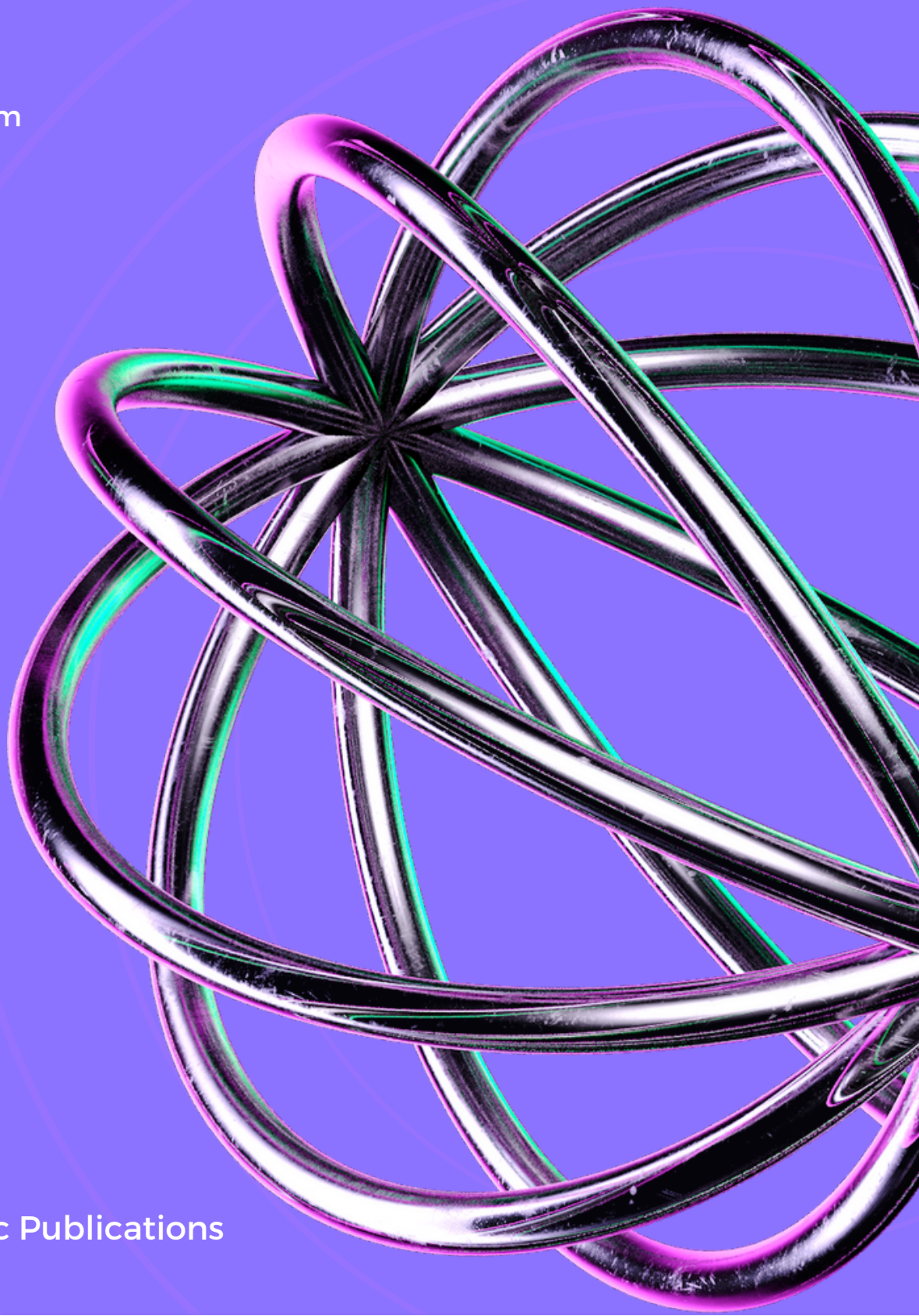


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PROPERTY OF MATERIALS

EDITED BY

Dr. Sidharth Gautam



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Preface

Essentially, petroleum is made up only of compounds of the two atoms carbon and hydrogen. However, because of the numerous, complex ways that these components can interact, crude oils have a wide range of chemical compositions. They also differ greatly in terms of their physical characteristics including colour, specific gravity, and viscosity. A material's intense attribute is a physical characteristic that is independent of the quantity of the material. These quantitative characteristics can be used as a yardstick to compare the advantages of various materials, assisting in the choice of materials. Petroleum, sometimes known as crude oil, is a naturally occurring liquid that may be processed to produce a variety of valuable goods, including petrol (also known as gasoline), diesel fuel, jet fuel, home heating oil, lubricating oil, wax and asphalt. Although it mostly happens in underground deposits, there are some places where crude oil seeps to the surface. The Latin roots of the word petroleum are *petra*, which means rock, and *oleum*, which means oil. Technically speaking, the term "petroleum" also refers to natural gas, a naturally occurring gas with properties comparable to those of crude oil and reserves beneath the earth's surface. Chemicals created by refining crude oil and processing natural gas are used by the petrochemical industry to create petrochemicals like plastic, latex paints, synthetic rubber, fertilisers, pharmaceuticals, synthetic fibres, and explosives.

The device is defined by its materials. When microsystems are designed, the mechanical and functional characteristics of the materials that are being utilised determine how they will behave and, consequently, how they will be physically constructed. Finding specifics of these material qualities and using them to create the device is not too difficult in the case of macroscale devices. In an evolution of this problem, the device needs to be rebuilt based on the material properties deduced from the changing behaviour because the material properties of the films are not as predicted. A substance's characteristic or behaviour that may be seen during a chemical change or reaction is said to have a chemical property. Since the arrangement of atoms inside a sample must be disturbed in order to examine the property, chemical qualities can be observed either during or after a reaction. This isn't the same as a physical property, which is a quality that can be seen and quantified without altering a specimen's chemical composition.

Keep in mind that a chemical characteristic cannot be observed or measured in the absence of a chemical change. For instance, iron rusts when it oxidises. Analysis of the pure element cannot be used to describe the property of rusting. Materials science is very interested in chemical characteristics. These properties aid in the classification of samples, the discovery of new materials, and the purification of compounds. Chemists can predict the kinds of reactions to expect by using the attributes. Chemical container labels incorporate chemical attributes because they are not always obvious. Containers should have warning labels that are based on the chemicals they contain, and thorough records should be kept for convenient access.

Dr. Sidharth Gautam
Editor

CHAPTER - 1

INTRODUCTION TO CHARACTERIZATION OF MICRO EMULSION BY SILICA NANOPARTICLES

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Oil that has not already been extracted using secondary or primary oil recovery techniques may be retrieved using enhanced oil recovery (EOR), often referred to as "tertiary recovery". As a generic strategy for enhancing oil recovery, no single EOR methodology has yet been developed; nevertheless, several techniques that are highly different from each other have been developed to manage reservoirs with specific features. The criteria for choosing a specific EOR approach are complicated because to the enormous number of chemicals, petro physical, environmental, geologic, and fluid factors that must be assessed for each unique situation. A petroleum reservoir is a porous, permeable material that stores oil, gas, and brine that move in the direction of the wellbore when pressure is added or already present. A network of interconnecting pores with varying sizes and shapes makes up the reservoir. A range of rocks, notably sandstones, semi-consolidated sands, conglomerates, dolomites, and limestones having pore spaces for fluids, make up reservoirs for oil and gas. Petroleum reservoirs that are commercially productive typically have porosities between 10% and 25%. The permeability of the reservoir rock controls how easily fluids may move through the microscopic pores of the oil and gas reservoir. mD, or Darcy, is the permeability unit of measurement. The Darcy is the flow rate in centimeters per second (cm s^{-1}) of a fluid having a viscosity of one centipoise through a one-centimeter cross-section of a porous material under a one-atm-per-cm pressure gradient [1]–[3].

The majority of oil reserves have permeability's between 0.50 milli Darcy (mD) and 3500 mD. The crude oil's viscosity affects how easily it may move about in a petroleum reservoir. Oil has a temperature-sensitive viscosity that decreases as the temperature increases. Therefore, it is important to take the temperatures of the petroleum reservoir into consideration while evaluating in-situ fluid flow. The geothermal gradients, including such $1.8^\circ\text{C}/100\text{ m}$, and the area's mean surface temperature may be used to estimate this temperature. The reservoir temperature will thus be roughly 61°C with a mean average temperature of 25°C and a depth of 2000 m, resulting in a significant decrease in oil viscosity compared towards the observed value at ambient temperature.

The three categories of oil recovery procedures are primary, secondary, and tertiary (Enhanced Oil Recovery). The pressure of an entrapped fluids throughout the reservoir causes the oil to be forced out of the petroleum reservoir during the primary phase. Freshwater or gas is injected to supplement or increase the current reservoir pressure whenever the reservoir pressure is reduced to the point that it is insufficient to drive hydrocarbon migration to the production wells [3]–[5]. The process of converting certain producing wells into injection wells and then injecting gas or water that maintain reservoir pressure is known as secondary oil recovery. The oil recovered by primary and secondary processes varies from 20 to 50%, depending just on oil and reservoir conditions. To collect at least part of the remaining oil in the reservoir, improved oil recovery methods are used. Chemical flooding, thermal oil recovery, and miscible displacement techniques are a few potential improved oil recovery techniques. EOR is made up of both thermal and non-thermal technologies, to put it simply. A useful EOR technique that falls under non-thermal approaches is chemical EOR (CEOR). Chemical EOR includes

surfactant flooding, which has lately become a well-liked recovery technique. Surfactant flooding, wetting agents, and caustic flooding are the three categories under which chemical flooding techniques are categorised. Polymer flooding itself, or surfactant injection accompanied by polymer flooding, results in controlling mobility, which increases oil recovery. Oil displacement through surfactant flooding is based on the generation of ultra-low interfacial tension (IFT). Among the most significant chemical EOR methods, alkaline-surfactant-polymer, was developed by combining the benefits of alkali and surfactants (ASP). Micro emulsion flooding is a subcategory of surfactant flooding. An oil, water surfactant, and co-surfactant dispersion system with a dispersed intermediate diameter in the range from 1 nm to 100 nm is referred to as a micro emulsion. It is also referred to as micellar solution, translucent solution, and inflated micelle.

Nanotechnology is a branch of study that emerged from the development of innovative methods for manipulating lone atoms and molecules in the physical, chemical, biological, and engineering sciences. A nanoparticle is a tiny item that functions as a single entity when it comes to its transport characteristics and possible applications. Simple or composite nanoparticles are crucial building blocks for the creation of innovative nanodevices, which have a wide range of physical, biological, biomedical, and pharmacological uses. The use of nanoparticles and nanostructured materials in catalysis, photography, photonics, electronics, labelling, imaging, sensing, and surface enhanced Raman scattering has captivated the scientific community for decades. Due to intriguing changes in their optical, magnetic, catalytic, electrical, and drug delivery properties along with improved physical properties such as mechanical toughness, thermal stability, or chemical passivity, they are among the most difficult areas of current technological and scientific research. Nanoparticles' optical characteristics often diverge significantly from single crystals that have the same chemical make-up in terms of several of these aspects. The presence of a large number of surface atoms and the quantum confinement impact of the electronic states have an impact on crystallites at the nanoscale scale, which affects the properties of nanomaterials in comparison to their bulk phases. Comparing the characteristics of matter at this scale to those of individual atoms or molecules and bulk materials reveals considerable differences.

It has been suggested that monodisperse silica nanoparticles having customised porosity and particle size (50–250 nm) provide good carriers for controlled release activities, including drug delivery. Amorphous silica particles, as opposed to crystalline silica, are chemically and physically robust, biologically inert, and biocompatible, making them an intriguing substitute for more widely used organic delivery methods such liposomes, micelles, polymeric nanoparticles, and polymeric particles. The specifications for a successful delivery system include precise control of the size for specifically targeting organs or avoiding immune system clearance as well as regulate of the release rate, which is typically accomplished by modifying the internal structure, concentration, or physical properties of the particles. This is accomplished in the situation of silica nanoparticles by combining sol-gel chemistry with such a micro emulsion technique, which allows independent control of a particle diameter and microstructure, offering a method of regulating the release rates of encapsulating species and targeting tumors. It is simple to create spherical silica particles in the desired size range by mixing silicon lakeside—typically tetraethylorthosilicate (TEOS)—into a reverse water-in-oil micro emulsion. Alkoxide is hydrolyzed when it diffuses into water droplets, forming alcohol and oxy-hydroxy-silicate species in the process. It allows for the efficient encapsulation of hydrophilic drug molecules that were present in the water droplets before the incorporation of silicon alkoxide into the nanoparticles when they formed in the micro emulsion. The porous structure of the nanoparticles, which is influenced by a variety of variables such as the

water/alkoxide molar ratio, the pH, as well as the kinetics of hydrolysis and condensation determines the subsequent release rate at which the drug from the nanoparticles.

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CHAPTER - 2

ENHANCED OIL RECOVERY

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Primary, secondary, then tertiary (or improved) recovery are the three stages of crude oil development and manufacturing in U.S. oil reservoirs. In primary recovery, oil is brought to the surface using artificial lift methods (such as pumps), which combine natural pressure from the reservoir or gravity to propel oil into the wellbore. However, only approximately 10% of the initial oil in a reservoir is normally produced during secondary recovery. By commonly adding distilled water or gas to displacement oil and move it to a producing wellbore, secondary recovery methods prolong the useful life of a field and enable the recovery of 20 to 40% of the original oil in situ. The process of enhanced oil recovery (EOR), commonly referred to as "tertiary recovery," is used to extract oil that hasn't yet been recovered using primary or secondary oil recovery methods. Although improved oil recovery works by changing the chemical makeup of the oil itself to make it simpler to remove, primary and secondary methods depend on the pressure difference between the underground and surface wells [1]–[3].

However, since a large portion of the easy-to-produce oil has already been extracted from American oil fields, producers have tried a number of tertiary, or enhanced oil recovery (EOR), mechanisms that have the potential to ultimately produce 30 to 60 percent more than of the original oil that was present in the reservoir. To varied degrees, three main kinds of EOR have been shown to be financially successful: The process of obtaining oil from a well after the main and secondary phases of oil recovery is known as enhanced oil recovery (EOR). The economic viability of EOR methods will depend on the price of oil. Though new developments in the industry could one day assist lessen this effect, EOR practices can have a detrimental influence on the environment. Enhanced oil recovery methods are difficult and costly, thus they are only used when primary and secondary recoveries methods are no longer effective. In fact, using EOR may not even be cost-effective depending on variables like the price of oil. When that occurs, oil and gas may not be extracted from the leftover volumes, leaving them in the reservoir [4], [5].

Three Main Types of EOR Techniques

The first method involves injecting gases into the well forcibly in order to drive the oil towards the surface and lessen its viscosity. Oil flows more easily and can be extracted more cheaply the less viscous it is. Carbon dioxide (CO₂) is the most often utilised gas in this procedure, while other gases may also be employed. Given that recent developments have made it feasible to transport carbon dioxide in the forms of foams and gels, this particular usage of carbon dioxide is expected to continue or even rise in the future. This would be seen by some as a substantial advance since it would enable the use of CO₂ injections at locations distant from carbon dioxide reserves that naturally exist. On the other hand, due of its detrimental impact on the environment, there are serious worries regarding the continuous usage of carbon dioxide. Currently, the majority of nations are looking for sustainable energy alternatives to CO₂. Pumping steam into the reservoir to heat the oil and reduce its viscosity is another typical EOR practice. Similar results may be obtained by "fire flooding," which entails starting a fire around the oil reservoir's edge in order to push the remaining oil into the well. Lastly, while these methods are sometimes prohibitively costly, different polymers and other chemical structures

may be introduced into the reservoir to decrease viscosity and raise pressure. EOR has the potential to increase the lifespan of wells in proved or likely oil resources, which is why scientists and petroleum firms are interested in it. Proven reserves have an oil recovery probability of more than 90%, whilst probable reserves have an oil recovery probability of more than 50%. Unfortunately, adopting EOR procedures may have unfavorable impacts on the environment, such as allowing dangerous chemicals to seep into the groundwater. Plasma pulsing is a modern method that could assist in lowering these environmental dangers. Similar to standard EOR methods, plasma pulse technology was invented in Russia and includes beaming oil fields using low-energy emissions to reduce their viscosity. Plasma pulsing might be less damaging to the environment than other existing oil recovery techniques since it doesn't involve pumping gases, chemicals, or temperature into the earth. The development equation's economics must make sense. To identify which kind of EOR will perform best on the reservoir, every field must be thoroughly assessed. Reservoir characterization, screening, scoping, reservoir modelling, and reservoir simulation are used to accomplish this.

Thermal Recovery

Oil viscosity is decreased via thermal recovery, which warms the reservoir. Steam is often used to thin the oil and improve its capacity to move through the reservoir. Thermal recovery presently makes up more than 50% of applied EOR within the United States after being used for the first time in Venezuela in the 1960s.

Chemical Injection

Injection of chemicals EOR aids in releasing trapped oil from the reservoir. In order to improve the efficacy of water flooding or the efficiency of surfactants, which seem to be cleaners that aid in lowering surface tension, which prevents the oil from flowing through into the reservoir, this approach adds long-chained molecules known as polymers into the reservoir. Chemical injections are now used in less than 1% of any and all EOR techniques in the US.

Gas Injection

As a tertiary recovery technique, gas injection includes pumping carbon dioxide, nitrogen, or oil and gas into the reservoir. The gases may either mix with or disintegrate in the oil to reduce viscosity and increase flow, or they may expand and force gases through into the reservoir. Techniques to inject CO₂ produced as a byproduct of industrial activities have been developed, and innovations have utilised naturally existing atmospheric carbon deposits. CO₂-EOR, which was first utilised in the US in Texas in the early 1970s, is effectively used in Texas and New Mexico and therefore is anticipated to be used more broadly in the future. A kind of gas injection is used in over half of an EOR operations in the US. Well stimulation, which is a very inexpensive option since it can be applied to single wells, and low-salinity water flooding, which would be anticipated to improve output by over 20%, are some other EOR applications that are becoming more popular (rather than the whole reservoir).

Offshore EOR Applications

Although onshore uses for EOR remain the majority, advancements are being made to extend the use of EOR to applications offshore. The economics of the development, the restrictions on weight, space, as well as power for adapting existing offshore infrastructure, and the fact that there are fewer, more widely spread wells all contribute to displacement, sweep, and lag time. EOR use is now being thought about for a variety of offshore ventures. The technology to use EOR procedures is rapidly approaching thanks to effective subsea reprocessing and secondary troubleshooting tools used in offshore settings via water and gas injection.

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CHAPTER - 3

APPLICATION OF KEROSENE

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Kerosene is often light yellow or colourless and has a nice, distinguishing smell. It is made from petroleum and serves as a solvent for greases and insecticides as well as a fuel or constituent for jet engines. Through its chemical composition, kerosene is a mixture of hydrocarbons. Depending upon the source, the chemical composition varies, but it typically consists of ten or more different hydrocarbons, each having 10 to 16 carbonyl group per molecule. The main components include ring-shaped cyclo-paraffins, saturated straight-chain plus branched-chain paraffins, and paraffins (also known as naphthenic).

Gasoline is more volatile than kerosene. Its flash point is 38 °C or higher, whereas gasoline's is just as low as 40 °C (the temperature where a flammable vapour would develop near its surface). The boiling point of kerosene, which ranges from 150 to 300 °C (300-575 °F), is what makes it an intermediate distillation of crude oil, along with diesel fuel. Kerosene, often written kerosene, is a flammable hydrocarbon liquid that is frequently used as a fuel. It is also known as paraffin or paraffin oil. Kerosene normally has a not unpleasant distinctive smell and is colourless or light yellow. It is made from petroleum and is employed as a fuel or fuel ingredient for jet engines, as a solvent for lubricating oils and pesticides, and for burning in kerosene lights and home heaters or furnaces [1]–[3].

Kerosene was first produced from coal tar and shale oils after being discovered by Canadian physician Abraham Gesner inside the late 1840s. However, oil swiftly took over as the main source of kerosene when E.L. Drake drilled Pennsylvania's first oil well in 1859. Kerosene was the main refinery product for many decades since it was used in lamps, but the invention of the electric lamp made kerosene less useful for illumination. As the popularity of cars increased, gasoline's status as a key petroleum commodity increased. Kerosene is still widely used as a cooking and heating fuel as well as a lamp fuel in many regions of the globe. Many military jet fuels are mixes based upon kerosene, while standard commercial jet fuel is basically a high-quality straight-run kerosene. Kerosene is made up of several hydrocarbons chemically.

Depending on the source, its chemical makeup may vary, but it typically comprises of 10–16 distinct hydrocarbon molecules with 10–16 carbon atoms apiece. Saturated straight-chain and branched-chain paraffins, in addition to ring-shaped cycloparaffins, are the major components (also known as naphthenes). Petrol is more volatile than kerosene. Unlike gasoline, which has a flash point as low as 40 °C (40 °F), it is at least 38 °C (100 °F) before it produces a flammable vapour close to its surface. Kerosene is a reasonably safe fuel to maintain and store because to this characteristic. Kerosene, along with diesel fuel, is regarded as one of the so-called intermediate oil products of crude oil, having a boiling point between 150 and 300 °C (300-575 °F). It may be generated as "straight-run kerosene," which is physically separated from the other crude oil components by distillation, or even as "cracked kerosene," which is made by chemically disintegrating, or cracking, larger sections of the oil at extreme temps.

History

Since ancient times, petroleum byproducts have indeed been employed as adhesives and waterproofing chemicals. Arabian researchers looked exploring methods to separate petroleum

into several components that may be utilised for specific purposes more than 2,000 years ago. The need for petroleum expanded as more applications were found. Abraham Gesner made the discovery of kerosene back in 1853. Gesner, a British surgeon, created a method to separate the combustible liquid from the waxy petroleum mixture that is asphalt. In actuality, the word "kerosene" comes from the Greek word for wax. Because it was originally made from asphalt, kerosene is also known as coal oil. Throughout the days before artificial lighting, kerosene was a valuable commodity and the first substance to be chemically extracted on the major industrial basis. Kerosene as well as other petroleum products were first refined in large quantities after oil was found in the United States in 1859. To create methods for oil drilling and purification, a whole industry was created. Throughout the latter part of the 1890s and the beginning of the 1900s, kerosene remained the most significant refinery product. In the 1920s, when the internal combustion engine gained popularity, gasoline overtook it. Kerosene was utilised for other purposes when oil lamps were abandoned, and now it is mostly used for home heating as well as a transportation fuel. Around 1 billion gal (3.8 billion l) of kerosene were produced annually in the United States alone by the late 1990s [4], [5].

Raw Materials

Deep under the soil, there lies a combination of petroleum components from which kerosene is derived. Subterranean reservoirs built of permeable sandstone and carbonate rock strata contain this combination of oil, rocks, water, as well as other contaminants. The oil itself comes from animals that have decomposed and were buried with early geological periods' deposits. Through two intricate chemical processes described as diagenesis and catagenesis, this organic waste was transformed into petroleum over the course of tens of millions of years. Under 122°F (50°C), diagenesis takes place and includes both microbial activity including chemical processes such as condensation, dehydration, cyclization, and polymerization. Around 122 °F and 392 °F (50 °C and 200 °C), catagenesis takes place and includes decarboxylation, hydrogen dehydrogenation, and thermocatalytic cracking. The hydrocarbon combination recognized as petroleum is produced by the conjunction of these intricate processes.

The Manufacturing Process of Crude oil recovery

The gathering of crude oil is the initial stage in the production of kerosene. The three main kinds of drilling operations are utilised to extract the majority of the world's oil reserves, which are buried deep inside the ground. One technique, known as "Cable-Tooled Drilling," is using a jackhammer hammer to move soil and rock in order to dig a tunnel to access oil resources that are located just a few meters under the earth's surface. To access oil deposits that are considerably further down, a second procedure called rotary drilling is employed. A drill pipe with a revolving steel bit must be inserted into the earth to complete this procedure. This rotary drill quickly rotates while crushing rock and soil. Offshore drilling, the third method of drilling, lowers a shaft to the ocean bottom using a large ocean-borne platform. When one of these drilling operations penetrates a subterranean reserve, dissolved hydrocarbon vapors force the crude oil onto the surface, causing a geyser to erupt. About 20% of an oil will be forced out of the well by these fumes. Then, water is poured into the well to clean out additional oil. About 50% of the buried oil will be recovered throughout this flushing operation. A surfactant may be added to the water to recover even more oil. The oil buried underneath cannot be completely removed, even with the most thorough cleansing. The recovered crude oil is poured into huge storage tanks and sent to a refinery.

Gross impurities including fumes, water, and soil are removed once the oil has been collected. One cleaning procedure that may be carried out both on the refinery site and in the oilfield is desalting. The water is then removed from the oil that after oil has been cleaned. The crude

oil's characteristics are assessed to determine whether petroleum products may be produced from it most effectively. The density, sulphur content, as well as other physical characteristics of the oil linked to its distribution throughout the carbon chain are the main factors of importance. Before crude oil can be converted into kerosene, it must be divided into its constituent parts since it is a mixture of several distinct hydrocarbon compounds that are miscible with one another.

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CHAPTER - 4

SEPARATION FROM THE CRUDE OIL

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Distillation is one of the major separation techniques for crude oil, which includes boiling the crude oil to separating its constituent parts. In this procedure, heated distillation column bottom contains a stream of oil that is injected into it. The majority of high boiling-point fractions were left at the bottom of a column while the lighter hydrocarbon component of the mixture ascend to the top. These lighter vapors are transported to the condenser there at top of the column, where they are cooled and transformed back into liquid. Since lighter oils only need air pressure, the columns sometimes used separate them are proportionately tall and thin (up to 116 feet [35 m] tall). Even though tall distillation columns give high-boiling compounds more opportunity to condense until they reach the highest point of the column, they can more effectively separate hydrocarbon mixtures. Distillation columns must be run at around one tenth of pressure and temperature to separate a portion of the heavier fractions of oil (75 mm Hg). To assist regulate pressure variations, these vacuum columns are designed to be both extremely broad and short. Their diameter may reach over 40 feet (12 metres). Separate collections of the condensed liquid components are possible. Kerosene is the proportion that is gathered between 302 °F as well as 482 °F (150 °C and 250 °C). In contrast, gasoline is distilled between 86 and 410 degrees Fahrenheit (30 and 210 degrees Celsius). The purity of the distilled kerosene may be raised by repeatedly passing it through the column. The term "refluxing" refers to this recycling process [1]–[3].

Purification

Kerosene must then be produced by further processing in a number of chemical reactors once the oil has indeed been distilled itself into the component fractions. Four of the main processing methods employed in the conversion of kerosene include catalytic reforming, akylation, catalytic cracking, but also hydro processing. By adding or deleting carbon atoms from the hydrocarbon backbone, these processes are utilised to regulate the distribution of carbon chains. The crude oil portion is moved into a different vessel for these reaction activities, in which it is chemically changed into kerosene. After the kerosene has reacted, further extraction is necessary to get rid of any secondary impurities that can influence the oil's ability to burn. Benzene is an example of an aromatic chemical, which is a kind of contamination that has to be eliminated. The majority of extraction procedures are carried out in sizable towers so that the contact duration between the kerosene as well as the extraction solvent is maximised throughout the kerosene distillation process. Considering the contaminants' solubility, solvents are selected. In other words, the solvent is more soluble in the chemical contaminants than kerosene is. Impurities will thus tend to be pulled through into solvent phase when the kerosene travels through the tower. Kerosene is more thoroughly refined once the impurities have been removed and the solvent has been eliminated. The purification of kerosene employs the following extraction methods.

In the 1970s, the Udex extraction method gained popularity in the US. As solvents, it makes use of a family of substances called glycols. Due to their strong affinity for aromatic molecules, both diethylene glycol but also tetraethylene glycol are used. The Shell Company invented the Sulfolane technique in 1962, and 40 years later, it is still used in several extraction units.

Sulfone, a strong polar molecule that is more effective than the glycol systems employed in the Due process, is the solvent utilised in this method. It is more chemically stable and has a higher heat capacity. In this procedure, the kerosene is purified with the use of a spinning disc contractor. Kerosene's future hinges on the identification of fresh uses and the advancement of fresh manufacturing processes. A growing number of new applications include the military's need for high-grade kerosene to replace most of its diesel fuel using JP-8, a jet fuel based on kerosene. In order to prevent low sulphur diesel fuel from gelling during cold weather, the diesel fuel business is also investigating a novel procedure that includes the use of kerosene. From developing a new low-mist kerosene, aviation industry may profit by lowering the danger of jet fuel explosion. New and enhanced kerosene heaters that would provide greater fire safety are expected to boost demand in the residential sector. New techniques for extracting and purifying kerosene will be increasingly more crucial as demand worldwide kerosene as well as its byproducts rises. Exxon Mobil came up with a novel, inexpensive approach to separate high purity conventional paraffin from kerosene. Ammonia is used in this procedure, which absorbs pollutants quite well. This process produces high levels of paraffin that are more than 90% pure and makes use of vapour phase fixed-bed adsorption technique [4]–[6].

Distilled water

Water which has been evaporated and then condensed is distilled water. Distillation has removed a lot of impurities from water, resulting in water of better quality. In application areas wherein water purity is crucial or in commercial processes wherein mineral deposits might over time cause corrosion and damage, filtered water is more often used. Distilled water competes against tap water at home while sharing a shelf with spring and filtered water inside supermarkets. Distillation, which involves heating water in a still and collecting the condensed steam, has been used by humans to create distilled water since the dawn of time. The evaporation of the water removes any impurities. This eliminates dangerous microorganisms as well as safe (and advantageous) minerals like calcium and magnesium. In contrast, filtering water eliminates microorganisms but leaves behind minerals. Rock serves as a type of natural filter for spring water, which is rich in minerals. Filtered and spring water taste much better than distilled water, which has a flat and flavorless taste due to its mineral content. Despite the fact that most individuals acquire their minerals through food, some people claim that drinking distilled water deprives them of essential elements. Water that has undergone distillation is also safe to be used in lead-acid batteries, automobile cooling systems, and other equipment where mineral accumulation might be harmful. To replicate the very soft water in Pilsen, Czech Republic, the birthplace of Pilsner-style beers, home beer producers often utilise distilled water. A boiling chamber is used to heat the water. When the water reaches a rolling boil, evaporating and steam creation occur. From the boiling chamber, steam emerges. Through a vent, vapour from the boiling water travels into a condenser made of stainless steel. The boiling chamber holds any germs, pollutants, or contaminants that cannot be transformed into gas particles.

Condenses from steam, As soon as steam enters the condenser, a fan chills it, causing it to condense back becoming water droplets. There is still one more filtering step to complete before these droplets may be gathered in a clean container. Contaminants that remain are eliminated. It is the time to clean out any contaminants that have evaporated then condensed with water. Typically, an activated carbon filter will employ the adsorption mechanism to capture these pollutants. In a container for storage, water gathers. Water will trickle out of the distiller's spout and into a holding container after passing through into the filtering medium. This water has become pure, clean, and usable. Water pollutants such as nitrate, iron, lead, harshness, and certain microbes may all be removed using distillation. The level of pollutants in the water affects how well distillation works overall. For instance, benzene has a lower

boiling point than water, among other organic substances. This implies that after the water has condensed onto liquid form, the pollutants will end up infecting it again. The majority of distillers employ a filter medium, often activated carbon, to remove any leftover impurities before the water is released.

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CHAPTER - 5

SYNTHESIZED SILICA NANOPARTICLES

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All-important branches of science and technology, including electronics, aircraft, military, medicine, and dentistry, are being quickly overtaken by nanotechnology. This includes the conception, creation, evaluation, and use of nanoscale materials and technology. Physical, chemical, and biochemical properties somewhere at nanoscale are distinct from those of individual molecules and atoms within bulk matter. As a result, it offers the chance to create new classes of cutting-edge materials that can satisfy the requirements of high-tech applications. In several fields, including synthesis and surface science, the development produced ceramic nanoparticles with better characteristics has been investigated with great success. Silica, alumina, titania, zirconia, silicon nitride, silicon carbide, and other materials are examples of ceramics. Nanosized silica, or SiO_2 , has been produced thanks to advances in nanotechnology and is often utilised as filler for engineering composites [1]–[3]. The metal contaminants in the silica particles that are recovered from natural resources make them unsuitable for use in sophisticated applications in science and industry. In contrast to natural mineral silica (quartz, tridymite, and cristobalite), which is generated largely in crystalline forms, attention is placed on synthetic silica (colloidal silica, silicon gels, pyrogenic silica, and precipitated silica), which would be pure and created in amorphous powder forms. Top-down and bottom-up are the two major methodologies that have been employed to generate silica particles using a variety of techniques. Top-down is defined by applying certain size reduction strategies to reduce the dimension of a original size (physical approach). A popular method for creating silica nanoparticles at the atomic or molecular scale is by a bottom-up or chemical approach. Sol-gel process, reversed micro emulsion, and flame polymerization are a few of the frequently used techniques to create silica nanoparticles (see Figure 1). Due to its capacity to regulate particle size, size distribution, and shape via systematic monitoring and reaction conditions, the sol-gel technique is often employed to create clean silica particles [1], [2], [4].

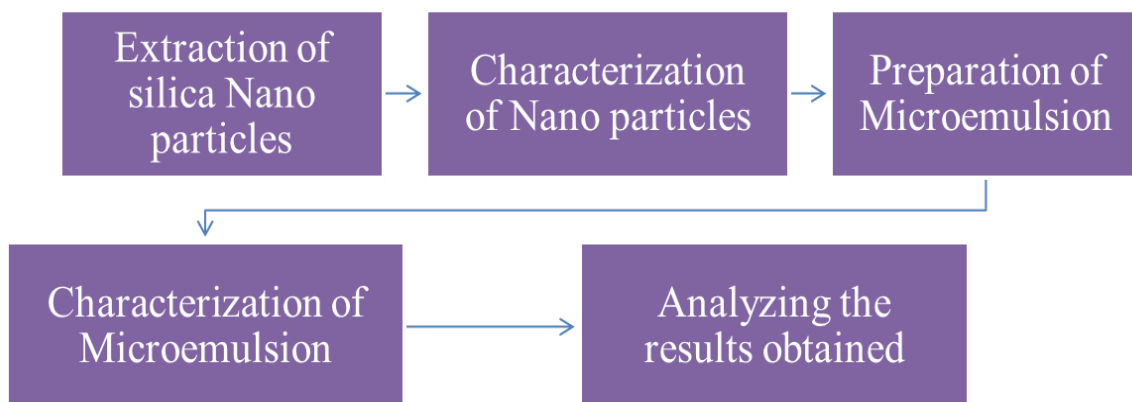


Figure 1: Illustrates the flow chart of extraction of silica Nano particles.

Drug resistance is continuing to spread quickly, outpacing the discovery of new treatments for the treatment of infectious illnesses. Drug access problems such poor intracellular drug assortments, drug efflux via efflux pumps, and/or enzymatic degradation now place restrictions on conventional treatment. Targeted distribution employing Nan carriers may provide the

quantum jump in intracellular medication transport and retention needed to increase access. Among the most often utilised nanoparticles throughout drug delivery applications is silica (SiNP), which has important benefits such a high surface area, simplicity in functionalization, and biocompatibility. Mesoporous silica nanoparticles (MSN), a porous version, also offers additional benefits such as adjustable pore size and volume, resulting in high drug loading capacity. SiNPs and their variations have the potential to be an effective tool for the targeted administration of antibiotics in the setting of bacterial infections, thereby minimizing the negative effects of large medication dosages. With an emphasis on cytoplasmic drug targeting in anti-tuberculosis therapy, nitric oxide delivering, and metal nanostructured materials, this review will provide a general understanding of the synthesis of SiNPs, their structural proficiency, which is essential in loading and conjugating antimicrobials, and their role in various antimicrobial applications. In the perspective of nosocomial infections with surgical implants, the function of SiNPs with ant biofilm coatings will additionally be addressed.

Synthesis of Nano silica

Reverse micro emulsion, flame synthesis, and the commonly used sol-gel are some of the techniques used to make silica nanoparticles. When surfactant molecules are dissolved throughout organic solvents, they create spherical micelles in a reverse micro emulsion. When there is water present, the polar head groups assemble themselves to create reverse micelles, which are tiny cavities that hold water. Through carefully regulating the addition additional silicon lakesides as well as catalyst into the media containing reverse micelles, silica nanoparticles may be synthesized and developed inside the micro cavities. The reversed micro emulsion method's main flaws are its high cost and the difficulty in getting surfactants out of the finished goods.

Nevertheless, the technique was effectively used to coat nanoparticles with diverse functional groups for a variety of purposes. Additionally, metal-organic precursors may be used to create silica nanoparticles by high temperature flame breakdown. Additionally known as chemical vapour condensation, this technique (CVC). Silica nanoparticles are created in a standard CVC method by reacting silicon tetrachloride, SiCl_4 , with hydrogen and oxygen. The fundamental drawback of flame synthesis seems to be the difficulty in regulating the size of the particles, morphology, and phase composition. However, this is the most utilised technique for producing silica nanoparticles throughout powder form for commercial usage.

Applications of Silica Nanoparticles in Antimicrobial Therapeutics

Due to its adaptability and improved capability to overcome physiological barriers, nanoparticle-based delivery of drugs has emerged to be one of the most promising therapeutic approaches. In this context, silica nanoparticles (SiNPs) have emerged as an advantageous material for a variety of medicinal uses, particularly in the treatment of cancer and microbial infections. Given the growing problem of antimicrobial resistance, SiNPs' adaptability is especially helpful for antimicrobial therapies, including biofilm treatment. The window again for development of antibiotic resistance is quite small because these nanoparticles could indeed attack pathogens through a variety of mechanisms, such as physical injury to cellular membrane, ROS production, and endo-lysosomal financial strain, in addition towards the antimicrobial activity stimulated by the cargo itself. As a result, this section discusses several ways that SiNPs might deliver their therapeutic payloads to bacteria-targeting diseases, with a focus on anti-tuberculosis (anti-TB) treatment, which necessitates intracellular targeting. In particular, various SiNP delivery compositions, including such metal-silica nanocomposites, nitric oxide (NO) delivery, antibiofilm coatings, and dental composites, are used to treat infectious diseases.

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CHAPTER - 6

SIZE-DEPENDENT PROPERTIES OF SILICA NANOPARTICLES

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Nanomaterials often have size-dependent characteristics. In contrast to its bulk counterparts, the nanomaterial often has distinct physical and chemical characteristics. As previously mentioned, there is a dearth of research detailing the size-dependent characteristics of silica nanoparticles. Few studies have been done on some qualities, such particular surface area and photoluminescence characteristics in relation to particle size. Consequently, some general size-dependent characteristics of Nano ceramics would be briefly looked into in this section [1]–[3].

Physiochemical Properties

With the reduction in particle size, there are more atoms present on the surface. Over half of the Si atoms are found on the surface of silica nanoparticles smaller than five nm. A silanol group (Si-OH) should thus be present on the surface in some form. As a result, the number of silanol groups per gramme of silica has a significant impact on the degree of chemical alteration of silica, including the grafting of organ functional groups and the insertion of metal ions. The distribution the silanol groups upon that silica surface may be determined by calculating the proportion of silanol groups per unit surface area of silica. When particle size decreases, silanol groups become more concentrated, which is proportional to specific surface area (Figures 1 and Figure 2). However, the fact that the silanol number decreases as the particle size decreases raises the possibility that these nanoparticles are chemically reactive and hence appropriate for catalytic applications [4], [5].

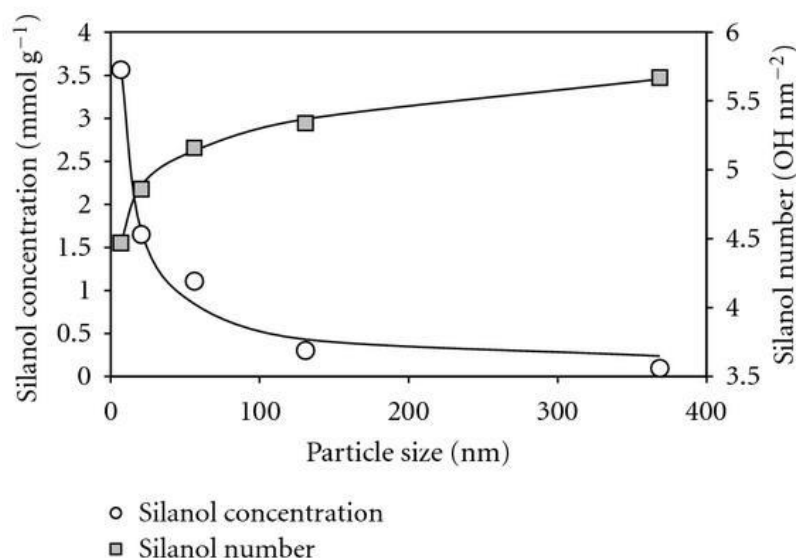


Figure 1: Illustrates the Variation of silanol concentration and silanol number with particle size of silica.

One of the exceptional qualities of ceramic nanoparticles is their unusual adsorption characteristics. The nanoparticles exhibit improved capacity to chemically adsorb and

sometimes even dissociate a range of harmful organic compounds when compared to conventional and commercial equivalents. The increase in porous structure at the nanoscale was directly connected to this special adsorption characteristic.

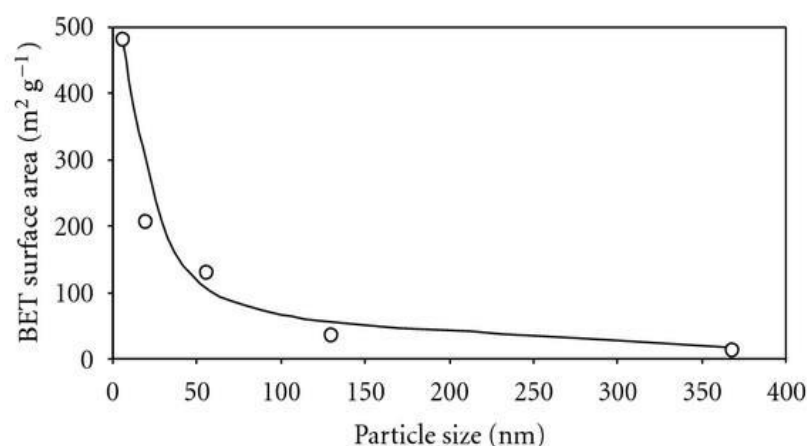


Figure 2: Illustrates the Variation of BET surface area with particle size of the silica.

Thermal and Mechanical Properties

Comparing Nano size particles to traditional sized powders, it was discovered that Nano size powders compact more quickly and sinter at a substantially lower temperature. For instance, sintering of 20 nm fumed silica nanoparticles to transparency was accomplished at 1200 °C as opposed to 1.6 μ m particles, which need up to 1600 °C. The increased surface region of the nanoparticles, which offers greater particle interactions than the ordinary particles, is thought to be the cause of this unusual sintering feature. Additionally, ceramic nanoparticles show improved ductility and decreased brittleness. Materials developed from nanoscale ceramics are more dependable than those made from regular ceramics because to their intriguing features.

Optical Properties

Due to various intriguing optical phenomena produced by point defects created from any defective SiO₄ continuous network, particularly oxygen and silicon vacancies, silica nanoparticles have been extensively explored. Numerous typical deficiencies for silicon nanoparticles, such as surface E' centres (paramagnetic positive electrode oxidation vacancies, "Si•Si," or neutral hanging upside down Si bonds, "Si•"), self-trapped electrostatic interaction (photo excited electron-hole pairs, "STE"), no two oxygen atoms hole centres (NBOHC, "dangling oxygen bonds, "Si-O•," neutral oxygen deficient centers (ODCs, "Si-Si"), The two classes of these point defects are paramagnetic and diamagnetic. A half-occupied remaining energy throughout the optical band gap is represented by the optical absorption that occurs in paramagnetic defects. As a result, the valence band may undergo a whole transition or perhaps an electron transition. Absorption band concomitant with electronic transitions towards the conduction band is seen in diamagnetic defects. These flaws, when combined, may display a variety of PL and absorption bands throughout a wide range of wavelengths, including near-infrared, visible, even ultraviolet (UV). As a consequence, absorption spectrum and photoluminescence (PL) constitute two helpful techniques for tracking optical changes brought on by structural flaws at the bulk and surface of nanoparticles.

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CHAPTER - 7

EFFECT OF SALT CONTAMINATION ON THE RHEOLOGICAL PROPERTIES OF WATER-BASED DRILLING MUD

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More efficient ways of producing oil and gas are required as demand for these commodities rises. Eighty percent of the cost of the well is related to the drilling procedure. From longitudinal, inclined, and hydraulic fracturing to subsurface and deep-sea drilling, drilling methods have advanced. These advanced drilling techniques need unique drilling fluids in order to accomplish the objectives. Because the kind of reservoir and the drilling approach used to harness the reservoir fluid are both distinct, the drilling fluid must be developed to fit the drilling process and reservoir conditions. Drilling fluid is a combination of elements that helps a bore keep its form throughout the boring process while loosening the material you're drilling through (i.e., Continuous phase, Reactive phase, Inert phase, Additives). Mud and barite are other names for it. Whatever name we give it, the drilling fluid's main function is to "improve stability and excavatability. The following tasks are also carried out by drilling fluids [1]–[3].

1. Move the drill cuttings through the annulus to the surface.
2. Lubricating and cooling the drill string.
3. Reduce reservoir damage as much as possible while increasing penetration rate (ROP).
4. Sealing the porous formations that the drilling process exposed.
5. Regulating downhole formation pressure to prevent production harm.
6. Transferring the hydraulic energy to the drill bit and downhole tools.
7. Create an atmosphere where there is no friction between the drill string and the borehole's sidewalls.

Drilling Fluids Types

WBM, or water-based mud The majority of water-based mud systems start off tasting like a hybrid between chocolate milk and malt before adding clays and other chemical components (depending on viscosity). The clay is often a mixture of natural clays floating in the drilling fluid or a particular kind of clay that has been gathered and offered as a supplement for the WBM system a majority.

The most prevalent of these is bentonite, a popular addition known as "gel" in the oilfield. Like chocolate milk, a fluid may be extremely thin and freely flow while it is being pumped, but when the pump is switched off, the static fluid congeals into a "gel" structure that obstructs flow. When sufficient pumping force is applied to "break the gel," flow resumes and the fluid returns to its initial condition of freeflow. A WBM system may also include other chemicals (such as potassium format) to achieve a number of objectives, including viscosity management, shale stability, enhanced drilling rate penetration, and equipment cooling and lubricating [4], [5].

An oil-based mud (OBM) is one that utilises an oil-based base fluid, such as diesel fuel. Oil-based muds are used for a variety of reasons, including increased lubricity, shale inhibition, and cleaning abilities with decreased viscosity. Muds made with oil are more heat resistant as well. Cost, environmental concerns, such as where to dispose of cuttings, and the exploratory disadvantages of using oil-based mud, particularly in wildcat wells, are all things to take into account. Because the base fluid and the oil extracted from the formation cannot be distinguished from one another, cuttings and cores are geochemically analysed with an oil-based mud, and API gravity is determined.

Fluid with a synthetic basis a mud that uses synthetic oil as its foundation fluid is known as a synthetic-based fluid. Even though the fluid fumes are far less toxic than an oil-based fluid, it is often used on

offshore rigs since it has the characteristics of an oil-based mud. This is essential when the drilling crew is handling fluid in a small space, such as an offshore drilling rig. The environmental and analytical problems with oil-based fluid are the same as those with synthetic-based fluid.

The drilling procedure and the kind of reservoir being drilled dictate the kind and quantity of additives utilised. Water-based mud (WBM), oil-based mud (OBM), synthetic mud (SBM), emulsions, inversion emulsions, foam, pneumatic drilling fluids (air, natural gas), etc. are several types of drilling mud. The primary categories of drilling fluids are three. Air, Oil, and Water-based systems. Water serves as the mud's basis in water-based muds. Drill cuttings may be easily disposed of since they are good for the environment. In a conventional WBM, a polymer is utilised as a viscosifying agent. Employable polymers include linear polymers, cross-linked polymers, synthetic polymers, and biopolymers. Additional developments/research.

To address the drawbacks of both VES and biopolymers, it would be best to integrate the advantages of both VE and biopolymers in WBM. The other kind is oil-based mud, which uses oil as its main fluid. The fluid formulation for OBM is more expensive and complex than for WBM. Some of its benefits include excellent fluid loss control, no shale swelling, optimum drill bit lubrication, exceptional cutting carrying capacity, and others. Their drawbacks include inadequate filter cake cleanup, poor cement-to-formation bonding caused by oil-saturated surfaces, and possible environmental issues such seepage into aquifers and pollutants. Whereas the most current innovation in OBM replaces diesel with crude oil or refined palm oil to make it more ecologically friendly. It is less harmful to marine and freshwater species because to its low aromatic content, making it ideal for most additions. Pneumatic drilling fluids are suggested for formations that might lose circulation. Pneumatic drilling fluids are used for underbalanced drilling. Pneumatic drilling penetrates more quickly, manages lost circulation zones better, and causes less formation damage. However, downhole equipment fires and corrosion have been attributed to pneumatic drilling fluids, notably dry air/natural gas.

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CHAPTER - 8

DRILLING MUD CONTAMINANTS

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Rheology is the study of matter movement and fluid deformation. Its relevance is acknowledged in the analysis of fluid flow velocity profiles, dynamic velocity (friction coefficient and elastic modulus), total pressure losses, and annular holes cleaning. Rheological characteristics are the foundation for every well bore hydraulics research and functionality assessment of mud systems. There are two more rheological characteristics of drilling mud: economic outcomes and gel strength. Rheological properties (such as concentration, stiffness, gel strength, etc.) are monitored during the drilling operation. Regulating and conserving rheological properties is essential since failure to do so may lead to time and money losses as well as the abandonment of the well in dire circumstances. Along with rheological testing, the drilling procedure also includes filtration tests, pH checks, chemical analyses (alkalinity and lime content, chloride, calcium, etc.), and resistivity tests. The optimum drilling fluid for the job is selected by drilling engineers. The bulk of dewatering capabilities are controlled by rheological properties. A "Mud Engineer," a drilling fluid expert, is typically present to monitor and adjust these parameters while drilling proceeds. The following are the most crucial factors to take into account while selecting drilling fluids: The drilling formation type [1]–[3].

While other factors including production concerns, environmental impact, safety, and logistics may also influence reservoir pressure selection, the "total well cost" is the key factor that determines drilling fluid choice. To mix, a Kitchenaid Beach mixer with three speeds and a jar is needed. Its quick integration and distribution of particles into water is remarkable. To enhance the surface area accessible to that same surrounding liquid and start the gelling process, the particles are broken down to their smallest possible components.

Salted makeup water, salt stringers, or saltwater flows may all result in contamination with salt, or NaCl. Saltwater-based drilling fluids are used when significant quantities of salt are drilled or salty makeup water is used. Salt is a pollutant in freshwater muds but not a problem in saltwater muds. Salt contamination is often visible. It will be followed by an increase in the chloride content of the filtrate. Possible signs include a rise in rheology, particularly the yield point, a rise in fluid loss, and maybe a decline in pH and alkalinities. Mud density may decrease if the salt source is a saltwater flow [4]–[6].

Salt contamination in a drilling fluid cannot be removed via chemical treatment. The sole method for lowering salt levels is dilution. An increase in concentration, which changes the stress distribution at clay surfaces, is what has a deleterious effect on drilling mud. The subsequent flocculation results in a fluid loss and an improvement in rheological properties. The reactive particles in the mud will dry out with continued contact to high salt concentrations, reducing viscosity and increasing fluid loss. In the event where the salt contamination is low (Cl_{20,000} mg/L) or can be tolerated for a little period of time, such as to TD the well or instal pipe within a few days, the mud should really be treated without water to dilute the chlorides to a suitable concentration level. This quantity will change depending on the mud's mass, the

number of active solids present, the temperature, and other elements. The fluid should be treated simultaneously with caustic zing agents and deflocculants to restore flow characteristics. To prevent fluid loss, utilise pre-hydrated bentonite, PAC, or other salt-tolerant additions. The fluid should be switched to a saturated salt system or replaced with an oil-based system if the existing level of salt contaminating cannot be tolerated or if greater contamination is predicted, such as when drilling large salt sections. The mud may be converted to a salt saturated mud by saturating the system with NaCl (125 lb/bbl) and adding significant volumes of deflocculant for viscosity control, potassium hydroxide or lime for pH and PF management, PAC materials, and pre-hydrated silica for fluid loss control.

It is important to remember that adding additives to the mud can prevent some contaminants, like cement and salt, from contaminating the mud system, provided that the additives are not added in excess. However, some of these additives can be unexpected and unpredictable because contaminants' concentration rises gradually. Therefore, a substance that alters the mud's characteristics in an unfavourable way when it is absorbed into the mud system is a drilling mud contaminant. The main source of contamination is solids. Additionally, the formation's rheological characteristics will have high values when there are too many solids coming from it, which will lower drilling rates.

Some contaminants are chemical in nature, necessitating a specific chemical treatment to return the mud's properties to their original state with a certain degree of engineering tolerance. Although it is not always possible to eradicate the contaminant(s) as from mud system, it is possible to do so with the least amount of error possible. When foreign materials are introduced into the drilling fluid system or when the drilling fluid system is overly treated with additives (incorrect mud additives), the drilling fluid is said to be contaminated. This results in unfavourable changes to the drilling mud's properties, such as viscosity, density, yield point, gel strength, and filtration.

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CHAPTER - 9

CONTAMINATION OF SALT

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Salt contamination may result from a number of things, including drilling salt deposits, formation water intrusion, and situations where salty makeup water is utilised. A rise in the filtrate's chlorides concentration makes it simple to identify salt as a contamination. Other probable signs include a rise in yield point, an increase in fluid loss, and even a decline in pH and alkalinities. The density of the mud could also decrease if the source of the salt is a saltwater flow. Therefore, it is important to emphasise that salt is not considered a pollutant when freshwater mud is used to drill huge amounts of salt formation. Salts that evaporate include: a calcium chloride (CaCl_2), potassium chloride (KCl), magnesium chloride (MgCl_2), and sodium chloride (NaCl) [1]–[3].

Apart from the well-known contaminations caused by salt water and rock salt, Chaney claimed in 1942 that sea water, which includes magnesium and calcium ions and is combined with clay particles, is a significant source of contamination. Seawater's magnesium and calcium are bad for water-base muds. Because the calcium and magnesium hydroxide are highly insoluble at higher pH levels, caustic is used to remove magnesium, reduce calcium's solubility, and precipitate lime. The Gulf of Mexico saltwater needs 1.5 to 2 lb/bbl of caustic soda (4.3 to 5.7 kg/m³), according to for all the magnesium to precipitate. Caustic is the primary method for removing magnesium from saltwater, while soda ash is the favoured method for removing calcium.

Acid Gas Contamination

From the natural gas stream, carbon dioxide (CO_2) and hydrogen sulphide (H_2S) are often created. When these gases are combined with water, they often produce mild acid solutions that cause the clays to flocculate and possibly intensify the viscosifying action of the polymer. With the use of water-based mud, formations that include H_2S or/and CO_2 may be safely drilled as long as the development pressures are maintained by a hydrostatic pressure larger than the pore pressure. To protect workers' safety and prevent embrittlement and drill pipe splitting when considerable H_2S pollution occurs, the mud characteristics must be properly controlled.

H_2S Identifications

1. Lower pH value of the mud
2. Darkening of the mud's hue as a result of iron sulfide's production from barite
3. A rotten egg smell
4. PH causes a rise in viscosity and fluid loss.

Contaminants Intended or

$\text{Ca}(\text{OH})_2$ cement

1. Seawater

2. Finishing up or working around liquids
3. Sponge liquid (generally a type of oil)
4. Sodium bicarbonate
5. Water-source bacteria or LCM

Contamination of Cement

Every time a well section is drilled, it is cased before being cement. As the well is drilled deeper, the mortar in the wellbore must be removed. As a result, calcium hydroxide is created in the process, and there is considerable flocculation of the drilling fluid's clay constituents. When the amount of calcium rises, along with the hardness, viscosities, and pH, it is simple to identify the contamination in the cement. The use of soda ash or calcium carbonate helps reduce cement contamination. If a low pH is needed, sodium bicarbonate is chosen over soda ash. Therefore, it may be appealing to convert the mud system to a calcium-based mud or maybe separate the contaminated mud and discharge it at the surface at a point in the drilling operation when cement contamination has reached a particular level and removal of the contaminant is no longer practicable [4]–[6].

Contamination by Carbonates and Bicarbonates

The intrusion of CO₂ during the drilling of a well using alkaline drilling fluids might result in the formation of bicarbonate or carbonate ions. When CO₂ first enters an alkaline mud environment, it immediately interacts with OH⁻ ions, causing soluble carbonates to build up. The issue known as "carbonate alkalinity" may also be caused by overtreating mud systems that have been polluted by other suppliers with quicklime or sodium bicarbonate. Practically speaking, this causes the lignosulphonate to be unable to handle high gel strengths and yield points.

Contaminants from Drilled Solids

These are the pollutants that were found during drilling. They are categorized as

- Clays and shale are examples of reactive solids.
- Inert substances, such as sand, limestone, etc.

Solids are an inevitable part of all drilling fluids that are introduced throughout the drilling process as commercially produced components or that are included as a consequence of the drilling operation. They may also result from drilling the rock, and they can be either cavings or cuttings. Conversely, clays are often found in drilling fluids and are either purposefully added to the mud as bentonite to condition it or they may be naturally present as drilled solids such as smectite, illite, chlorite, kaolinite, etc. We should be aware that the mud fundamentally lacks access to the water that is bonded to the clay. The effective viscosity of the mud increases as a result of this decrease in the fluid phase component.

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CHAPTER - 10

RHEOLOGICAL CHARACTERS

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The study of compression and base fluid of all sorts of materials is known as rheology (i.e., from gases to solids). This word is a combination of the Greek words "rheo," which means "to flow," and "logos," which means "science" or "logic." The link between flow rate, flow pressure/temperature, and the effect of fluid flow properties is really the subject of drilling fluid rheology. These qualities, sometimes referred to as flow attributes, define how a mud flows under various flow circumstances. The flow behaviour of the mud at different sites of interest in the mud circulating system must be understood in order to forecast or understand the implications of this flow. The behaviour of the fluid under an applied force determines the types of drilling fluid (shear stress). It would be crucial to know the following based on fluid behaviour:

The tensile stress is the contact drag that a flowing fluid creates on the surface of a conduit; the size of this drag depends on the friction between previous layer of fluid moving at various speeds as well as the velocity differences between adjacent layers near to the pipe wall. Shear rate refers to the difference in speeds between successive strata along a flow channel. For a driller, the impact of the flow at the wall where both shear stress and shear rate are at their peak—is his main concern. Fluids may be divided into two groups based on their rheological characteristics, depending on their viscosity [1]–[3].

Newtonian fluids (a)

Fluids that aren't Newtonian

Newtonian fluids are very basic fluids that have a constant shear stress to shear rate ratio, such as water or oil. For this reason, measuring shear stress at a single shear rate is sufficient to predict flow behaviour across the board. Viscosity is defined as the relationship between shear stress and shear rate. Newtonian fluid flow behaviour is described using viscosity, a unit of measurement for a fluid's resistance to flow. Centipoise units are used. It may be stated to be a measurement of the internal friction created when one layer glides over another and reveals the thickness of a fluid between layers of a liquid equation in mathematics,

Shear rate/shear stress equals viscosity is short for viscosity, shear stress, and shear rate. The degree of flow or flow is therefore linked to the applied stress when a force or shear stress of any size causes instantaneous warping of a Newtonian fluid. When the effective viscosity, or the ratio of shear stress to shear rate, is high at low shear rates and low at high or rising shear rates, this phenomenon is referred to as "shear thinning." Or, to put it another way, the improvement in friction factor above that of water decreases with increasing shear rate. "Non-Newtonian fluids" are drilling fluids that have a non-linear flow connection between shear speed and shear stress. They need a certain amount of shear stress to start flowing, and as the shear rate increases, more stress must be supplied. When the pressure or shear stress is lowered to a point where it is less than the shear strength of the structure, the flow of certain fluids, such

as drilling fluids and cement slurries, stops [4]–[6]. This is because the solids in these fluids join with one another to create a structure. The fluid's ductility or point is the location where a shear stress is necessary to start a flow. If these non-Newtonian fluids were to remain static for a while, a semi-rigid structure would continue to develop, raising the shear stress necessary to start a flow. The gel strength at this moment is the shear stress, and as the structure becomes stiffer over time, the gel strength increases. Shear rate data are very significant to the driller in four key areas:

1. The annulus, where flex rates are low.
2. The very high shear rates of the bits.
3. The pits, which seldom ever have shear rate values.
4. The drill string and collars, which allow hydraulic power from a pump to be delivered to the bit.

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CHAPTER - 11

PETROLEUM VISCOSITY

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It is a crucial mud characteristic that measures the internal flow resistance caused by the quantity, kind, and size of particles in the mud. Mechanical friction is created as a result of collisions between solids and the liquid portion of the mud, preventing movement. The amount of particles included in a mud and the thickness of the liquid phase both significantly affect the plastic viscosity. It explains how mud at the bit is supposed to behave. It is necessary to reduce the plastic viscosity in order to reduce high shear rate viscosity. Drillers may increase ROP by lowering the plastic viscosity, which in turn lowers the viscosity at the bit [1], [2].

Generally speaking, a high plastic permeability is never desired since, despite what one may believe, it would do more damage than good to a mud's capacity to clean holes. Actually, a decrease in plastic viscosity would slow the rate of flow and likely to cancel out any improvement in lifting capacity by increasing the tension drop down the drill string. Therefore, it is a good idea to maintain the plastic stiffness as low as is practically feasible. Any soluble substance may enhance the stickiness of the liquid phase [3]–[5].

As a result, the water of hydration truly becomes a component of the solid insofar as its impact on viscosity is concerned. In a mud, the volume of solid is mainly composed of the sum of the dry weight of aggregate and the increase in volume generated by hydration. As was previously indicated, any sort of solid may be added to mud to raise plastic viscosity, but solids like clays that absorb water and swell cause the plastic viscosity to rise even more as a result of hydration. Individual clay platelets tend to separate and enable hydration, which results in higher viscosities, when conditions like time, temperature, and agitation are present.

The quantity of drilled particles in the mud must be maintained to an absolute minimum in order to reduce plastic viscosity. However, increasing the volume % of solids in the mud would increase plastic viscosity. If the volume percent solids remained constant, the next course of action would be to reduce the size of the solid. This may be accomplished in one of two ways: either by lowering the solid's concentration or by introducing a flocculant, which enlarges the particles' surface area while decreasing the solid's concentration.

Yield Point

This is a measurement of the attractive forces that exist between mud particles because of the opposing charges that occur on their surfaces, which initially oppose movement. This mud feature depends on the kind of particles present, their surface charges, their concentrations, and any additional ions or salts that may be present, as well as their types and concentrations. There are many ways to raise yield point, including:

1. Increased solids concentration, for example, by adding bentonite, which happens when solids are in an active phase and have higher surface charges. If the particles are passive, this shrinks the distance between them.

2. Bit action, which involves grinding the particles and exposing additional surface charges that are active.
3. Less chemical processing is used as dispersants, releasing some active charges for interaction.
4. The introduction of pollutants that induce the mud particles to flocculate, such as salt, cement, etc.

Large molecules or colloidal materials in a fluid have a tendency to collide with one another, creating significant flow resistance. When particles are orientated randomly in the flow stream, which occurs with particles that are fairly long relative to their thickness, at low shear rates, the inter-particle interference will be extremely substantial, which will cause the particles to connect together. However, when the particles are lined up in the flow stream at higher shear rates, the impact of particle contact is diminished. The connected connections would be broken as a result, increasing mobility. The yield point of a mud is determined by the interaction of these two factors. While the mechanical interaction of the particles is regulated by adjusting the kind and amount of solids in a mud, the electrical interaction of the solids is controlled by chemical treatment.

In conclusion, flocculation of clay particles or large concentrations of colloidal solids result in a high yield point. High temperatures, a lack of deflocculant, or the introduction of pollutants may all contribute to flocculation. Sometimes, to encourage linking and raise yield points, flocculating agents or clay extenders are applied. Examples include polyacrylates, soda ash, and a number of calcium compounds. The capacity of the mud to clean holes and manage pressure are two crucial mud functions that are related to yield point.

A greater yield point increases the carrying capacity of a mud and the circulating annular pressure decrease in terms of hole cleaning. A balance must be achieved since an increased yield point is bad for the issues with lost circulation and swabbing but beneficial for hole cleaning. Higher yield points are often not required in high weight muds to provide excellent cuttings carrying capacity since hole cleaning capabilities are increased by increasing mud weights. Additionally, if high weight muds are needed, this is often crucial for pressure management. As a result, in high density muds, the necessity to reduce yield point often exceeds any benefits of retaining a high yield point.

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CHAPTER - 12

GL STRENGTH

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This crucial mud feature assesses the shear force required to start a fluid flowing after it has been stationary for a while, i.e., a measure of the fluid's thixotropic nature. In very simple terms, it refers to the mud's capacity to hold cuttings when circulation is interrupted. Because the structure is stiff as a consequence of the connection of electrically charged particles inside it, anything that inhibits or encourages the bonding of molecules in the mud will diminish or enhance, respectively, the ability to relate [1], [2].

Using a V-G metre, the peak dial deflection at which the gel structure breaks is measured to determine the gel strength of a mud at predetermined intervals of 10 seconds and 10 minutes. The differences in the two experimental measurements simply indicates the rate of gelation. These fixed periods are required to offer a comparison of the characteristics of muds in terms of gelation. A mud must have gel strength between 2 and 4 lb/100 sq ft in order to be able to suspend barite. Gel strength is measured in lb/100 sq ft. Barite won't hang at levels below this and instead will sink to the bottom of the mud, independently of how viscous it is. High viscosity would merely slow down the pace and duration of settling. Because the crystallites are far more active in water than they are in oil, barite can be suspended more easily in steam muds than in oil-based muds. High viscosity muds do not always have high gel strengths since they are two distinct phenomena that shouldn't be combined. As drilling operations progress, particles such as shot trimmings, barite, etc. are added to the mud system, which tends to increase viscosity and gel strengths. By adding additional fluids or scraping mud solids from the surface, this may be decreased [3]–[5]. In water base muds, a rise in gel strength indicates that crystallisation has just started, while a decrease in gel strength indicates deflocculation. In a mud, increased gel strengths are undesirable since they lead to the following issues. Large surge pressures may be experienced when running the pipe during tripping, potentially leading to formation breakage. It prevents solids from sinking down during solids separation increased issues as a result of swabbing.

Solids Analysis

The quantity and kinds of particles in a mud are the major factors to focus on in order to influence its filtering characteristics and flow behaviour. As a result, it would be possible to estimate the quantity of each sort of solid present by conducting tests also on muddy. It is necessary to know the % solids, the mud density, the volume percent water, the volume percent oil, and the specific gravities of such substances. The three main non-reactive materials that make up drill mud are bentonite, drilled solids, and barite, which serves as a weighing agent (reactive solid or colloidal phase). The mud retort is the tool used to calculate the percentage of oil and distilled water in the mud. The volume percent distilled water from the retort is less than the real volume percent distilled water because the large quantities of dissolved salt in the mud increase the volume capacity of water and its specific gravity. The quantity of suspended particles may be determined by subtracting from the actual volumes of the oil and water. The

relative quantities of barite and ragdoll physics solids may be estimated if the mud weight has been examined and or the container percent of suspended particles has been discovered. The main component of the mud, bentonite, and the low-quality drilled solids, and that have significantly lower exchange capacities, may be distinguished because various kinds of solids have varied cation exchange capabilities. The capacity to exchange cations of the clay solids could be assessed using a methyl blue test, and estimates of the volume percent low gravity solids, percent bentonite, and percent drilled solids could be made using this information [6], [7].

Filterness

Filtrate invasion and filter cake deposition are both potential issues with filtering because when mud pressure is greater than formation pressure, filtrate is pushed to flow into the formation and mud solids are deposited on the borehole walls. Filtrate invasion issues more often relate to formation assessment and completion issues. For instance, high fluid loss may result in flushing of the area surrounding a well bore, which might lead to inaccurate logging and testing data being obtained. A significant decrease in formation permeability caused by fluid invasion may also be an issue. As a result, the kind of filtrate is more important than the amount of filtrate lost, and from the perspective of the drilling operation, the filter cake should get more attention than the filtrate volume. This is due to the fact that it is directly related to issues like bad primary cement work, lost circulation, two pressure sticking, torque, and drag. Therefore, methods to reduce the thickness and permeable of the accumulated cake should be of key importance.

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