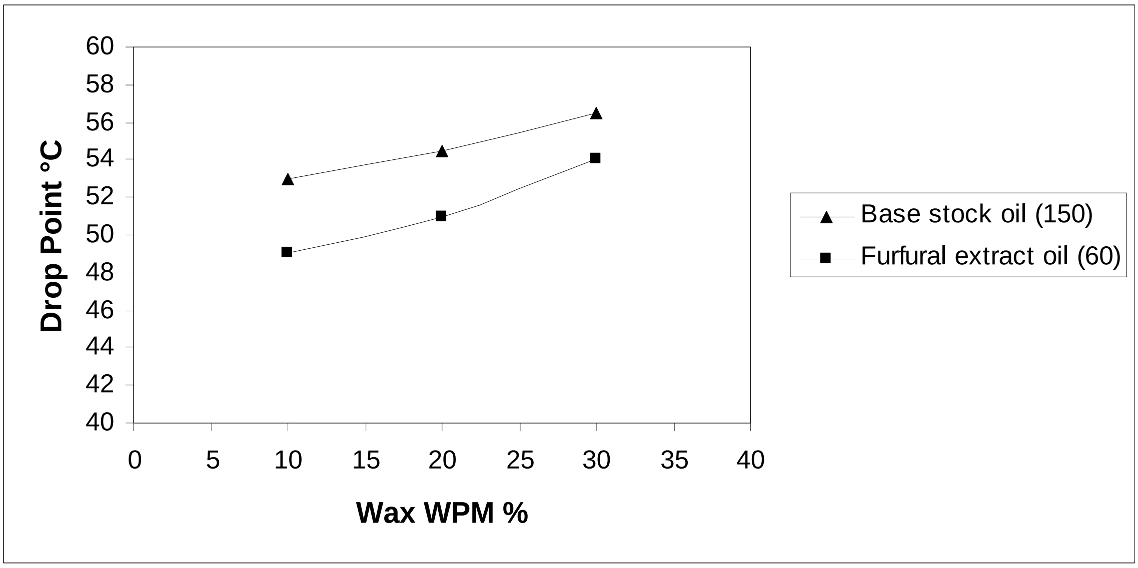


Fig 4.20: Effect of wax WPM on drop point for paraffin wax

Figure 4.20: illustrates the effect of oil type degree on the drop point in presence of microcrystalline wax. It is clear that when the wax WPM increases, the drop point increases. The drop point of mixture that composed from base stock oil 150 is higher than of drop point of mixture that composed from furfural extract oil 60. Which may be due to the close viscosities values, such that μ base stock oil 150 > μ Base stock oil 150, since the M.Wt. of furfural extract oil 60 > the M.Wt. of furfural extract oil 60.

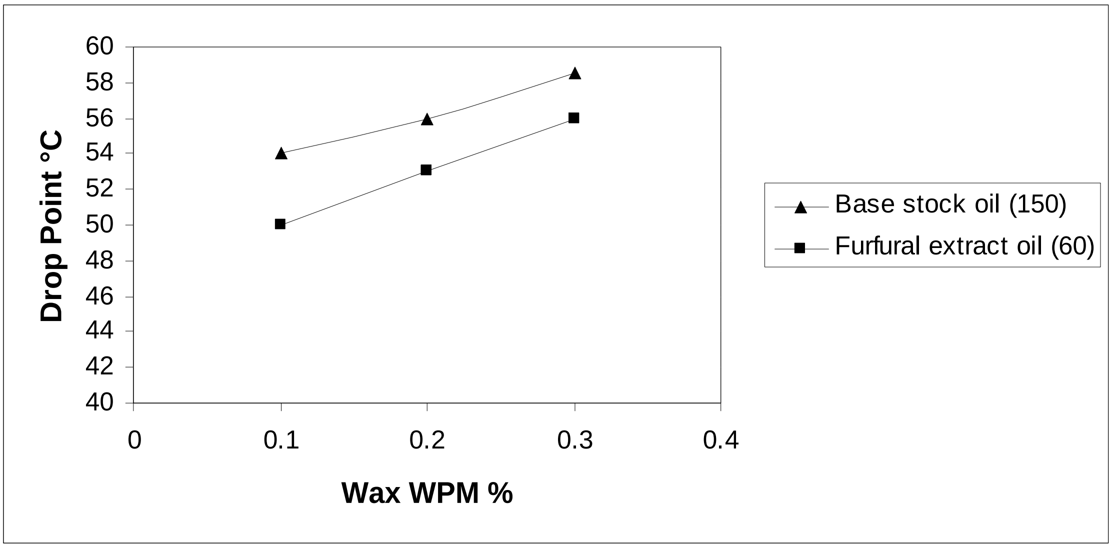


Fig 4.21: Effect of wax WPM on drop point for microcrystalline wax

Figure 4.21: reveals the effect of base stock degree on the drop point in presence of microcrystalline wax. This figure shows that as the wax WPM increases, the drop point increases. Also the figure shows that of mixture of base stock oil 150 is higher of drop point than of mixture of furfural extract oil 60. The higher the M.Wt., the higher the drop point will be. Although the use of other compound wax (paraffin, microcrystalline) the result of the drop point with wax WPM still the same with results indicated in figure 4.20.

the drop points for the mixture are variable it will be high if the mixture consists of crystalline wax and its WPM in the mixture 30% with

Furfural extract oil 150 like in sample F_6 which has a drop point 60.5 °C examining the other mixtures reach to the less drop point which is the mixture that composed from of paraffin wax with 10 % WPM and Base stock oil 40 like in sample A_1 which has a drop point is 47 °C.

4.3 Discussions of Experimental Penetration

The effect of various wax types and oil type on the penetration is investigated and discussed. As shown before the importance of drop point in determining the mixture which represents the best anticorrosion used in endurance of temperatures without melting to protect minerals from corrosion.

It must be noted that the Penetration measurement is important to know how much the mixture protect from corrosion, from this experiment we can find what are the mixtures which have the ability to protect minerals or to prevent the reaching electrons to the mineral's surface as far as possible

If saw the sample B_1 which represents the mixture that consists of base stock 60, 90% with paraffin wax 10% and penetration is 540 mm which is different from the sample F_5 which represents the mixture that consists of furfural extract 150, 80% with crystalline wax 20% and penetration is 240 mm.

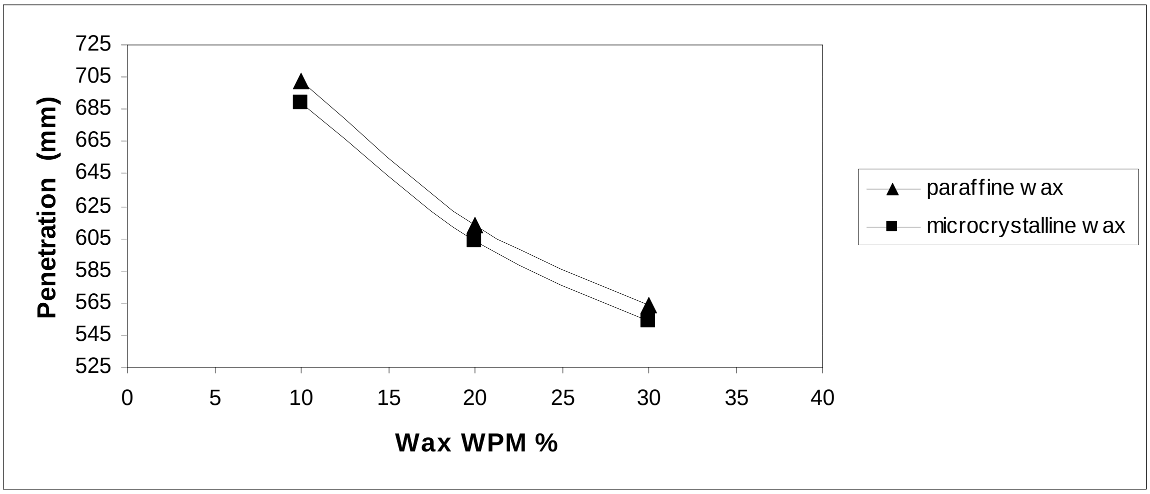


Fig 4.22: Effect of wax WPM on the penetration for base stock oil 40

Figure 4.22: shows the variation of penetration with wax WPM for two types of waxes for base stock oil 40. It is clear that as the wax WPM increases the penetration decreases for the two types. Also, the microcrystalline wax gives lower values of penetration for mixtures. The drop point penetration decreases with the wax WPM increases because the penetration of the wax is lower than that of the base stock. The higher the wax WPM, the lower the penetration will be. In case of microcrystalline wax the penetration is lower than that of paraffin wax, because the M.Wt. of microcrystalline wax is higher than the M.Wt. of paraffin wax.

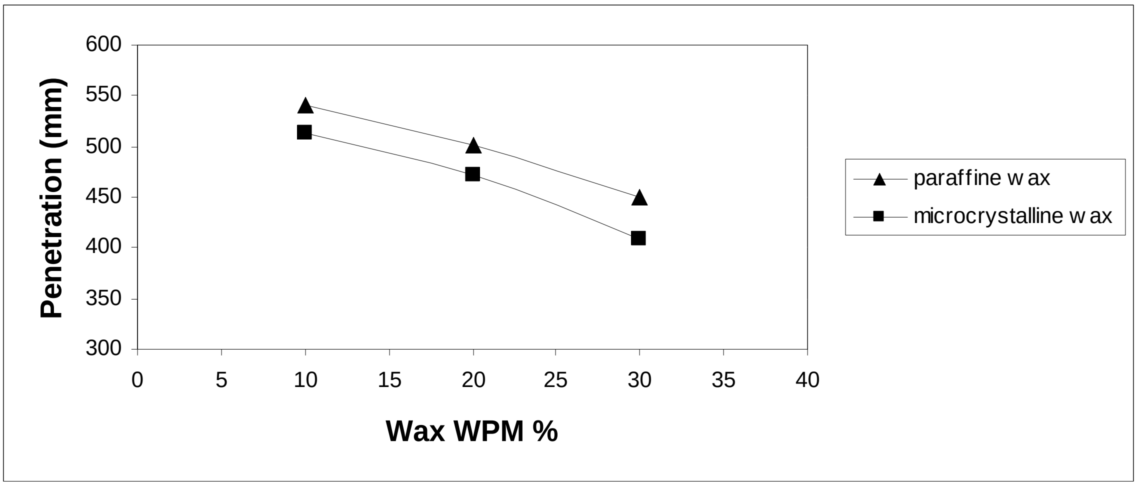


Fig 4.23: Effect of wax WPM on the penetration for base stock oil 60

Figure 4.23: illustrates the variation of penetration with wax WPM for two types of waxes for base stock oil 60. This figure shows that the increase in the wax WPM leads to decreases the penetration. The penetration in case of microcrystalline wax is lower than the penetration of paraffin wax. The higher the M.Wt., the lower the penetration will be. Although the use of other type of base stock oil does not affect the behavior of the penetration with wax WPM in figure 4.22.

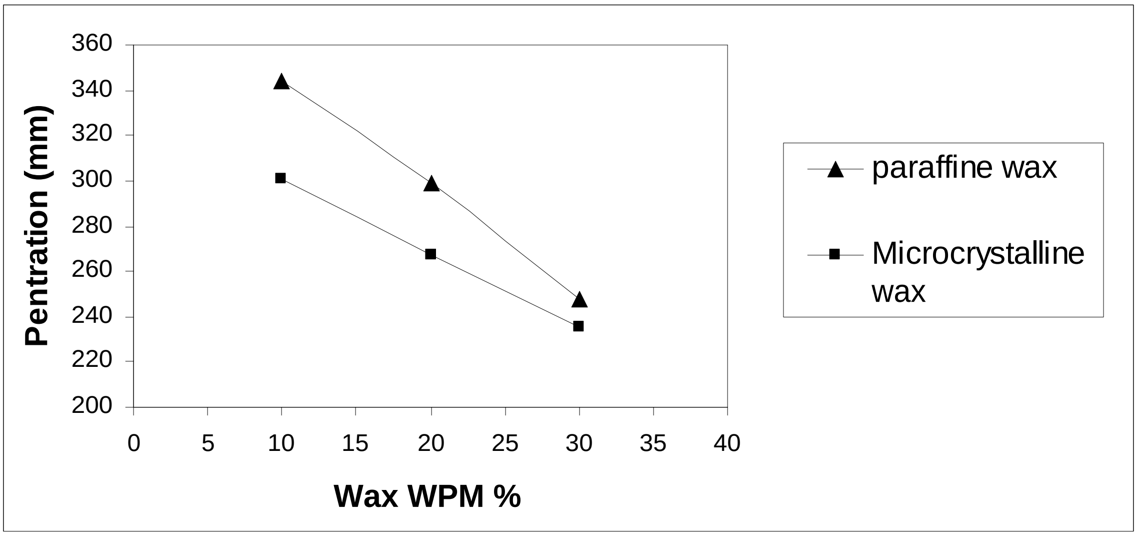


Fig 4.24: Effect of wax WPM on the penetration for base stock oil 150

Figure 4.24: reveals the variation of penetration with wax WPM for two types of waxes for base stock 150. This figure obviously indicates that when the wax WPM increases, the penetration decreases too. It has been found that the mixture that formed from microcrystalline wax and base stock oil 150 have penetration lower than the mixtures the formed from paraffin wax and base stock oil 150, and this may be due to microcrystalline wax penetration lower than that of paraffin wax, since the M.Wt. of microcrystalline wax is higher than the M.Wt. of paraffin wax.

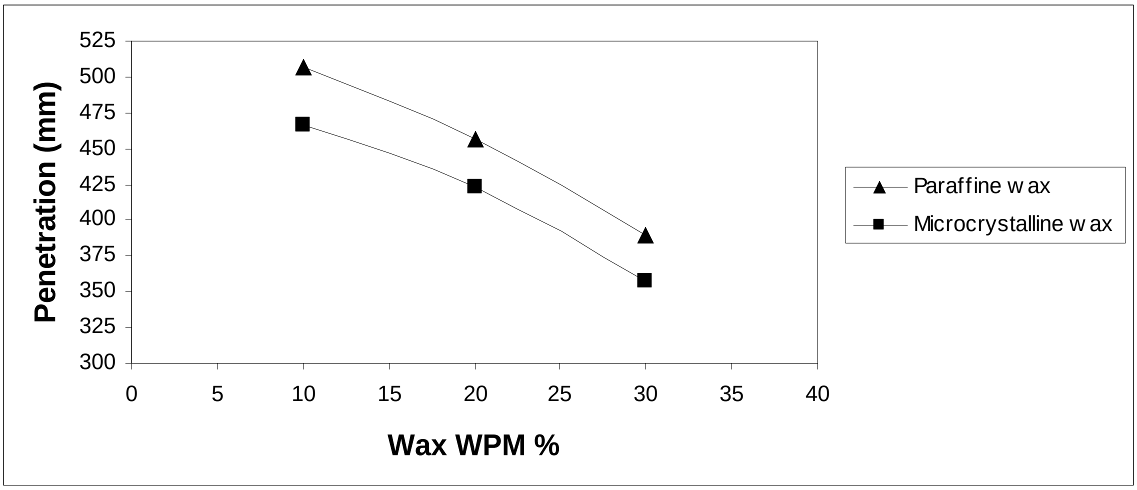


Fig 4.25: Effect of wax WPM on the penetration for furfural extract oil 60

Figure 4.25: shows the variation of the penetration with wax WPM for two types of waxes for furfural extract oil 60. It is evident that the wax WPM increases, the penetration decreases. Also this figure shows that the mixtures that composed from microcrystalline wax and furfural extract oil 60 have penetration lower than the mixtures that composed from paraffin wax and furfural extract 60.

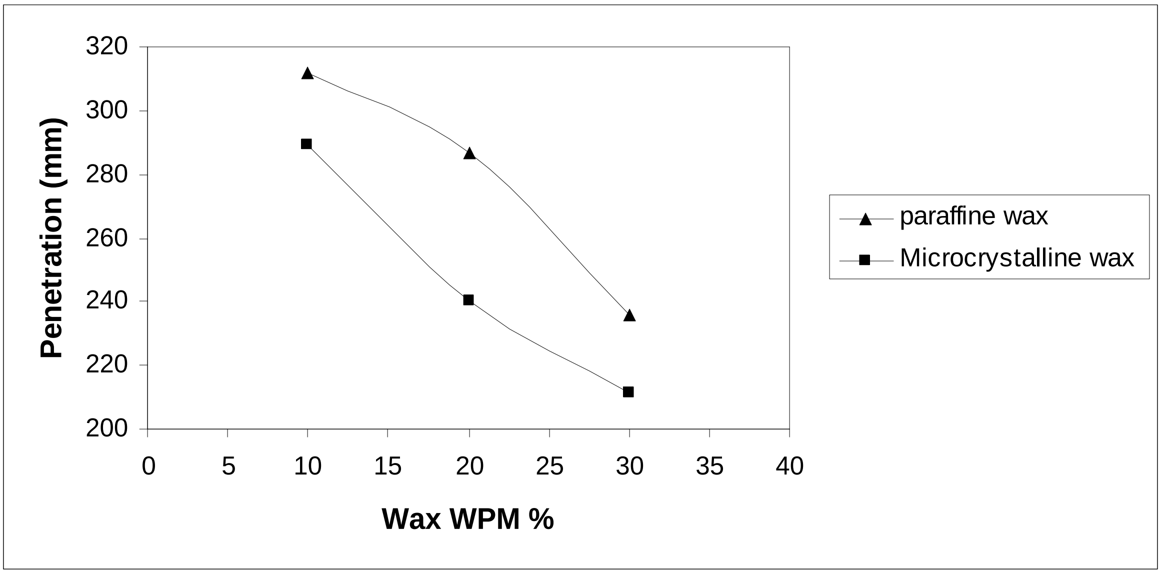


Fig 4.26: Effects of wax WPM on the penetration for furfural extract oil 150

Figure 4.26: shows the variation of the penetration with wax WPM for two types of waxes for furfural extract oil 150. This figure indicates that when the wax WPM increases, the penetration decreases. The penetration in case of microcrystalline wax is lower than that of paraffin wax. Although the use of other type of furfural extract oil the result of the penetration with wax WPM still the same with results indicated in figure 4.25.

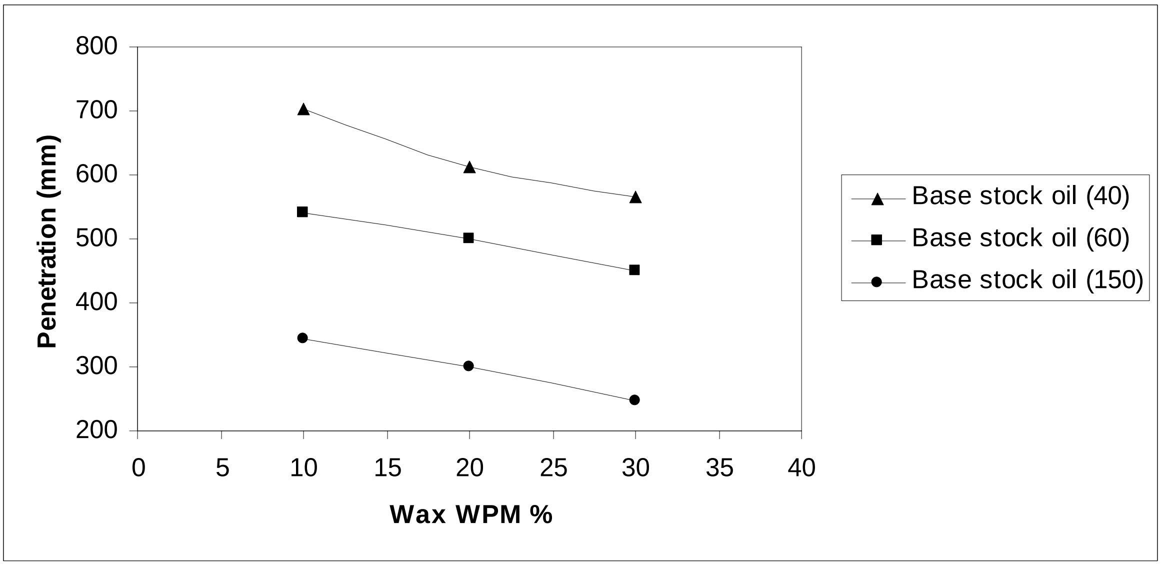


Fig 4.27: Effect of wax WPM on the penetration for paraffin wax

Figure 4.27: reveals the effect of base stock degree on the penetration in presence of paraffin wax. This figure obviously reveals that the increase in the wax WPM leads to decrease the penetration. Also this figure shows that the base stock oil of degree 150 gives lower penetration than that of degree 60 and the penetration of degree 60 is lower than degree 40. This is ascribed to the fact that the lower the degree is the higher the viscosity will be. As the viscosity increases the penetration decreases, this may be due to the significant variation in the oils viscosities, such that μ base stock oil 150 > μ base stock oil 60 > μ base stock oil 40 and that is come from that the M.Wt. of base stock oil 150 > the M.Wt. of base stock oil 60 > the M.Wt. of base stock oil 40.

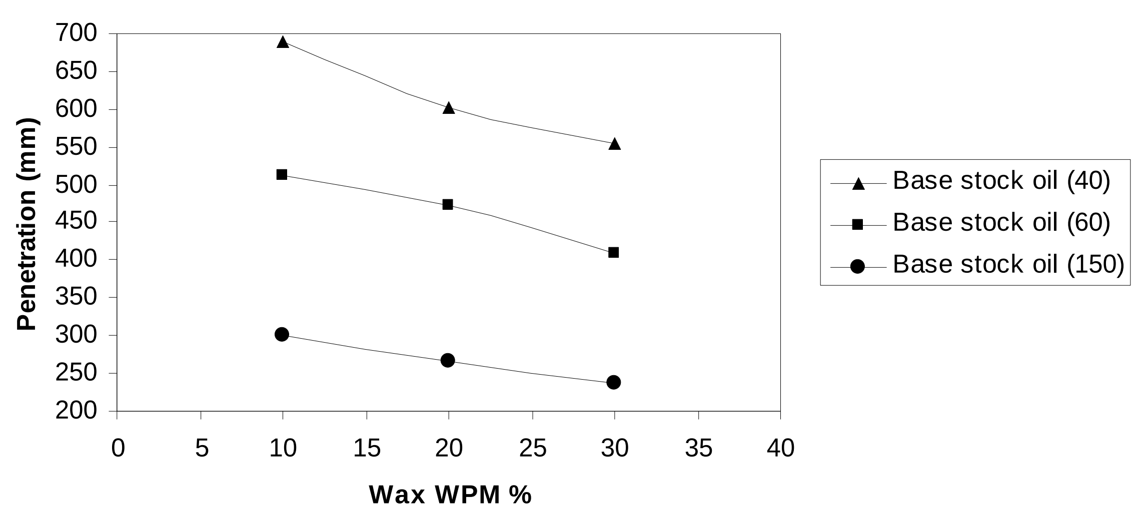


Fig 4.28: Effect of wax WPM on the penetration for microcrystalline wax

Figure 4.28: shows the effect of base stock degree on the penetration in presence of microcrystalline wax. It is clear that when the wax WPM increases, the penetration decreases. This figure reveals that the base stock oil of degree 150 is gives lower penetration than the degree 60 and the letter is lower than degree 40. The higher the M.Wt., the lower the penetration will be. This illustrates the mixtures that formed from base stock oil 150 and microcrystalline wax is lower penetration than the mixtures that formed from base stock oil 150 and paraffin wax in figure 4.6.

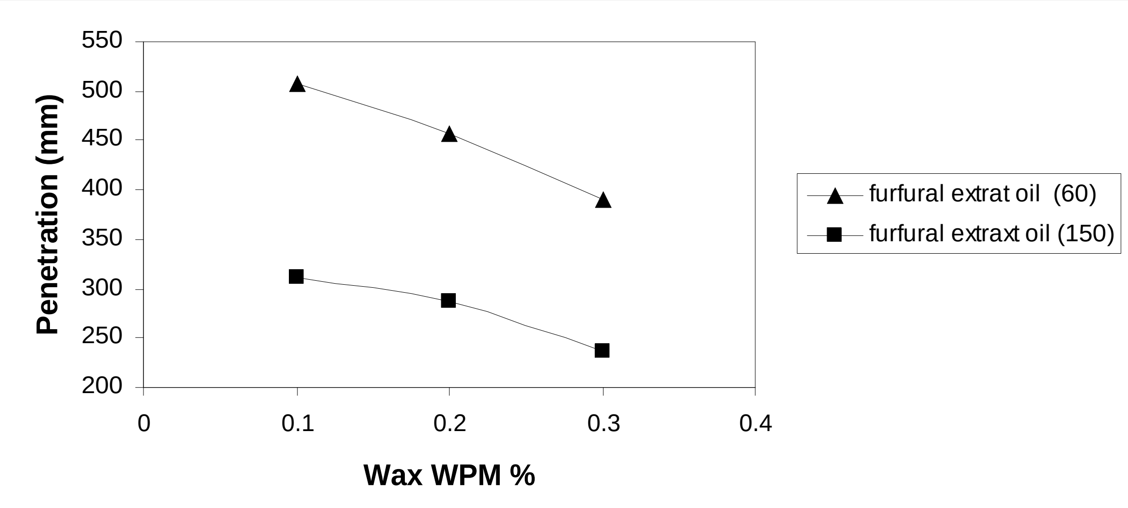


Fig 4.29: Effect of wax WPM on the penetration for paraffin wax

Figure 4.29: illustrates the effect of furfural extract oil type on the penetration in presence of paraffin wax. The penetration decreases as wax WPM increased, the furfural extract oil 150 causes the penetration to be lower than that of furfural extract oil 60, this may be due the significant variation in the oils viscosity value, such that is µ furfural extract oil 150 > µ furfural extract oil 60, since the M.Wt. of furfural extract oil 150 > the M.Wt. of furfural extract oil 60.

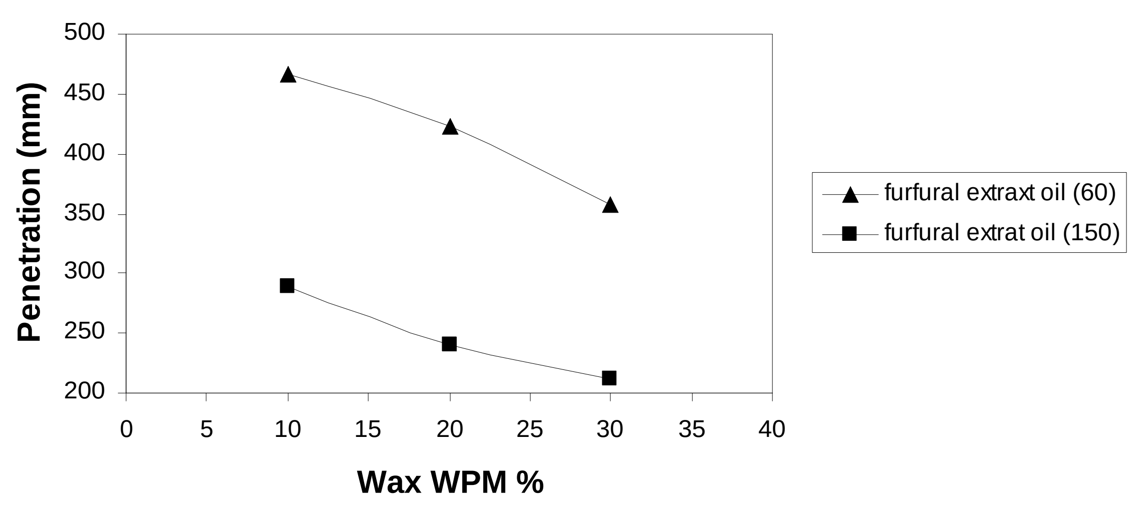


Fig 4.30: Effect of wax WPM on the penetration for microcrystalline wax

Figure 4.30: reveals the effect of furfural extract type on the penetration in presence of microcrystalline wax. This figure shows that the penetration of mixture composed from the furfural extract oil 150 become lower than when the mixture composed from furfural extract oil 60, this may be due the variation in the oils viscosity such that µ furfural extract oil 150 > µ furfural extract oil 60, although the use of other compound wax (paraffin, microcrystalline) the result of the penetration and wax WPM still the same with the results indicated in Fig. 4.29.

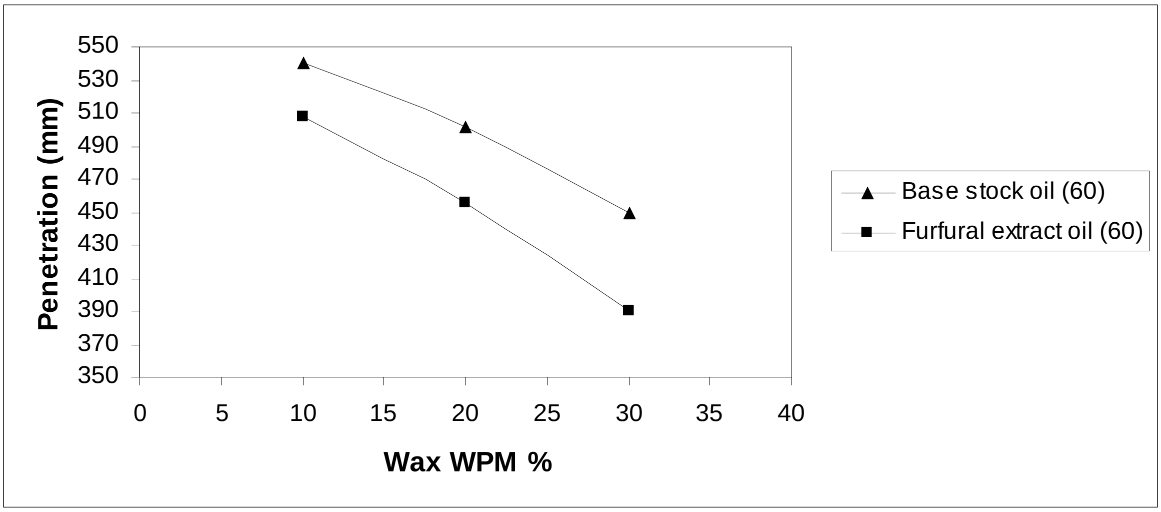


Fig 4.31: Effect of wax WPM on the penetration for paraffin wax

Figure 4.31: shows the variation of the penetration with wax WPM for two types of oil degree 60 in presence of paraffin wax. This figure obviously indicate that base stock oil 60 and furfural extract oil 60 having almost the same results for the effect of wax WPM on degree of penetration, the drop point of mixture of furfural extract oil 60 is lower than of penetration of mixture of base stock oil 60. which may be due to the close viscosity values, such that µ furfural extract oil 60 > µ base stock oil 60, becues the M.Wt. of furfural extract oil 60 > the M.Wt. of base stock oil 60.

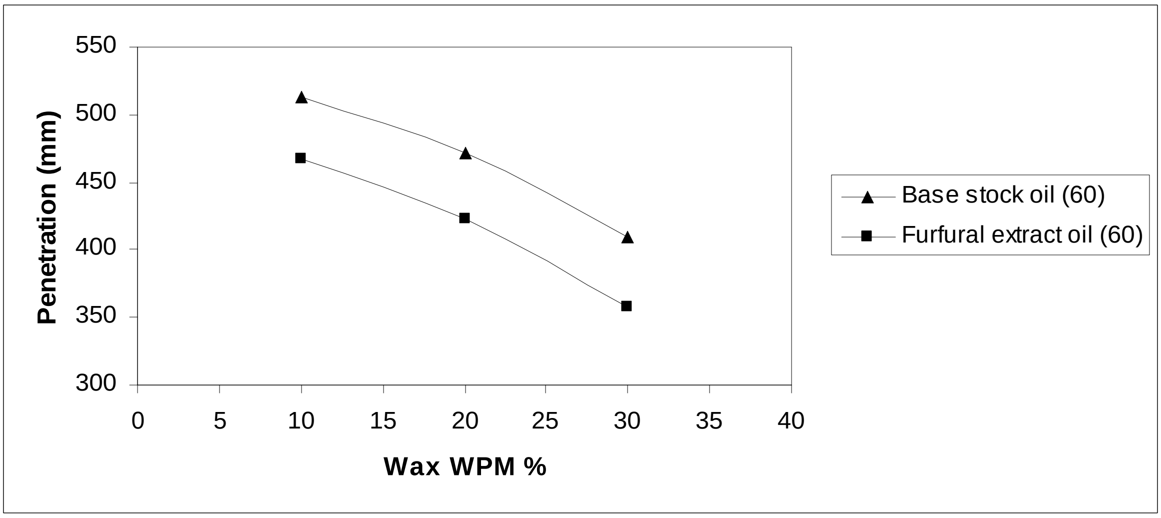


Fig 4.32: Effect of wax WPM on the penetration for microcrystalline wax

Figure 4.32: shows the variation of the penetration with wax WPM for two types of oil degree 60 in presence of microcrystalline wax. It is evident that as the wax WPM increases the penetration decreases for the two oil degree 60 types. The higher the M.Wt., the lower the penetration will be. Also the furfural extract oil 60 gives lower values of penetration for mixtures, the penetration of mixture of furfural extract 60 is lower than of penetration of mixture of base stock oil 60.

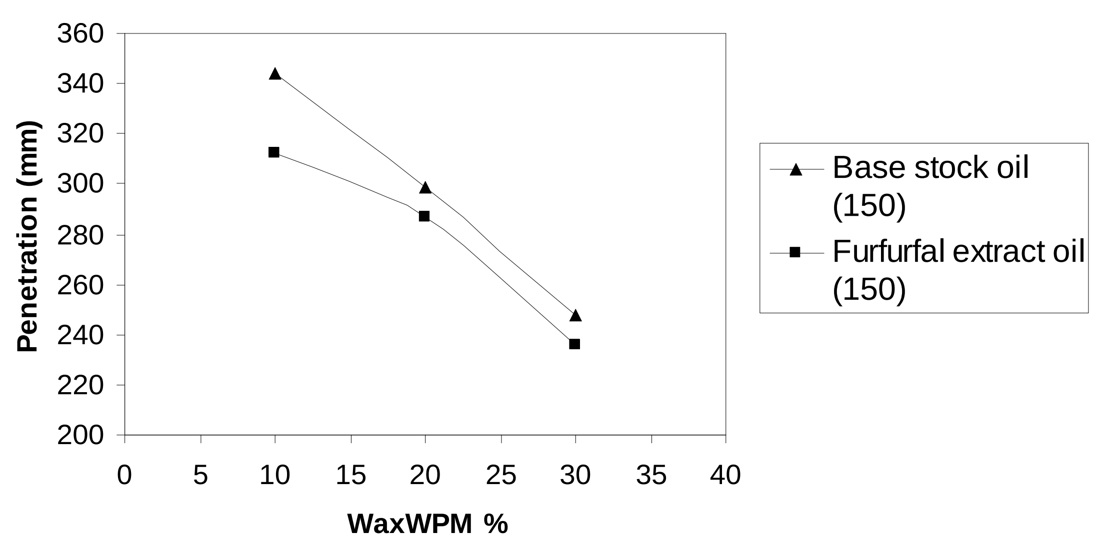


Fig 4.33: Effect of wax WPM on the penetration for paraffin wax

Figure 4.33: reveals the variation of the penetration with wax WPM for two types of oil degree 150 in presence of paraffin wax. This figure indicates that the wax WPM increases, the penetration decreases too. This figure shows that the mixture that composed from the furfural extract oil 150 lower penetration than the mixture that composed from base stock oil 150, this may be due the variation in the oils viscosity values, such that µ furfural extract oil 150 > µ base stock oil 150 and that is come that the M.Wt. of furfural extract oil 150 > the M.Wt. of base stock oil 150.

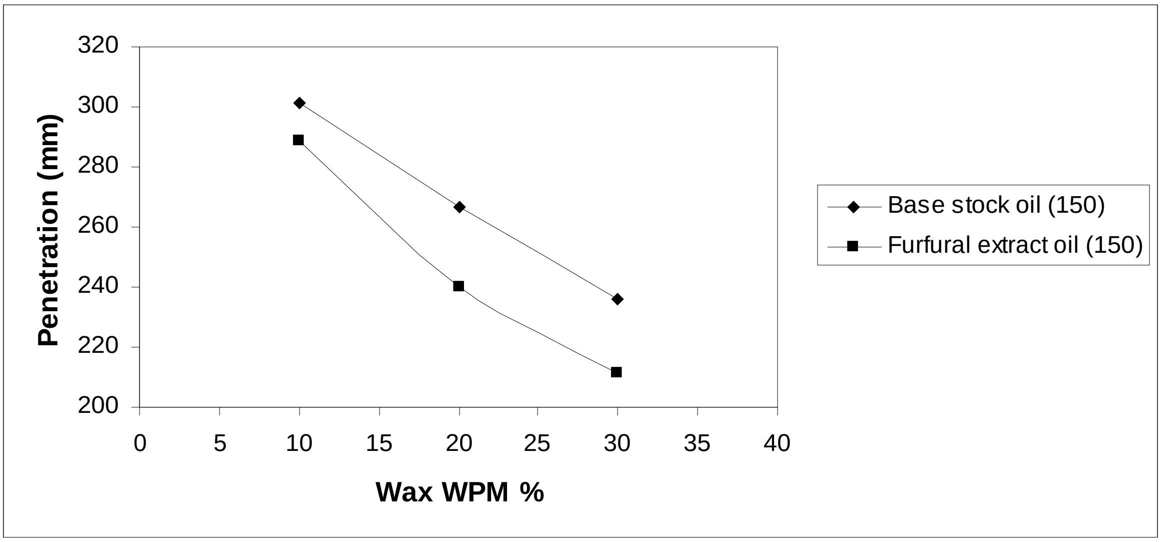


Fig 4.34: Effect of wax WPM on the penetration for microcrystalline wax

Figure 4.34: shows the variation of the penetration with wax WPM for two types of oil degree 150 in presence of microcrystalline wax. This figure obviously reveals that when wax WPM increase in the penetration decreases. The penetration in case use of furfural extracts oil 150 is lower than that use of base stock oil 150. The higher the M.Wt, the lower the penetration will be. Although the use of other compound wax (paraffin, microcrystalline) the result of the penetration with wax WPM still the same with results indicated in figure 4.33.

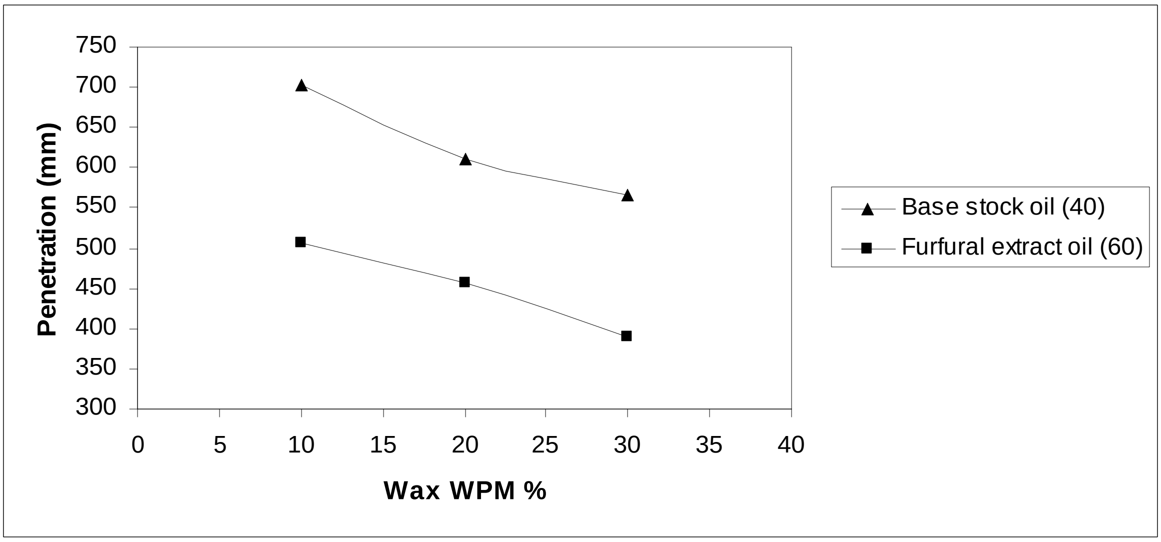


Fig 4.35: Effect of wax WPM on the penetration for paraffin wax

Figure 4.35: illustrates the effect of oil type degree on the penetration in presence of paraffin wax. It is clear that as the wax WPM increases the penetration decreases for the two type's oil degree. It illustrates that lower penetration is obtained when furfural extract oil 60 is presented and gives lower values of penetration for mixtures of base stock oil 40. This may be due to the variation of oils viscosity values, such that µ furfural extract 60 > µ base stock oil 40, since the M.Wt. of furfural extract oil 60 > the M.Wt. of base stock oil 40.

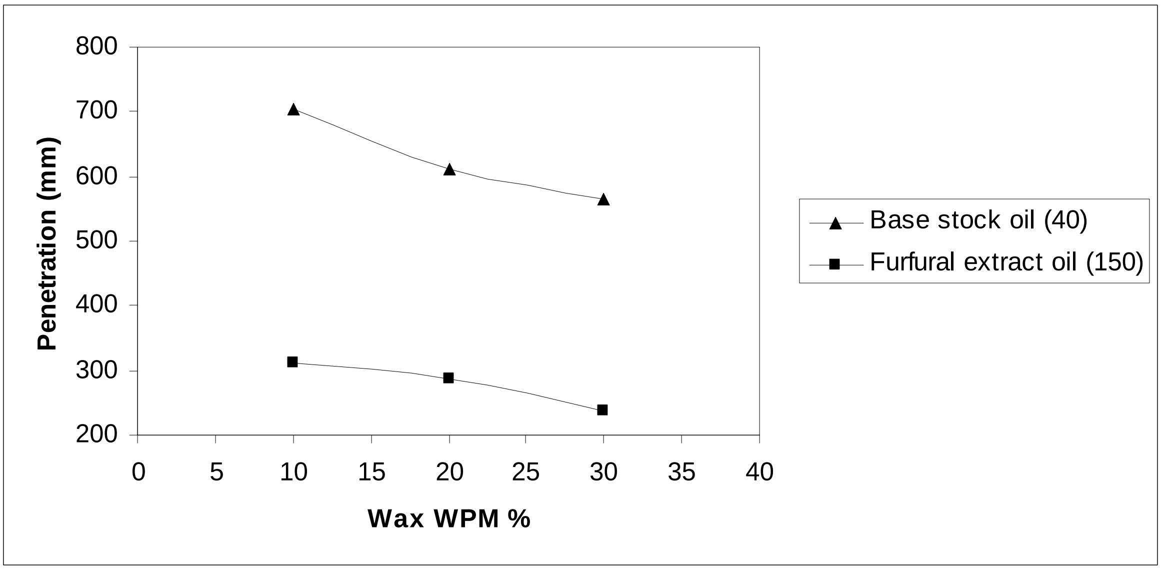


Fig 4.36: Effect of wax WPM on the penetration for paraffin wax

Figure 4.36: reveals the effect of oil type degree on the penetration in presence the paraffin wax. The figure shows that the increase in the wax WPM leads to decreases the penetration. Also, the furfural extract oil 150 gives lower values of penetration for mixtures, the penetration of mixture that formed from furfural extract 150 more lower than that of penetration of mixture that formed from base stock oil 40, which may be due to the variation of oils viscosity values, such that µ furfural extract 150 > µ base stock oil 40, becues the M.Wt. of furfural extract oil 150 is higher than the M.Wt. of base stock oil 40.

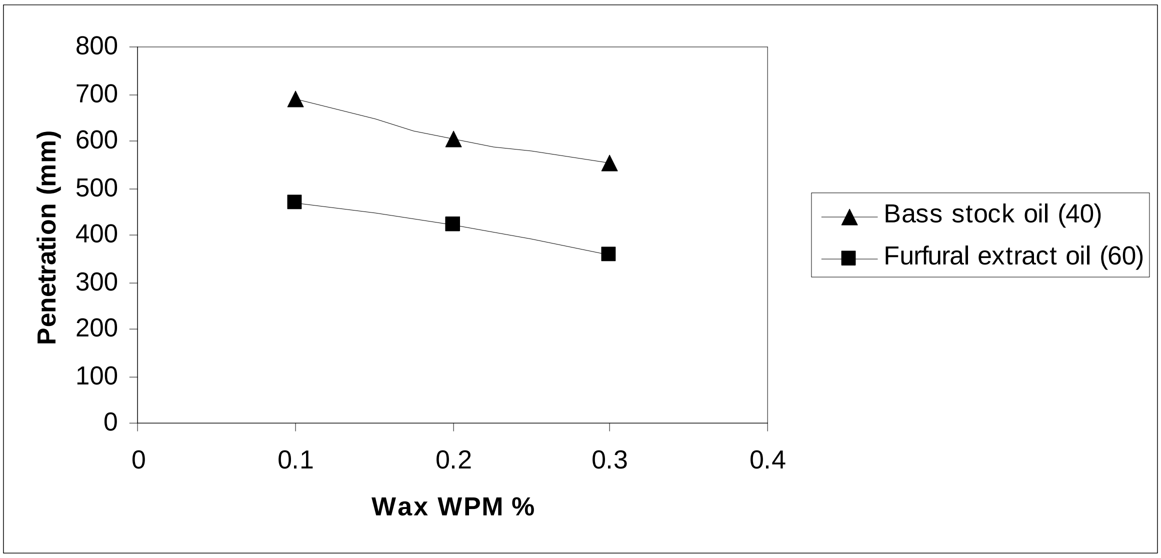


Fig 4.37: Effect of wax WPM on the penetration for microcrystalline wax

Figure 4.37 shows the effect of oil type degree on the penetration in presence of microcrystalline wax. This figure obviously indicates that when the wax WPM increases, the penetration decreases. It has been found that the mixtures that composed from furfural extract oil 60 and microcrystalline wax has a penetration lower than the mixtures that composed from paraffin wax and base stock oil 40. The higher the M.Wt, the lower the penetration will be. Although the use of other type degree oil does not affect the behavior of the penetration with wax WPM in figure 4.35.

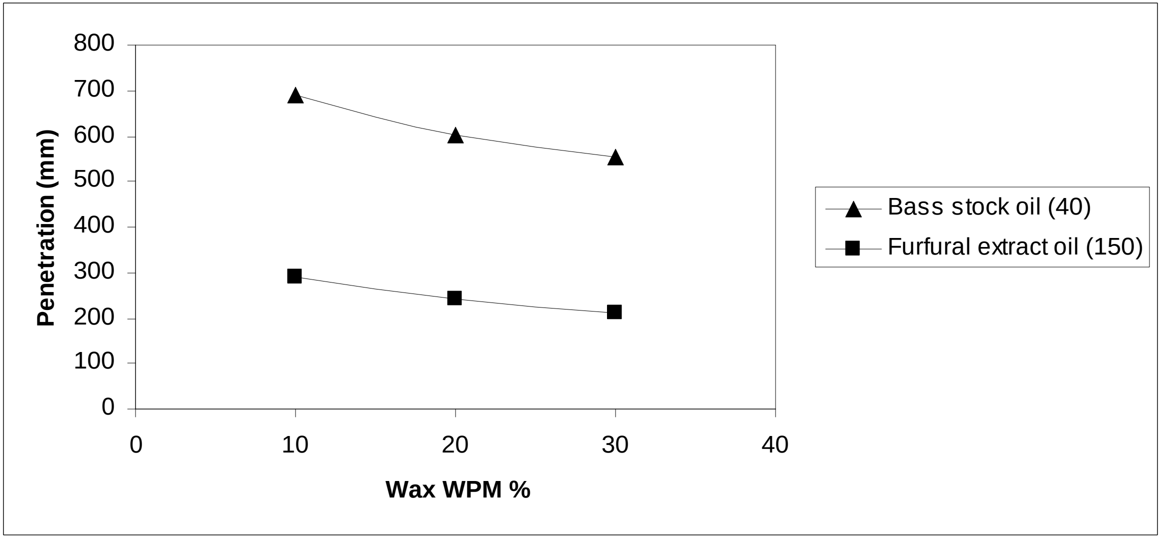


Fig 4.38: Effect of wax WPM on the penetration for microcrystalline wax

Figure 4.38: shows the effect of oil type degree on the penetration in presence of microcrystalline wax. It is evident that when as the wax WPM increases, the penetration is decreases. Also the figure shows that the mixtures that formed from microcrystalline wax and furfural extract oil 150 has a penetration lower than the mixtures that formed from paraffin wax and base extract oil 40. Also the figure shows although in the use of other degree oil types the result for penetration and wax WPM still the same with the result in figure 4.37.

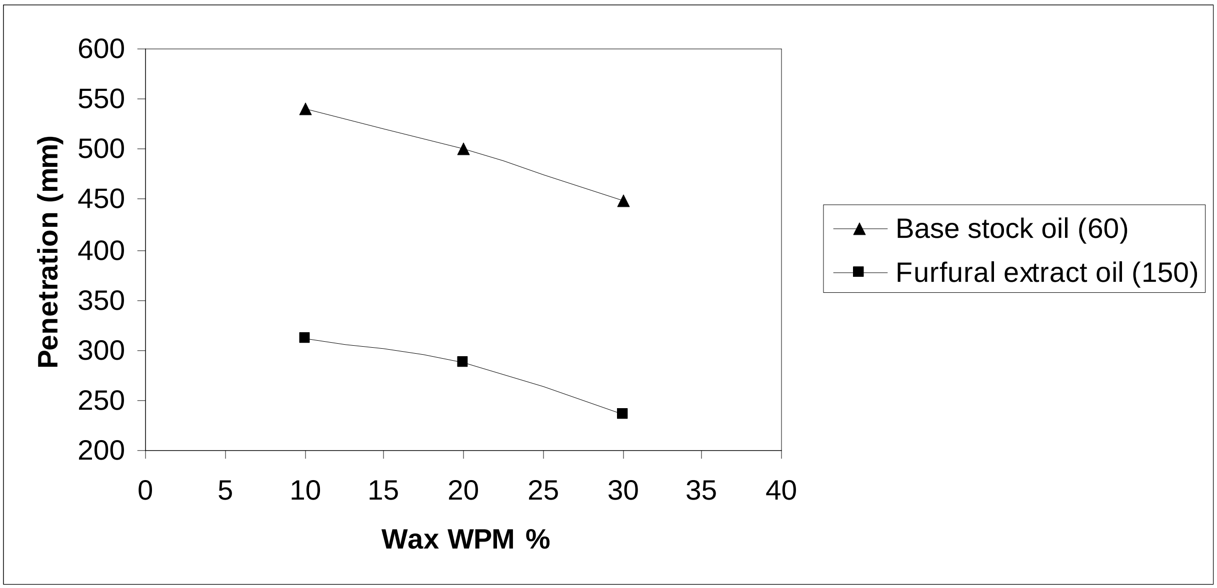


Fig 4.39: Effect of wax WPM on the penetration for paraffin wax

Figure 4.39: reveals the effect of oil type degree on the penetration in presence of paraffin wax. This figure obviously reveal that the wax WPM increase the penetration decreases. The drop point in case of furfural extract oil 150 is lower than that of base stock oil 60. This is ascribed to the fact the lower the degree is the higher the viscosity will be, this may be due to the variation of viscosity values, such that µ furfural extract oil 150 > µ Base stock oil 60 and that is come from that the M.Wt. of furfural extract oil 150 is higher than the M.Wt. of base stock oil 60.

.

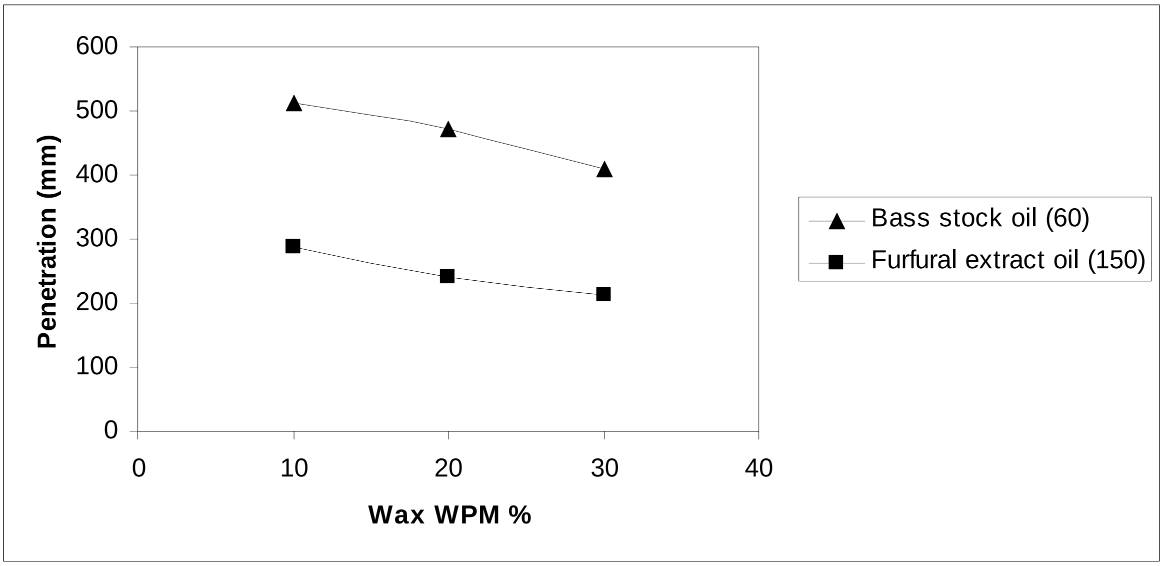


Fig 4.40 Effect of wax WPM on the penetration for microcrystalline wax

Figure 4.40 shows the effect of oil type degree on the penetration in presence of microcrystalline wax. This figure indicates that when the wax WPM increases, the penetration decreases. It is clear that the mixture formed from furfural extract oil is gives lower penetration than the mixture formed from base stock oil 60. The higher the M.Wt., the lower the penetration will be.

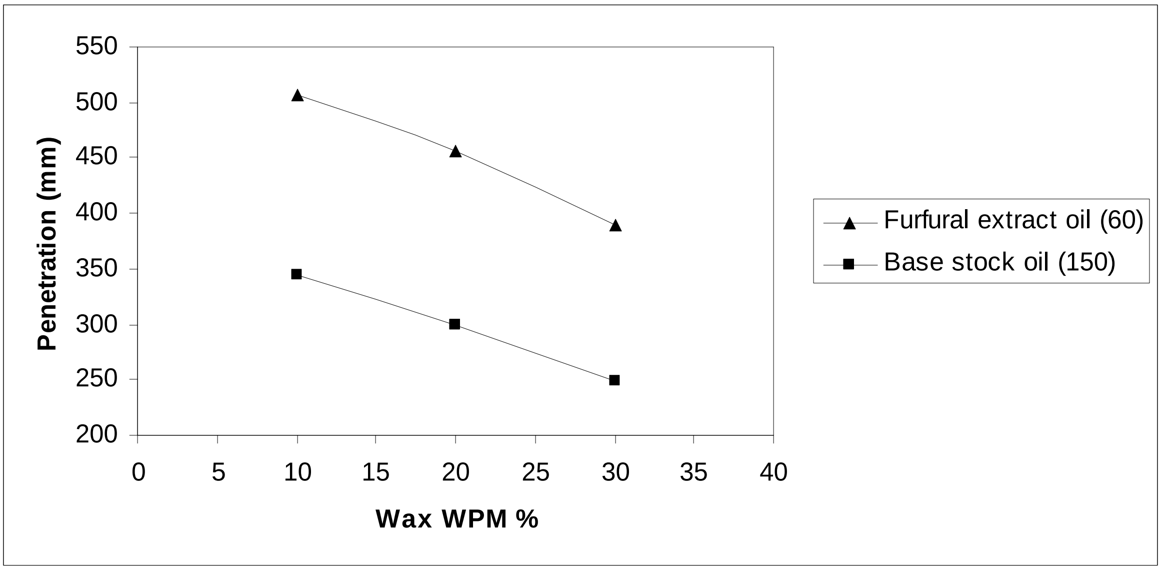


Fig 4.41: Effect of wax WPM on the penetration for paraffin wax

Figure 4.41: illustrates the effect of oil type degree on the penetration in presence of microcrystalline wax. It is clear that when the wax WPM increases, the penetration decreases. The penetration of mixture composed from base stock oil 150 is lower than of penetration of mixture composed from furfural extract oil 60, which may be due to the close viscosities, such that µ base stock oil 150 > µ furfural extract oil 60, becues the M.Wt. of base stock oil 150 is higher than the M.Wt. of furfural extract oil 60.

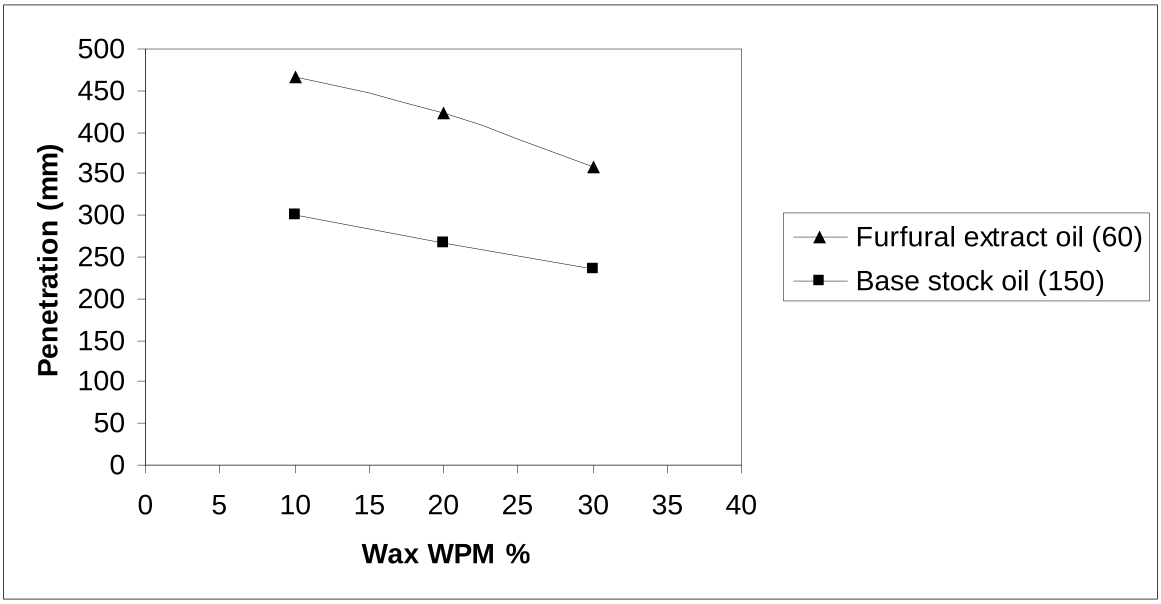


Fig 4.42: Effect of wax WPM on the penetration for microcrystalline wax

Figure 4.42: reveals the effect of base stock oil degree on the penetration in presence of microcrystalline wax. This figure shows that as the wax WPM increases, the penetration decreases. Also the figure shows that of mixture of base stock oil 150 is lower of penetration than of mixture of furfural extract oil 60. Although the use of other compound wax (paraffin, microcrystalline) the result of the penetration with wax WPM still the same with results indicated in figure 4.41.

4.4 Discussions of Experimental Copper Corrosion

We noted from the last experiments on the mixtures samples the importance of the best usage mixtures, so that there was the drop point measurement to express mixtures bearing for temperature and the penetration measurement for mixtures to know how much it prevents reaching the electronic charges to the minerals surface to prevent corrosion.

The two last experiments was not enough to define the best using mixtures, so it was necessary to do another experiment to continue the two last experiments, this was copper corrosion processing experiment to know how the anticorrosion prevents the minerals from oxygenation in high temperature and standard periods otherwise the anticorrosion will be use less and can not protect minerals surface from electronic charges.

The differences about this experiment based on the characters which represent the color of copper cast that is different in colors according to oxidizing inside the tube and filled with anticorrosion which is the mixture in this experiment, this is based on the copper color, as the color was closer to yellow the oxidizing will be useless that means the anticorrosion can prevent the oxidizing processing, but if the color changed to black then the minerals surface is affected with oxidizing that means the anticorrosion is useless and cannot prevent the oxidizing processing.

Results are reported as a number followed by a letter according to the following scheme:-

The oxidizing effect on the copper casts surface affects with some factors like the difference in wax type and WPM in the mixture and oil type and degree , for example the effect of copper cast with oxidizing is different when we put the cast in type different mixtures like in samples e , and B_5 the symbols of there effect are B_2 and C_1 serially , the sample E_1 represents the mixture that formed from of paraffin wax 10% with furfural extract 60 , the sample B_5 represents the mixture that consists crystalline wax 20% and Base stock oil 60.

Table 4.1: shows that the copper corrosion of base stock oil 40 with paraffin wax. Sample A_1 which is composed from 10% paraffin wax and 90% base stock oil 40, sample A_2 which is composed from 20% paraffin wax and 80% base stock oil 40 and sample A_3 which is composed from 30% paraffin wax and 70% base stock oil 40.

From the table, it is clear that the mixture A_3 gives lower copper corrosion than mixture A_2 and the latter is lower than mixture A_1 indicating that when the wax WPM of the mixture increases the protection of metal from corrosion increases too, i.e. , the copper corrosion decreases. This may attribute to two reasons:

1. The decrease in oxygen solubility and increase of the wax WPM will lead to reducing the corrosion
2. The increase in wax WPM leads to decrease the penetration, and consequently the protection from oxygen corrosion increases.

Table 4.2 illustrates that the copper corrosion of base stock oil 40 with microcrystalline wax. Sample A_4 which is formed from 10% microcrystalline wax and 90% base stock oil 40, sample A_5 which is formed from 20% microcrystalline wax and 80% base stock oil 40 and sample A_6 which is formed from 30% microcrystalline wax and 70% base stock oil 40.

From the table, it is evident that the mixture A_4 gives higher copper corrosion than mixture $A_{5,}$ and the latter is higher than mixture A_6 indicating that as the wax WPM in the mixture increases the protection of metal from corrosion increases, i.e., the copper corrosion decreases.

Table 4.3 reveal that the copper corrosion of base stock oil 60 with paraffin wax. Sample B_1 which is formed from 10% paraffin wax and 90% base stock oil 60, sample B_2 which is formed from 20% paraffin wax and 80% base stock oil 60 and sample B_3 which is formed from 30% paraffin wax and 70% base stock oil 60.

From the table obviously reveal that the mixture B_3 gives lower copper corrosion than mixture B_2 and the latter is lower than mixture B_1 indicating that as the wax WPM in the mixture increases the protection of metal from corrosion increases, i.e., the copper corrosion decreases, due to decrease in oxygen solubility and penetration.

Table 4.4 indicates that the copper corrosion of base stock oil 60 with microcrystalline wax. Sample B_4 which is composed from 10% microcrystalline wax and 90% base stock oil 60, sample B_5 which is composed from 20% microcrystalline wax and 80% base stock oil 60 and sample B_6 which is composed from 30% microcrystalline wax and 70% base stock oil 60.

From the mixture B_4 gives higher copper corrosion than mixture B_5 and the latter is higher than mixture B_6 indicating that as the wax WPM in the mixture increases the protection of metal from corrosion increases, i.e., the copper corrosion decreases.

Table 4.5 shows that the copper corrosion of base stock oil 150 with paraffin wax. Sample C_1 which is composed from 10% paraffin wax and 90% base stock oil 150, sample C_2 which is composed from 20% paraffin wax and 80% base stock oil 150 and sample C_3 which is composed from 30% paraffin wax and 70% base stock oil 150.

From the table it is evident that the mixture C_3 gives lower copper corrosion than mixture C_2 and the latter is lower than mixture C_1 indicating that as the wax WPM in the mixture increases the protection of metal from corrosion increases, i.e., the copper corrosion decreases.

Table 4.6 illustrates that the copper corrosion of base stock oil 150 with microcrystalline wax. Sample C_4 which is formed from 10% microcrystalline wax and 90% base stock oil 150, sample C_5 which is formed from 20% microcrystalline wax and 80% base stock oil 150 and sample C_6 which is formed from 30% microcrystalline wax and 70% base stock oil 150.

From the table it is clear that the mixture C_4 gives higher copper corrosion than mixture C_5 and the latter is higher than mixture C_6 indicating that as the wax WPM in the mixture increases the protection of metal from corrosion increases, i.e., the copper corrosion decreases.

Table 4.7 reveals that the copper corrosion of furfural extracts oil 60 with paraffin wax. Sample E_1 which is formed from 10% paraffin wax and 90% furfural extract oil 60, sample E_2 which is formed from 20% paraffin wax and 80% furfural extract oil 60 and sample E_3 which is formed from 30% paraffin wax and 70% furfural extract oil 60.

From the table it is evident that the mixture E_3 gives lower copper corrosion than mixture E_2 and the latter is lower than mixture E_1 indicating that as the wax WPM in the mixture increases the protection of metal from corrosion increases, i.e., the copper corrosion decreases.

Table 4.8 shows that the copper corrosion of furfural extracts oil 60 with microcrystalline wax. Sample E_4 which is composed from 10% microcrystalline wax and 90% base stock oil 60, sample E_5 which is composed from 20% microcrystalline wax and 80% furfural extract oil 60 and sample E_6 which is composed from 30% microcrystalline wax and 70% furfural extract oil 60.

From the table obviously reveal that the mixture E_4 gives higher copper corrosion than mixture E_5 and the latter is higher than mixture E_6 indicating that as the wax WPM in the mixture increases the protection of metal from corrosion increases, i.e., the copper corrosion decreases.

Table 4.9 shows that the copper corrosion of furfural extracts oil 150 with paraffin wax. Sample F_1 which is composed from 10% paraffin wax and 90% furfural extract oil 150, sample F_2 which is composed from 20% paraffin wax and 80% furfural extract oil 150 and sample F_3 which is composed from 30% paraffin wax and 70% furfural extract oil 150.

From the table shows that the mixture F_3 gives lower copper corrosion than mixture F_2 and the latter is lower than mixture F_1 indicating that as the wax WPM in the mixture increases the protection of metal from corrosion increases, i.e., the copper corrosion decreases.

Table 4.10 illustrates that the copper corrosion of furfural extract oil 150 with microcrystalline wax. Sample F_4 which is formed from 10% microcrystalline wax and 90% furfural extract oil 150, sample F_5 which is formed from 20% microcrystalline wax and 80% furfural extract oil 40 and sample F_6 which is formed from 30% microcrystalline wax and 70% furfural extract oil 150.

From the table it is clear that the mixture F_4 gives higher copper corrosion than mixture F_5 and the latter is higher than mixture F_6 indicating that as the wax WPM in the mixture increases the protection of metal from corrosion increases, i.e., the copper corrosion decreases.

Chapter Five
Conclusions and Recommendations

5.1 Conclusions

From the experimental work the following conclusions are obtained:

1. The wax WPM increases the drop point of all types of mixture and the drop point of mixtures in case of microcrystalline wax is higher than that of paraffin wax.
2. Increasing the wax WPM leads to decrease in penetration and the mixtures that formed from of microcrystalline wax is lower penetration than the mixtures that formed from of paraffin wax.
3. As the wax WPM increases, the copper corrosion decreases and protection of metals from corrosion is higher in case of microcrystalline wax than that of paraffin wax.
4. The value of drop point of mixtures increases in the following manner: base stock oil 40, base stock oil 60**,** furfural extract oil 60, base stock oil 150 and furfural extract oil 150.
5. The value of penetration of mixtures increases in the following manner: furfural extract oil 150, base stock oil 150**,** furfural extract oil 60, base stock oil 60 and base stock oil 40.
6. The value of copper corrosion of mixtures decreases in the following manner base stock oil 40, base stock oil 60**,** furfural extract oil 60, base stock oil 150 and furfural extract oil 150.
7. The M.Wt. increase the drop point increase too of all types of mixture, The M.Wt. increase leads the penetration and the copper corrosion are decreases for all mixtures.
8. As the drop point increases the penetration decreases and the copper corrosion decreases for all mixtures.

9. The drop point of mixture (F_6) which is composed of 30% microcrystalline wax and 70 % furfural extract oil 150 is higher than other types of mixtures, while its penetration and copper corrosion is lower than other mixtures leading to conclusion that this type of mixture is better than other types and can be used in product the waxy greases .

5.2 Recommendations

Further studies could be conducted to:

1. Investigation of the preparation of hydrocarbon mixtures from used other wax compound and oil compound.
2. Investigation of the additions to mixture to make the special greases called waxy grease.
3. Investigation of the additions to mixture corrosion inhibitors to the protect the metal from corrosion.
4. Caring out more test on the mixture such as Evaporation Loss ,Bleeding and Wear and Extreme Pressure Properties

Reference

1. Nelson W.L., Oil Gas J., 5th edition, p. 131 (1959).
2. Bondi A., physical chemistry of lubricating oils, 2nd edition, Vol. 2 p.116, (1947)
3. Smith K.W. Starr W. C., Oil and Gas J., 2nd edition, p. 75-84, (1980).
4. Nelson W.L., Refinery Petroleum, 4th edition, Vol.3 p.374,(1946).
5. Dunstan A.W., the science of petroleum, 5th edition, Vol. 6 p. 2586, (1938).
6. James H.G., Petroleum Refining Engineering, (2nd edition), p 233 (1984).
7. Smoley and Fulton, Modern Manufacture of Lubricating Oils, Vol. 3 p.594, (1947).
8. Foster A.L., Vacuum Distillation, Chemical Treatment make Quality Lubricating Oils, Oil Gas J., p.78, (1946
9. Robert W.B. and Kenneth R.G., Process for preparing a very high quality lube base stock oil, Mobil Oil Corporation, New York, issum Number 289341, (1988).
10. Bell H. S., "American Petroleum Refining", D. Van Nostrand Company Inc., pp. 393-405, (1945).
11. Thomas C. L., Ind. Eng. Chem., 3rd edition, Vol. 6,p. 2564, (1949).
12. Bernard M.A., Michael S.P. and Kenneth W.K., Manufacture of lube base stock oil , Mobil Oil Corporation, New York, issum Number 862460, (1977).
13. Teintze L.M., Used Oil Issues and Opportunities, American Chemical Society, pp. 1356-1366, (1992).
14. James H.G, Petroleum Refining, (2nd edition), p 235 (1984).

15. Khan H.U., Nautiyal S.P., Anwar M.W. and Agrawal K.M., Studies of lubricating oil base stock: characterisation and composition, John Wiley & Sons, Vol. 12, Issue 1 , pp 57 – 65, (2005).
16. King E. P., Lubricating Oil Manufacture, Oil Gas J., p.122, (1953).
17. Petroleum Refining Corrosion Copyright , in 2004, The Hendrix Group http//www.hghouston.com/refining.htmel
18. James N. Z., Phil W. and Jirong X., Base stock lube oil manufacturing process, United States Patent Issued 6264826, (2001).
19. Sequeria A., an Overview of Lube Base Oil Processing, American Chemical Society, R&D Texaco, Vol. 2 pp. 1286-1293, (1992).
20. Roger A. and Voorhees V. "Furfural". *Org. Synth.* Vol.1 p 49; Coll. Vol. 1 p 280, (1921).
21. D?bereiner J. W., "Ueber die medicinische und chemische Anwendung und die vortheilhafte Darstellung der Ameisens?ure". Berichte der deutschen chemischen Gesellschaft, Vol. 3 pp 141-146, (1832).
22. Carter R.C., Furfural Refining, Oil Gas J., p. 137, (1954).
23. Douglas J., Lubricating oil refining process, Mobil Oil Corporation, Issue number: 5328596, (1994).
24. Biswas G.K., Saha S.K., and Biswas D., Hydrothermal Cracking of Furfural Extract into Middle Distillat, Journal of the Japan Petroleum Institute, Vol. 47, No. 1, p.37 (2004).
25. Wax India http://www.waxindia.com/abouts.htm/
26. Clark and Smith, Ind. Eng. Chem., Vol. 23, p. 697, (1931)
27. Mueller A.J. Oil Gas J., p. 54, (1940).
28. John W., Waxes Colloidal properties and systems, Journal of Polymer Science, Vol. 58, pp 273 – 288, (1993).
29. Kalichevsky V.A. , Petroleum Refining with Chemicals, Elsevier Publishing Company, London pp 382-456 ,1956

30. Paraffine wax , in 2005, Article given on the internet at the web site: "http://en.wikipedia.org/wiki/Paraffin"
31. Paraffin wax , in 2003 China Trade Directory, http://www.trader-china.com/Energy/Paraffin.html
32. Paraffin Wax, in 2006,The International Group, http://www.igiwax.com/ resource/ Paraffin _ wax
33. John C.D., Petroleum Waxes, p. 87, (1946).
34. Bowman and Bark, Sweating of paraffin wax, Ind. Eng. Chem., 2nd edition, Vol. 6, p. 2017, (1949)
35. Nelson and Stewart, Ind. Eng. Chem., effect of oil on plastic properties, pp. 2223-2231, (1949).
36. Lund H. A., Meeting Product Quality in Wax Crystallization, Pet. Processing, p. 326, (1952).
37. Microcrystalline Wax, in 2006, The International Group, http://www.igiwax.com/resource/ Microcrystalline _wax
38. Glaeser W.A. and Dufrane K.F., "New Design Methods for Boundary-lubricated Sleeve Bearings." *Machine Design*, pp 207-213. (1978).
39. Grease, in 2007, Article given on the internet at the web site: "http://en.wikipedia.org/wiki/Grease_(lubricant)"
40. Potteiger J., "Step-by-Step Grease Selection." *Machinery Lubrication* magazine. Issue Number: 200509, 2005.
41. Khonsari M.M., *Applied Tribology-Bearing Design and Lubrication*. Wiley Book. 2001
42. Booser. E.R., "Life of Oils and Greases." *Tribology Data Handbook*, pp 1018-1028, CRC Press. (1997).
43. Simpson and Welch, Manufacture of Grease, Ref. Nat. Gaso. Mfr., p. 77, (1931).

44. Ebaugh I.A., Service Tests Must Determine Value of extreme Pressure Lubricants, 2nd edition, p. 26, (1936).
45. Booser E.R., and Khonsari M.m., "Systematically Selecting the Best Grease For Equipment Reliability". *Machinery Lubrication* Magazine, Louisiana State University, pp 367- 384, (2007).
46. U.S. Army Corps of Engineers grease definition and application guide(filePDF)chapter5http://www.usace.army.mil/publications/eng-manuals/em1110-2-1424/c-5.pdf
47. drop point, in 2005, Article given on the internet at the web site: http://en.wikipedia.org/wiki/Dropping_point
48. Ronald L.H., understanding the basic grease, Reliability Center, Vol. 27 pp 237-254 ,(2000).
49. Grease Viscosity and NLGI Number Grades, in 2004, http://www.GreaseDispensing.com/penetration
50. Thomas E. K., , Myung S. J., Harmonic analysis in grease rheology, Journal of Applied Polymer Science,Vol. 30, pp 334-343, (2003).
51. Corrosion Test Bomb Copper corrosion, in 2003, Article given on the internet at the web site: http:// www.koehlerinstrument.com/

الخلاصة

العمل التجريبي هو دراسة سلوك المزيج المكون من خلط نوعان من الشموع (البارافيين والبلوري) مع انواع مختلفة من الزيوت النفط الثقيلة (زيت اساسي ٤٠، زيت اساسي ٦٠، زيت اساسي ١٥٠ ، زيت منزوع الفورفورال ٦٠ ، زيت منزوع الفورفورال ١٥٠).

العمل التجريبي يتضمن قياس الخصائص الاساسية للمزيج مثل نقطة السقوط ، الاختراق و التاكل النحاسي. ويتضمن العمل التجريبي ايضا مناقشة مدى تاثير نوع الشمع ، نسبة وزن الشمع في المزيج ، نوع الزيت الثقيل و درجة الزيت الثقيل على تلك الخصائص المذكورة اعلاه.

الانواع المختلفة للمزيج تستخدم نسبة مختلفة من الزيوت الثقيلة والشموع. النتائج المتعلقة بنسبة وزن الشمع في المزيج تعتبر موثرة على نقطة السقوط ، الاختراق و التاكل النحاسي للمزيج . حيث انه وجدان زيادة نسبة وزن الشمع في المزيج تقود الى زيادة درجة السقوط في كل انواع المزيج. اما الاختراق و التاكل النحاسي وجد انهما يقلان مع زيادة نسبة وزن الشمع في المزيج .

عامة الشمع البلوري يظهر نقطة سقوط اعلى من الشمع البارافييني. وايضا الشمع البلوري يعطي اقل اختراق وتاكل نحاسي من شمع البارافييني.

ان قيمة نقطة السقوط للانواع المختلفة للمزيج تزداد على النحو التالي بثبوت نوع الشمع ونسبتة: (زيت اساسي ٤٠، زيت اساسي ٦٠، زيت منزوع الفورفورال ٦٠ ، زيت اساسي ١٥٠، زيت منزوع الفورفورال ١٥٠). ان قيمة الاختراق والتاكل النحاسي للانواع المختلفة للمزيج تزداد على النحو التالي بثبوت نوع الشمع ونسبتة: (زيت منزوع

الفورفورال ١٥٠، زيت اساسي ١٥٠، زيت منزوع الفورفورال ٦٠ ، زيت اساسي ٦٠ ، زيت اساسي ٤٠).

بالنسبة الى العمل التجريبي ، فان نقطة السقوط للمزيج F6 المكون من ٣٠ % شمع بلوري و ٧٠% زيت منزوع الفورفورال ١٥٠ وجد انه اعلى درجة سقوط من كافة انواع المزيج ، وايضا الاختراق والتاكل الحاسي هو الاقل من جميع الانواع المزيجات، ذلك يشير ويقود الى الاستنتاج ان المزيج F6 هو الافضل من باقي الانواع في تحضير نوع خاص من انواع الدهون (الدهون الشمعية) .

شكر وتقدير

الى من منَ عليَّ بنعمة العلم ورضا الوالدين وحب الناس وتيسير الدرب . . .

الهي أحمدك حمداً كثيراً لنعمتك ورجاءاً لأتمامها .

شموع معرفتي . . . وسراج عقلي . . . أساتذتي الكرام .

شكراً لتنوير معرفتي وقلبٌ فرحه لتشجيعكم

قره عيني ، أمي أهديك ما بين أضلعي ونتاج عقلي عسى أن أرد الجميلا . . . أبي أوفيت عهدي لك وأسعدتُ روحك الطاهرة.

أخواني . . . أحبائي . . . زملائي شكراً جزيلاً لكم وبارك الله فيكم .

سرمد كمال

١٦ / ٣ / ٢٠٠٨

دراسة سلوك مزيج الزيوت النفط الثقيلة مع الشموع

رسالة
مقدمة الى كلية الهندسة في جامعة النهرين
وهي جزء من متطلبات نيل درجة ماجستير علوم في
الهندسة الكيمياوية

من قبل
سرمد كمال فخرالدين
بكالوريوس علوم في الهندسة الكيمياوية ٢٠٠٤

ذو الحجة ١٤٢٨ هـ
كانون الاول ٢٠٠٧ م