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POLYMER IN PETROLEUM ENGINEERING

EDITED BY
Bhairab Jyoti Gogoi

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Preface

The petroleum industry uses polymers as fluid additives or fluid component parts to address issues that reduce oil production and/or raise production costs. The science of polymers, more specifically, its synthesis, characterization, and physicochemical properties in solutions, has broad applications in this industry. All phases, including drilling and the treatment of water and oil, use polymers. In order to create new molecules with controlled structures for a variety of applications, research on the synthesis of polymers and their respective characterization aims to: (1) improve operating efficiency; (2) lower costs; and (3) elucidate mechanisms of action that can aid in the development of new technologies. In many cases, evaluating an apolymer's physicochemical characteristics in solution enables the establishment of useful correlations between those characteristics and performance in a particular application, in addition to illuminating the production system's underlying mechanisms, as is the case with asphaltene stabilisation. Our research team has applied polymer science knowledge to the petroleum industry, focusing on the following functions, among others: viscosification, inhibition of clay swelling, formation of filter cake, drag reduction, divergence, modification of wax crystals, stabilisation of as-phaltenes, emulsification, demulsification, and cleaning of solids systems contaminated with petroleum.

Biopolymers like polyhydroxyalkanoates are a possible alternative to conventional petroleum-based polymers as a raw material for the production of plastics. Utilising organic wastes from the food and agricultural industries, which contain a variety of carbon sources, is one method of lowering the costs associated with the production of microbial PHA. Fructose, found in waste fruit juice, and acetate, found in waste wine or biogas production, are two examples of organic waste carbon sources. The spectrum of ideal substrate combinations can be narrowed down through simulations utilising kinetic models, saving time and money by avoiding time-consuming and expensive experimental studies.

The book focuses on the use of polymers in various facets of the oil and gas sector. Among these uses are increased oil recovery, cleanup of oil spills, membranes, adsorbents, and coatings. Most of the chapters provide an overview of the state-of-the-art polymer applications in these fields. The importance of polymers and polymer nanotechnologies used in the oil and gas industry, as well as how to control their performance to produce a certain set of qualities suitable for their applications, have also been covered in great detail. In conclusion, the book is a handy resource for working scientists in both business and academia, as well as new researchers, chemical, petroleum, and mechanical engineers, and plastic technologists. The book also acts as a reference work for graduate students studying mechanical, chemical, petroleum, polymer, and materials engineering.

Bhairab Jyoti Gogoi
Editor

CHAPTER - 1

INTRODUCTION TO ENHANCED OIL RECOVERY (EOR) METHODS

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Numerous oil reservoirs can no longer produce oil using conventional primary and secondary extraction techniques as the global demand for oil rises. These oils must be extracted using enhanced oil recovery (EOR) methods that reduce oil viscosity, interfacial tension, and wettability on reservoir surfaces to increase oil mobility [1]–[3]. Since wettability and interfacial tension are highly reliant on temperature and pressure to function properly, it is essential to be able to test them at temperatures and pressures that are appropriate for reservoir conditions. A significant area of petroleum engineering called enhanced oil recovery uses several methods to increase oil recovery from petroleum reservoirs while using physics principles. Improving oil mobility by reducing oil viscosity or its interfacial tension with EOR fluids is a key EOR technique. As explained in greater detail below, these EOR technologies typically fall under the thermal, gas, as well as chemical injection categories. Viscosity fingering, whereby less viscous EOR fluids penetrate the oil with poor displacement effectiveness, is reduced by lowering the viscosity and increasing the dewetting of the oil from solid surfaces in the reservoir [4]–[6].

Three methods of EOR:

Gas, chemical and thermal-enhanced oil recovery

The gas and oil industries are acquainted with various techniques, and part of the issue is figuring out which technique is best for the reservoir at hand. Each of these approaches has unique difficulties. Enhancing oil recovery using gas in a carbonate reservoir, CO_2 Gas Injection, also known as Miscible Gas Injection, is the most often utilised EOR technique. Both mature and waterflooded carbonates use this EOR technique. When used properly, the CO_2 is poured into the formation water, dissolving it, and forming carbonic acid, which interacts with the reservoir rock and mixes the oil. The decreased viscosity of the CO_2 makes the displacement front unstable and affects mobility, which is one difficulty with CO_2 flooding. Due to these difficulties, oil in the poor permeability areas of the reservoirs may not be reached by CO_2, which might result in low volumetric sweep efficiency. Enhanced Thermal Oil Recovery The wettability of the carbonate reservoir is changed using the thermal recovery process, also known as steam injection, to reduce the oil's viscosity. The solubility of materials adsorbed on the surface rises as the wettability changes at high temperatures. Thermal EOR techniques are thus frequent in carbonate reservoirs as a result of the interfacial tension between the water and oil being reduced. Due to the fragmented structure of carbonate reservoirs, uneven sweeping and poor recovery factors might ensue.

Enhanced Oil Recovery Using Chemicals

Different kinds of polymers, surfactants, and low-salinity water injections are used in chemical recovery techniques. By lowering interfacial tension (IFT) and changing wettability, surfactant flooding, a subset of chemical-enhanced oil recovery, may boost recovery from these reservoirs. In our investigation, we primarily concentrated on the effects of plant-based solutions on a mineral surface for wettability change, including extracting neem, mango, and curry leaf solutions. To determine if these solutions may function as natural surfactants for wettability change, they are made to go through contact angle research and IFT test.

Contact Angle

The angle at which a liquid-vapour interface contacts a solid surface, as traditionally measured via the liquid, is known as the contact angle. There is a specific equilibrium contact angle for any system comprising a particularly solid, liquid, and vapour at a specified pressure and temperature. The flow properties of fluids in hydrocarbon reservoirs, and therefore the recovery of hydrocarbons in such media, is greatly influenced by surface forces between rock and fluid systems. These forces are measured in petroleum engineering by the interfacial tension (IFT) between various phases and the contact angle between the fluids and reservoir rock. Planning, managing, and operating reservoirs for optimal recovery requires the examination and modification of these factors. A contact angle of 0° indicates full wetting if the liquid spreads equally over the solid surface. The surface is wettable when the angle is between 0 ° and 90 °. The surface cannot be wettable if the angle is between 90 and 180 degrees. When the angle is visibly close to 180 degrees, it is entirely liquid-repellent.

Wettability

The propensity of one fluid to spread over or stick to a solid surface while additional immiscible fluids are present is known as wettability. Electrical characteristics, capillary pressure, the behaviour of water floods, relative permeability, or dispersion have all been found to be impacted by changes in the wettability of reservoir formation rocks.

Water-wet:

The rock or mineral's surface is covered with water, with oil and gas filling the biggest holes in the middle. When a rock or mineral is oil-wet, water is located in the biggest pores and the relative positions of water or oil are reversed from when the material is water-wet. The phrase intermediate wettability refers to reservoir rocks that have a moderate propensity for both water and oil to attach to the pore surface (Figure 1).

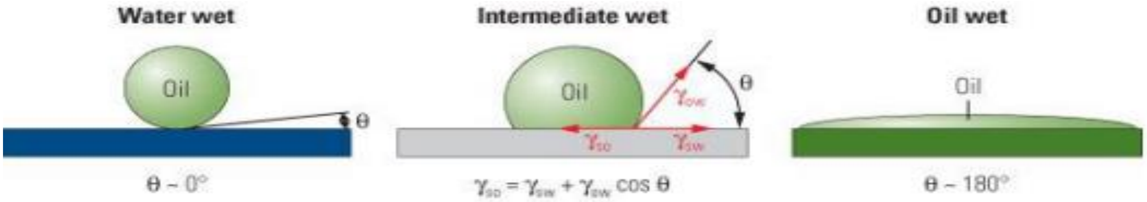

Figure 1: Illustrate the Contact Angle and Wettability

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CHAPTER - 2

EFFECT OF NATURAL LEAF-DERIVED SURFACTANTS ON WETTABILITY ALTERATION

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To reduce oil entrapment inside reservoir rock pores, enhance oil recovery (EOR) approaches are applied. One of the tested techniques in the area of EOR is surfactant flooding, whose goal is to lessen oil trapping by lowering the interfacial tension (IFT) of the water and oil systems and changing the wettability of the crude oil/brine/rock systems, which can increase the effectiveness of the water flooding sweep. There are two significant impacts of surfactant solutions on the rock/fluid system. The first result is a decrease in IFT between the injected aqueous phase as well as the trapped oil, and as a result, trapped oil is mobilised. The second consequence is the change in the rock's wetability, which indicates that the rock is becoming more water-wet and would result in higher rates of brine absorption. To be a cost-effective process, surfactant flooding may be influenced by a variety of factors, such as surfactant cost, IFT reduction, wettability modification, oil recovery, and others4). Natural-based surfactants may now be utilised in place of industrial surfactants due to environmental concerns, and many academics have been studying these types of surfactants recently. Quillaja Saponaria Molina, which was taken from a Chilean Soar bark tree, was the first natural surfactant. Zizyphus Spina-natural Christi's surfactant was extracted using an Amott cell, and its use in oil recovery was pioneered [1]–[3]. The behaviour of this surfactant's adsorption onto carbonate rocks under various circumstances was then examined by Ahmadi and Shadizadeh; this adsorption will lead to further alterations in the wettability of the rock. To study the impact of surfactant produced from Mulberry leaf on the IFT between oil and water at various surfactant concentrations, a microfluid was created using micron-sized Mulberry leaf particles. They showed that the IFT between distilled water and kerosene could be reduced by 60% when a microfluid containing 1 wt% of Mulberry leaf particles was used.

The production life of a hydrocarbon resource has been divided into three phases: primary, secondary, or tertiary production to produce oil with a maximum recovery factor (EOR). Only the reservoir's inherent energy sources, such as solution gas, gas cap, water aquifer, rock or fluid expansion, and gravity drainage, may be used to create oil during the primary phase. The reservoir pressure decreases as oil is produced until it reaches a point where there is not enough pressure to sustain oil production to the surface. With the reservoir under pressure and oil being displaced toward the producing wells, a secondary recovery technique that involves injecting gas or water into the reservoir may be used. Due to the low viscosity of the water injected, even though water flooding has been employed as a promising and successful recovery procedure, some crude oil still stays as a residue and is trapped. More sophisticated thermal and chemical processes known as EOR methods must be used to create the trapped or residual crude oil [4]–[6]. A thermal approach was more often used for EOR than chemical flooding, according to published research of up to 2000 publications, although chemical techniques are currently more frequently used in large-scale projects. Surfactant, Alkaline, or polymer fluid injections are part of the chemical EOR. Each of these fluids performs a particular role and may be combined, as in the cases of combinations of alkaline-surfactant-polymer (ASP) and surfactant polymer (SP), for example.

To lower interfacial tension (IFT), lower capillary pressure, and boost sweep efficiency, the rheological characteristics of these chemical solutions must be thoroughly evaluated. This enables the displacement of trapped and leftover oil from the injection well into the production well. The mobility ratio (M) might be altered to a more advantageous ratio by polymer flooding, increasing sweep effectiveness. Surfactant flooding, on the other hand, may change the wettability and lessen IFT between the displacing fluid and the oil. Numerous studies have recently shown that improving the efficacy of chemical EOR may be done by incorporating nanoparticles (NPs) into chemical solutions. In diverse dispersion media, such as distilled water, brine, ethanol, and diesel, the researchers conducted several EOR studies utilising various NP kinds and sizes. They claimed that since alumina NPs reduce oil viscosity, they have a strong potential to boost oil recovery when distributed in distilled water and brine. While wettability alteration was the reason why both kinds of silica-based NPs dispersed in ethanol were able to boost oil recovery. However, when magnesium oxide or zinc oxide were dissolved in distilled water and brine, certain permeability issues were discovered, and this led to subpar oil recovery.

Effect of Nanoparticles on Modification of Wettability

The change in wettability from a water-wetting system to one that is highly water-wet, which is a key EOR process, has a big impact on oil output. It is generally recognised that certain active substances and procedures, such as low salinity brine, surfactants, and selective ions, may be utilised to change the wettability of rock surfaces to a beneficial state. Many researchers discovered NPs had a significant impact on the change of wettability a few years ago. Consider the idea of disjoining pressure during nanofluid flooding to better comprehend the process of lowering the contact angle and changing the wettability of the reservoir from an oil-wet system to a water-wet system. Disjoining pressure may significantly improve how well crude oil is displaced in porous material. This is mostly caused by changes in wettability, although interfacial tension cannot be changed. They claimed that nanoparticles prefer to organise themselves in well-ordered layers and form a thin film on a rock surface when driven by injection pressure.

The chemical EOR still does not play a significant role in the world's oil production. China, however, is at the forefront of using chemical techniques to extract oil. Although there are many surfactants, polymer, SP, and ASP process initiatives happening in both Canada and the USA, they are primarily on a pilot size despite the growing interest in chemical-based ways to increase oil recovery during the last 20 years. In recent years, the use of nanoparticles in EOR has drawn considerable research attention in addition to applications in exploration, production, drilling technology, refinery, or transportation. This article provided a critical analysis of current developments in the NPs application for Chemical-EOR.

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CHAPTER - 3

NUTRIENT-RICH GREEN-MANURE CROPS

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Numerous possible green-manure crops were examined for production and nutritional content, particularly for N, P, K, S, and B. Several developmental phases were used to harvest a few green-manure crops. Several vegetable crops were tried in pot and field studies using fresh, moist, ensiled, and dried green manures. According to the findings, cruciferous crops including dyer's woad and fodder radish had high S concentrations, whereas garden sorrel, dyer's woad, or fodder radish had high P concentrations. While plants including chicory, dandelion, and garden sorrel had high concentrations of K, Dyer's woad, salad burnet, or stinging nettle displayed high concentrations of B. Plants were gathered at a developmental stage that corresponded to their maximum leaf/stem ratio to compare plant species. The pot studies revealed that nutrient absorption and output of cauliflower and kale were boosted by green manures with high concentrations of P and S. Even though P boosted vegetable yield, the findings show that S was the primary growth-limiting component. The field tests revealed that when the C/N ratio of the green manure grew, the yield of vegetables declined. It was determined that variations in vegetable output were not caused by the quantity of nitrogen applied, but rather by the availability of nitrogen [1]–[3].

Crops often need extra fertiliser sprayed throughout the season to guarantee excellent yield and quality in the production of organic vegetables. Slurry made from animal manure is one option. However, farmers of organic vegetable crops are exploring alternatives because of the possibility of microbial contamination from slurry. Utilizing green manure is one option. A fertiliser that is used as a top dressing on vegetable crops must meet certain criteria. The fertiliser must first be nutrient-rich. Second, nutrients must be released rather quickly. A fertiliser must also maintain its quality and be simple to use throughout shipping, crop application, and soil integration. Traditional green manure, on the other hand, does not meet any of the aforementioned criteria. More than a few days cannot be spent storing fresh green manure. It is difficult to handle since it is heavy and damp. Before the fertilizer's nutrients are accessible to the vegetable plants, they must further decay. Weeks or even months may pass throughout this procedure. Our research's goal was to create green manures that meet the aforementioned criteria and to determine how they affected the nutritional content of diverse vegetable crops.

Garden sorrel, dyer's woad, and fodder radish have high P concentrations, while cruciferous crops like dyer's woad and fodder radish have high S concentrations, according to the screening of possible green-manure crops taken at a developmental stage corresponding to a high leaf/stem ratio. The developmental stage, however, affects the chemical makeup of a plant species. Typically, a dilution effect during plant ontogeny causes the content of N and other macronutrients to drop. In the current study, we sought to collect plant samples when the ratio of fresh, green leaves to stems was at its highest. This period often correlates to the beginning of blossoming. However, it might be challenging to choose the best sample time for certain plant species, making comparisons of nutrient content across plant species challenging. The pot studies revealed that nutrient absorption and output of cauliflower and kale were boosted by green manures with high P concentrations. The R2 rose to 0.7022 when fodder radish and dyer's woad were excluded. Although P boosted kale output, the findings show that S was the key growth-limiting component. The fodder radish, dyer's woad, and garden sorrel in the current experiment all exhibited low C/P ratios and low C/S ratios. Low C/P and C/S ratios cause P and S to release more quickly, which increases the absorption of P and S by vegetable crops.

Potential Green-Manure Crop Field Trials In the field tests, chopped dry green manures with various C/N ratios were mixed with 160 kg of total nitrogen per ha of cauliflower or kale. Vegetable plants that weren't fertilised produced less throughout each of the three experimentation years. Additionally, when the green manure's C/N ratio increased, the yield of vegetables fell. It was determined that variations in vegetable output were not caused by the quantity of nitrogen applied, but rather by the availability of nitrogen. However, even though N immobilisation most likely took place in the current tests, all green manures produced positive net mineralization. Following the integration of the green manures into the soil, the N immobilisation varied among the green manures and likely increased with higher C/N ratios [1], [4], [5].

In general, N immobilisation occurs when the C/N ratio rises over 18 to 20. In the current experiment, garden sorrel and late-harvested lucerne both had C/N ratios exceeding 20. The greatest dry matter concentration was found in the plants that weren't fertilised. The application of stinging nettle and fodder radish, both of which had a high S concentration, led to kale leaves with a high S content. Leeks and celery were given varying doses of fresh, dried, or ensiled green manure on vegetable fields. Leeks and celery both produced more when given more green manure. However, it was shown from these tests that the C/N ratio of the green manures had to be low, and ideally below 12 if a speedy reaction was required. The C/N ratio of the green manures affected the yield response. The necessity of green manure that can be kept until required and is simple to manage during transport, crop application, and soil integration was also established by these field studies.

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CHAPTER - 4

IMPACT OF IRON MINERALS IN PROMOTING WETTABILITY ALTERATION

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When reservoir rocks change in wettability, it's often because polar compounds like asphaltenes or resins have coated the surface of the rock. Many scholars have studied wettability modification from the perspective of fluid-fluid interaction, but the goal of this study is to shed light on the role of solid-fluid interaction in the issue of asphaltene deposition. Asphaltene, the most polar and heavy component of crude oil, is often referred to as a solubility class that is soluble in aromatic fluids but insoluble in alkanes. Because of the intricacy of the asphaltene molecule and the uncertainty surrounding its behaviour in various fluid conditions and interactions with various rock mineralogies, research towards a reliable solution to its adsorption on reservoir rocks is currently ongoing. Since asphaltene is thought to be negatively charged, only positively charged sites may allow for its adsorption on rock surfaces [1]–[3].

Due to the precipitation of ferric and ferrous irons, iron minerals such as hematite, pyrite, magnetite, and ankerite are among those that act as a site for asphaltene molecules. One important mechanism that affects the movement of colloidal particles, mineral dissolution & kinetics, or the movement of cations and anions in porous media is the adsorption of ions on rock surfaces. Iron mineral interactions are governed by their stability, dissolution rates, specific surface area, as well as their mineral structure and behaviour in various settings, making it crucial to understand the dominant mechanism that governs ion exchange in reservoir conditions. Alkaline flooding (pH > 10), acidizing (pH 2-3), low salinity water flooding (pH = 6-7), treatment after drilling operation (pH 4), as well as other operations affect the surface of the rock by changing the reservoir's pH, allowing for rock-fluid interactions that would not otherwise be feasible. Thus, this encourages the precipitation of mineral particles, modification of the surface's chemistry, and adsorption of asphaltene.

Mineral dissolution, the adsorption of counterions, and the creation of complexes cause colloidal particles in aqueous solutions, such as hydroxides, oxides, sulphides, and oxyhydroxides, to acquire charges on their surfaces. These charges are what maintain the chemical equilibrium in the reservoir. The colloidal stability of the particle in suspension is also shown by the zeta potential values of colloidal suspension, in addition to the sign of the charge on the particle surface. As a result, if all particles have significantly different values of their zeta potential, they will reject one another and their dispersion will be regarded as stable [4], [5]. Pointed out that particles having zeta potentials of less than 30 mV are thought to be unstable and might have their charges reversed when they contact other fluids.

The nature (pH) of the environment and various good activities, such as acidizing, low salinity water flooding, fracking, and CO_2 injection, which induce varying pH environments in the reservoir, determine how the charge development of the iron minerals occurs. To identify the factors that would favour the adsorption of asphaltene molecules and result in changes to wettability, it is crucial to investigate the many surface charge possibilities of the iron minerals.

To the best of our knowledge, no one has looked into the possibility that the surface charge of completely oxidised iron minerals may serve as an adsorption site for asphaltene molecules even though it has been mentioned in the literature. The right design of corrective action may be put into practise to reduce production loss caused by wettability changes, particularly in the area surrounding the wellbore.

Compared to carbonate formation, iron minerals are more prevalent in sandstone reservoirs. It is unknown, however, whether a component of the sandstone rock which mostly contains quartz, iron minerals, feldspar, and clays in addition to iron minerals is mainly responsible for determining the wetting condition. As a result, the effects of minerals on surface wetness have been widely studied. Sandstone is oil-wet, neutral wet, and water wet. Although the impact of iron minerals is researched in this paper. Due to their magnetic response qualities, iron oxides have lately been claimed to have been used as Enhanced Oil Recovery (EOR) fluids. Their strong hydrophobicity, adsorption, and magnetoresponsive qualities, which function as a driving force for their interactions with surfaces, moreover cause their nanoparticles to lead to a decrease in interfacial tension.

Due to the formation of Fe_2+ complexes with chloride, magnetite, an iron oxide (Fe3O4), has high solubility. Its surface chemistry and this characteristic have been shown to change with temperature, yet it can still maintain its surface charge at high temperatures. Additionally, magnetite may serve as an adsorption site even in the case of petroleum reservoirs since it is an effective adsorbent for dangerous species from aqueous solutions (such as uranium, cesium, etc.). However, there are data concerning its function in the polar portion adsorption of crude oil, which affects wettability. Studies that accurately link changes in magnetite interfacial or surface chemistry to operations are also rare.

It is reasonable to state that the existence of iron minerals in reservoir rocks raises issues, particularly when such minerals are those that come into contact with crude oil. This is because their surface chemistry (charge), which impacts their colloidal stability and tendency to precipitate, is governed by the surrounding fluid. We use electrophoresis techniques to examine the surface charge of iron minerals in various pH conditions and their interactions with salts. This will provide light on the kind of charge they carry and how stable the particles are under various conditions. Determining the roles of iron minerals as possible determining minerals in asphaltene deposition in reservoir rocks is the goal of this research. Based on the idea that asphaltene, which is negatively charged, would only adsorb on a rock if it comes into touch with a positively charged rock mineral, this method is used. However, these minerals have various charges and may also have their charges reversed. Therefore, it is crucial to comprehend the behaviour of rock minerals under various situations and determine their involvement in assisting polar compound adsorption owing to their surface charge interactions to battle wettability change caused by asphaltene adsorption onto the rock surface.

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CHAPTER - 5

BASICS OF MICRONUTRIENTS

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Plants absorb the cationic forms of the micronutrients Fe, Mn, Cu, Zn, and Ni, whereas they absorb the anionic forms of B, Mo, and Cl. Most soils often have high concentrations of Fe and Mn, yet adsorption processes seldom ever affect how readily these elements are available to plants. The content of Fe and Mn in soil solutions is primarily regulated by oxidation and precipitation processes. The three secondary Fe oxides that are most often found in soils are goethite, hematite, and ferrihydrite. Fe oxides have large specific surface areas and provide plenty of adsorption sites for both cationic and anionic elements in all types of soils because of their microcrystalline structure.

Goethite and hematite, the two most stable Fe oxides, are known to contain significant structural substitution of trace elements including Ni, Zn, Mn, and Cu. Fe oxides are more prevalent and plentiful than manganese minerals. They often appear in soils as nodules, mineral coatings, or finely scattered particles within the soil matrix. Either Fe or Mn oxides are typical soil minerals that serve as significant substrates for the preservation of a variety of macro- and micronutrients. Due to the highly poor solubility of Fe and Mn oxides and Mn carbonates, plant availability of both Fe and Mn is significantly decreased in calcareous soils. In these conditions, plants trigger metabolic reactions that improve the availability of Fe, Mn, or other micronutrients by releasing reducing and chelating chemicals, acidifying the rhizosphere, and other processes [1]–[3]. At low solution concentrations, copper, zinc, and nickel are absorbed by Fe and Al oxides via generating inner-sphere complexes. Therefore, metal hydroxides precipitate at greater solution concentrations (Ginder-Vogel & Sparks 2010). Zn_2+, Cu_2+, and Ni_2+ are adsorbed by the formation of outer-sphere complexes on the negatively charged surfaces of 2:1 phyllosilicates, and perhaps by the development of inner-surface complexes on the surfaces of kaolinite. Zn may bind to calcite in alkaline soils and co-precipitate with copper in calcite.

Plants absorb B and Mo as H_3BO_3 or MoO_4^{2-}, respectively. There is some evidence to support the theory that B species, namely $B\ (OH)\ _3$ and $B\ (OH)\ ^{4-}$, are adsorbed into soils by creating inner-sphere complexes on the surfaces of Fe and Al oxides. Similar to this, metal oxides significantly adsorb MoO_4^{2-}. The chloride (Cl^-) form of chlorine is absorbed by plants, and adsorption mechanisms involving Cl ions are comparable to those involving NO_3^- ions. Because variable-charge minerals like kaolinite and Fe and Al oxides predominate in heavily worn soils, there is a very large potential for exchange-based adsorption of Cl ions in these soils. Cl may occur as precipitated mineral forms including NaCl, $CaCl_2$, or $MgCl_2$ in some soil settings, such as those with limited leaching or low-lying places in dry climates.

Infertility of the Soil and Secondary Minerals

The weathering of primary minerals in the aqueous environment at the Earth's surface often results in low-temperature processes that produce secondary minerals, which are different from the main minerals. Dissolution-precipitation, adsorption-desorption, and oxidation-reduction processes are the main mechanisms by which secondary minerals regulate nutrients [4]–[6]. Mineral adsorption processes often have a greater role in regulating plant nutritional element availability than does mineral weathering, which releases nutrients. Ca^{2+}, Mg^{2+}, K^{+}, and Na^{+} are among the important nutrients that may be held at exchange sites by phyllosilicates with a permanent charge, such as vermiculite or smectite. These nutrients are preserved through outer-sphere complex development and are simple for plant roots to absorb. However, certain nutrients (P, Zn) are retained by variable charge minerals such as Fe oxides by creating inner-sphere complexes, making them unavailable to plants.

For plants, phyllosilicates store and release K in exchangeable and fixed forms that are non-exchangeable or fixed (i.e., exchanged slowly and only when the K content in soil water falls below a threshold value). Potassium ions on the exchange sites are easily accessible for plant uptake after being absorbed by outer-sphere complexation. However, compared to exchangeable K, illite, vermiculite, or interstratified 2:1 clay minerals release fixed or non-exchangeable K from interlayer sites more slowly via cation exchange and diffusion mechanisms. Similar to NH4+ ions, K from fertilisers or other additions may be fixed in the 2:1 minerals' interlayers. If the K content in the soil solution falls below a certain threshold, the non-exchangeable or fixed K may be released back into the soil solution.

Primary minerals undergo chemical, physical, and biological weathering, which releases a variety of nutritional components into the soil solution. Primary mineral weathering rates and routes are very diverse and influenced by several elements, such as climatic conditions and mineral characteristics. Mineral weathering is an essential and long-term source of various geochemically derived nutrients, even though the rates of primary minerals for only certain elements might not be quick enough to fulfil plant nutrient needs on a short-term basis, especially in controlled cropping systems. As soil weathering progresses, a soil's ability to deliver nutrients via the weathering of primary minerals declines.

Essential plant nutrients are both sourced from and sunk by soil minerals. When primary minerals in the metamorphic and igneous rocks weather in soils, they release plant nutrients into the soil solution. These minerals were created at high temperatures and pressures. In watery phases of soil ecosystems, new minerals may develop. These secondary minerals act as nutrition sources, or they precipitate as well as adsorb necessary elements, preventing plants from easily absorbing them. Secondary minerals often act as significant reservoirs for nutrients that are kept in a way that prevents leaching while yet allowing plants to draw on them to fulfil their nutrient requirements. The soil organic matter holds and releases plant nutrients in various soils and topsoils.

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CHAPTER - 6

FUTURE SCOPE OF EOR TECHNIQUES

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In EOR, sufactant flooding to clean the formation often uses chemicals [1]–[3]. These pollutants could damage the reservoir and have a detrimental effect on the rock formations. Natural substances may be used by people to decrease their negative impact on the environment. Mango, neem, and curry leaves were used in the experiment to examine how leaves influenced wettability. The leaves were tested with a light paraffin material, such as crude oil, for the presence of IFT. A contact angle test was also conducted, and the results provided information on the contact angles between crude oil and the solutions of leaves.

As knowledge and technology progress, there is always an opportunity for improvement in any product or equipment. In this sense, EOR is comparable. By repeating this experiment in the future at different temperatures, which simulate fluctuations in reservoir temperature, it will be possible to assess the effectiveness of the created surfactant in real use. Natural surfactant is also readily available, advantageous for EOR activities, and perhaps cost-effective and ecologically safe.

Surfactant usage in the industry boosts recovery to a greater extent, but it also produces a large amount of effluent that is difficult to manage and has little possibility of being recycled. These surfactants and their additives are also often expensive and difficult to acquire. By employing natural, readily available, and ecologically safe additives, surfactant flooding problems may be minimised. In this case, humans created a natural surfactant using curry, mango, and neem leaves. The properties of the surfactant (IFT or Wettability Alteration Capabilities) were studied to decide which was better.

After primary and secondary recovery, the remaining crude oil in the reservoir is extracted using EOR processes. One of the EOR techniques that are most often employed in the sector is surfactant flooding. Chemical surfactants used in surfactant flooding for wettability change and IFT reduction include C15-18 BABS/C16-18 BABS. We are primarily investigating the "Effect of plant-based solution on a mineral surface for wettability modification," an EOR application, to determine how it affects contact angle and wettability. In this work, we are primarily interested in creating an environmentally friendly natural surfactant using neem, mango, and curry leaves. For our experiment, we consulted a number of studies that discuss natural surfactants. The documents that followed also matched what we were searching for. We thoroughly investigated mulberry and henna leaves because they had the potential to change from being oil-wet to being water-wet. In this study, IFT measurements are used to calculate the CMC for surfactants made from mulberry and henna leaves, respectively. The CMC is 2.6% by weight for mulberry leaves and 2.8% by weight for henna leaves, respectively. The IFT was determined using the prospective drop technique. The oil phase was kerosine. As for the contact angle, the measurement reveals a decrease from 62.5 to 48.5, demonstrating that the contact angle is decreased at increasing concentrations of Mulberry leaf extract. This demonstrates how mulberry leaf extract can change how moist the water is. The average contact angle decreased from 66 to 37 for henna leaf extract, demonstrating that a greater concentration causes a lower contact angle. Additionally, this changes how moist the water is.

Vernonia Amygdalina leaves are used to research the wettability alteration and foaming qualities in the publication "Oil-water interfacial tension, wettability alteration, and foaming investigations of natural surfactant derived from Vernonia Amygdalina." 100 cc of distilled water was used to dissolve 2g of the powdered leaves. The Easy Dyne tensiometer was used to get the SBNS (0.1-3%), which was present in the IFT. Tests are conducted on foam stability and foamability. Additionally, a wettability test was carried out, and it was discovered that the contact angle changed from 118.5 to 45.7, indicating that an increase in concentration influenced how wet the sandstone core was.

Formation and Deposit Structure

The deposit formation as well as its effect on the availability of active components is the most difficult or least understood procedure in the foliar application of agrochemicals. This is definitely because there are so many variables that might affect deposits in various ways, even when just one substance is used in the spray. Last but not least, although all of these components are physical and significantly interact, we may group them into biological, environmental, application, and environmental categories based on where they came from [1], [2], [4]. The fundamental physical factors include those that affect the evaporation of spray liquid based on droplet or leaf dimensions, such as droplet size or unstirred layer thickness as well as weather patterns and formulants present; the propensity for ring accumulation with any surfactant-containing aqueous environment; the uniformity in the dispersion of dissolved or suspended particles actives across the droplet contact area; and the effectiveness of the contact of active particulate to the droplet surface.

The processes and methods for enhancing spray retention, droplet adhesion, spreading, and coverage are thoroughly defined. There are several ways to modify these for particular leaf surface characteristics of a crop or target plant, application circumstances, or product. Adjuvants have varying degrees of particular efficacy to enhance spray application procedures for built-in and tank-mix applications. The optimal option is still a shifting target due to variables like cost pressure, the intended usage in a formulation with little room for activators, various extra roles as formulants, plant compatibility considerations, environmental acceptability, and other issues. However, the fundamental principles are understood, and models are available to anticipate how altering pertinent spray parameters might alter spray retention. Then, with the aid of certain pertinent experiments, wetting procedures may be optimized.

In contrast, models on delivery and foliar penetration often do not take into account the deposit qualities, and it is not feasible nor required to include all of the significant factors. Instead, it is necessary to determine the crucial parameter that is most susceptible to fluctuation and has the most promising manipulation possibilities. In many instances, the right quantity of adjuvant will have a good impact on a variety of minor processes and elements of influence, leading to noticeably improved biological performance. As a result, individually important components become insignificant, yet it still may be difficult to pinpoint the limiting factor. Deposit characteristics are a great target for nanotechnology-driven advances because they provide several unique approaches to enhance the effectiveness of agrochemicals.

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CHAPTER - 7

INTRODUCTION TO GEOPOLYMER CEMENT PERFORMANCE IN PRESENCE OF DRILLING FLUID AS CONTAMINANT

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One of the most crucial procedures involved in drilling and finishing wells is cementing. The main goal is to completely isolate the zones by preventing fluid movement between the wells and formations. Losing zonal isolation might lead to serious operational troubles, significant environmental problems, and expensive remediation. For many years, coarse aggregate has been utilised in the cementing process. The problems Portland cement encounters include radial fissures in the cement sheath, micro-annuli at the cement's interfaces, and channels in the cement matrix. Recently, a brand-new substance called geopolymer has been researched as a Portland cement substitute. Fly ash, a byproduct of burning coal in power stations, reacts with alkaline activator, a combination of sodium or potassium hydroxide (NaOH, KOH) and sodium silicate (Na2SiO3) or potassium silicate, to produce geopolymer (K_2O_3Si). Recent investigations have shown several problems with the usage of Portland cement, including leakage, well cement degradation and sensitivity to chemical reactions [1]–[3]. Therefore, there is an urgent demand for sustainable cement technology that has superior properties to regular Portland cement for cementing oil wells. This study's focus is on the geopolymer cement's potential for improving wellbore integrity.

Concrete for oil wells

Cementing operations are divided into two groups in the petroleum and natural gas industries. Secondary cementing is the two kinds. The former is true in terms of a technique for burying cement. The annulus refers to the region that is located between the enclosure and the formation. The latter might be described as remedial measures done to address issues with the first cementing process' flaws. A well for oil was found. The steps involved in cementing may be summarized in the following manner [4]–[6]. Following mixing, the cement slurry is poured down the casing to the annulus or open hole, which is the region around the casing. Oil well cement is primarily used to restrict fluid from flowing back and forth between rock formations and to hold the cylinder in place. Additionally, it serves the following purposes as it settles halfway between the casing and the borehole:

1. To protect the casing against corrosive chemicals from the start.
2. Bengaluru's Presidency University / June 2022.
3. To prevent blowouts by creating a solid seal.
4. To shield the casing from stress loads, especially if you're drilling in a deep zone.
5. To establish sealing zones if circulation is lost.

Geopolymer Properties

The usage of geopolymer is more enticing because of its numerous benefits over Portland cement. In comparison to Portland cement, geopolymer has two primary benefits that make it a superior choice:

Geopolymer is more economical: Fly ash is the primary component of geo-polymer. Fly ash is a byproduct of burning coal, and since there is no significant market for it, it may be purchased for very low prices. In contrast to geopolymer, however, Portland cement needs specialised chemicals that are more costly to purchase.

Eco-Friendlier than other materials: Since fly ash makes up a large portion of geopolymer, it promotes the use of a waste product that would otherwise be disposed of in landfills. Due to its production process, which involves burning a sizable quantity of fuel and the deterioration of limestone, Portland cement produces a sizable amount of carbon dioxide (CO_2) emissions.

It shows that geopolymer offers a consistent compressive strength at various sodium hydroxide (NaOH) concentrations and curing circumstances. Compressive strength is favourably impacted by sodium hydroxide concentrations. The alumino-silicate gel that developed as a result of the polymerization process is what gives geopolymer its increased compressive strength. The compressive strength improves with increasing sodium hydroxide concentrations. Additionally, the proportion of alkaline activator to fly ash has a significant impact on compressive strength.

The strength of the geopolymer increased with an increase in the alkaline activator to fly ash ratios. The effects of utilising varied silicate-to-hydroxide ratios and varying sodium hydroxide concentrations on compressive strength were shown by the mechanical characteristics of geopolymer and Portland cement at various curing temperatures. According to their findings, the compressive strength increased as sodium hydroxide concentrations rose. Geopolymer is also described in terms of its endurance, minimal surface roughness, and thermal stability. Portland cement is less resistant to acid than geopolymer. When exposed to corrosive conditions, geopolymer is more durable than Portland cement.

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CHAPTER - 8

CRYSTALLINITY PARTICLE SIZE

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Oil well drilling involves cementing work that is exposed to extremely high pressures and temperatures. OPC Oil-well cement is utilized for this purpose. Typically, they are made of Portland cement that has been specially treated with organic retarders to stop it from forming too soon [1], [2]. The attributes are:-

Fineness: The crystallinity, or particle size, of Portland cement, affects the rate of hydrate, which determines the pace of strength increase. More seawater area is available because the pore volume ratio increases with decreasing particle size. In reaction to volume units, the typical cement particle size is 45 microns, and around 95% of aggregate particles are smaller than that. Surface temperature per unit mass, which is measured in units of 15 microns, is used to quantify fineness.

Consistency: A cement paste's consistency refers to its flow ability. Normal consistency granules must be made to evaluate cement specimens. The Vicat devices plunger must penetrate a paste by 101% before judging its consistency to be normal. Millimetres are used to indicate the water-cement ratio. The initial setting time is the time taken for the substance to cease functioning like a flowing after being first exposed to water Plastic, On the other hand, the final setting time describes the time it would take for the plaster to reach a certain degree of hardness. Maintain a certain load. The setting time is determined using either the Gillmore needle or the Vicat instrument.

Specific Gravity: Specific gravity is often necessary when calculating the proportions of a concrete mix. OPC has a particle density that is estimated to be between 3.1 and 3.25 Megagrams per cubic metre. The relative density of OPC is high. 3.15 is assumed. The Le Chatelier apparatus is used to figure out how dense cement is.

Compressive Strength: 50mm motor cubes manufactured from standard sand and properly cured are used to evaluate the cement's compressive strength. A decompression experimental setup is used to test the cubes. Because cement's strength changes over time, it is often described as having a 1, 3, or 28-day strength.

Density: To calculate density, divide the volume of the mechanical mixture by the mass of the cement particles and the air between them. OPC may vary in density from 830 kg/cu.m. To 1650 kg/cu.m.

Pellets of sodium hydroxide (NaOH)

In this investigation, 96% pure sodium hydroxide was employed, which was procured from Qualigens (Thermo Fisher Scientific India Pvt. Ltd.). In this work, sodium hydroxide concentrations of 10 molarity were utilised. The molarity is sometimes referred to as the concentration in a solution and is expressed as the number of particles divided by volume [3]–[5].

Powdered Sodium Silicate (Na_2SiO_3)

The term "water glass" also applies to sodium silicate. This material was utilised exactly as supplied by Karnataka Fine Chemicals, with no modifications.

Ash Fly

In this investigation, class C fly ash was employed. According to the American Society for Testing and Materials, fly ash is classified as class C fly ash if it contains more than 50% of silicon dioxide (SiO_2), aluminium oxide (Al_2O_3), and iron oxide (Fe_2O_3). The fly ash utilised in this investigation was categorised as Class C based on the XRF data.

Portland cement

For our experiments in this paper, we utilised regular Portland cement (OPC). It is the kind of cement that is used most often as a basic component worldwide. It is a hydraulic binding substance made by grinding clickers of Portland cement with 6%–15% mixed materials and the proper quantity of gypsum.

Drilling Fluids

Nonaqueous mud was used for this investigation. Bentonite and water were combined to create the drilling fluid, which was then prehydrated for 24 hours. Since when bentonite comes into touch with water, it absorbs it. To make sure that all of the clay was thoroughly absorbed while the liquid was ready, prehydration was performed.

Drilling Fluids

Bentonite

Bentonite is a frequent component of drilling mud that also helps in the production of mud cake since it is utilised in drilling fluids to help lubricate and temper the drill bit as well as to remove cuttings. In this investigation, the OPC and high-strength concrete cement were contaminated with bentonite drilling fluid.

Sulfuric Acid

The mineral acid, known historically as "oil of vitriol," has the chemical formula H2SO4 and is made up of the elements sulphur, oxygen, and hydrogen. It is a volatile fluid that is colourless, odourless, and miscible with water. Here, we use it to determine the cement blocks' resilience (OPC and FAGP) because sulphuric acid exposure causes mould to lose compressive strength.

Sulfuric Acid,

In this project, we utilised a hot air oven to cure the geopolymer moulds over many days. Hot air ovens are electric machines that employ dry heat to sterilise. The basic purpose of a thermostat is to control temperature. Due to the outer layer's metallic composition and the inner layer's weak conductivity, its double-walled insulation retains heat while also saving energy. A hot air microwave is a device used in science that uses dry heat to sterilise materials and lab equipment. The temperature range of a hot air oven is 50 to 300 degrees C. It can be controlled using a temperature regulator.

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CHAPTER - 9

MACHINE FOR COMPRESSION TESTING

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It is a testing device made especially for determining how well materials and goods withstand compression pressures. This device was employed in our investigation to get OPC and FAGP compression results. To examine the strength of the geopolymer, compressive strength is a crucial aspect. In this investigation, after the slurries were blended with various drilling fluid ratios, high-strength concrete strength and Concrete mixtures strength were investigated. Using platens or other specialised fixtures on a compression testing machine, compressive pressure is often given to a test specimen to assess how a material will behave under crushing pressures [1]–[3].

Remi Stirrer

REMI offers the most recent iteration of lab stirrers for mixing and stirring chemicals, drilling fluids, and other materials. The primary purpose of a stirrer is to stir a liquid to hasten reactions or enhance a combination. The electromagnetic bar that is submerged in the liquid to create the string motion is the stir bar.

Mud Balance

We are determining this same density of the bituminous mixtures using equipment that was intended to measure density. The density of cement typically ranges between 14 and 17 lb/gal.

Speed Viscometer

A device for determining viscosity and gel strength is sometimes known as a direct-indicating viscometer or V-G metre. There are six changeable speeds on the Fann-type viscometer. Since we can determine the plastic viscosity from the dial reading at a particular speed, this instrument is known as a direct indicating viscometer. This is a significant aspect of cement flow ability determination. The drilling fluid containing bentonite, which is used in OPC and FAGP moulds in various percentages, will first be prepared. We will test the compressive strength and durability of OPC and FAGP after various curing times. The rheological characteristics of OPC and FAGP slurries will be discovered subsequently.

Manufacturers of coatings use a variety of QA/QC, or quality assurance and quality control, techniques. The gadgets are easy to use and inexpensive. Data is often presented as a single point, thereby providing a "go/no-go" test. The use of tests that produce more useful data at affordable prices is being pushed by increased market competitiveness, stronger consumer expectations for product tolerances, and widespread adherence to (or other) standards. The "one-point" tests are also fundamentally restricted since they are unable to characterise the behaviour of the material at a variety of shear rates, which may be necessary for optimum product performance. For instance, many coatings spray onto surfaces, necessitating extremely low stickiness at very higher pressures, but subsequently must remain on the substrates without additional dripping, necessitating quick structural recovery and, thus, high viscosity at almost zero shear rate. Therefore, a rheological or viscometric automated, multi-speed test is necessary. In this article, these ideas are examined, and a solution is offered.

The opposition to flow is called viscosity. Rheology is the study of flow, to put it simply. Rheology and viscosity of coatings play a crucial role in producing suitable goods. We analyse three white house painting paintings that are readily accessible on the market and give results from that investigation in this article. Shear rate describes how quickly a material is sheared, or when a force is transferred in the opposite direction of flow, as a result of friction between vanishingly thin fluid layers. Geometry and testing or application speed are used to calculate the shear rate.

It seems like paint is unsheared when it is left undisturbed in a container on a shelf. Like us, it doesn't seem that the paint is being moved. The resulting viscosity is the "zero-shear-rate" viscosity since the shear rate is nearly zero. However, over time, the gravity-induced settling of solids is possible. Under these circumstances, it is ideal to have a viscosity that is high enough to ensure that settling either doesn't happen or happens very slowly. Nearly zero shear rates would make it exceedingly difficult to collect measurements; hence, they are conducted at somewhat higher rates. Quickly level off to provide a pleasant, smooth look after being brushed on; effortlessly flow while being brushed onto the surface; and remain on the surface without flowing off or leaking.

Therefore, the viscosity must be low at high shear rates, such as when brushing or spraying. It must also be short enough, at least temporarily, for levelling to take place. When the material is always at rest after levelling, the viscosity must, however, immediately rise to a high enough value to avoid dripping.

Rotational viscometers,

The information in this article was gathered using rotational viscometers, which are devices that make contact with the test liquids using revolving spindles. Depending on the cone spindle diameter and angle, this shape offers easy access to and cleaning of the sample and only needs a modest amount of material. More surface area in contact with the sample is made possible by larger cones with lower angles, which increases sensitivity for lower viscosities. Greater angles on smaller cones enable the testing of more viscous, or greater viscosity, liquids [1], [3], [4].

A Brookfield CAP 2000+L Viscometer was used to evaluate each paint, first by raising and subsequently by reducing the shear rate. Over the studied speed range, is substantially more viscous than Paint. Furthermore, the results show increased hysteresis. In other words, the increasing-speed ramp has viscosities that are greater than the decreasing-speed ramp does. The fluid's structure must take time to reconstruct after being sheared, which is an indication of thixotropy.

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CHAPTER - 10

TESTING AT MODERATE SHEAR RATES

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Coaxial or concentric cylinder geometry is another often-used shape. This is also known as Couette geometry or Searle geometry. According to strict definitions, Searle's instrument featured a revolving inner canister with a stationary outside cylinder, but Couette's viscometer had a turning outer cylinder with a spinning inner cylinder. Depending on the spindle and sample chamber configuration used, this shape also needs very small sample volumes and provides somewhat straightforward sample access. When tested with the Brookfield Enhanced UL Adapter on a Brookfield RVDV-III+ Rheometer, Paint is not only more viscous than Paint at all shear rates, but it is many times more viscous at shear rates below 0.5 s-1. While the canned item is on the shelf, this could imply significant work durability and strength to settling [1]–[3].

It calculates the force necessary to spin a mobile that is submerged in a fluid. A motor powers the mobile using a calibrated spring. A pointer on a circular clock or a digital display serves as an indicator for this spring's torsion. A wide range of measurement ranges may be crossed by employing various speeds and mobiles, giving the instrument a lot of flexibility. The degree of internal spring compression, which represents the viscous resistance or flow resistance, is related to the speed of the needle's rotation for a certain viscosity. It is connected to the mobile's size and form (its geometry). When the mobile's size or rotational speed rises, the resistance also does so. As a result, an increase in viscosity will be signalled by an increase in the internal spring's compression for a given mobile shape and rotational speed. The smallest mobile is used at the fastest speed for all viscometer types to determine the minimum range. Using the smallest mobile at the slowest pace results in the greatest range [4]–[6].

The rheological characteristics of the tested product are identified and assessed using measurements made with the same mobile device at various speeds. Chapters 4 and 5 discuss these characteristics and methods. Various mechanical subassemblies make up the viscometer. On the top of the unit, within the casing to which the metal identification plate is fastened, are the drive motor and multi-speed gearbox. A calibrated beryllium-copper spring is built into the case, with one end attached to the pivot axis and the other directly to the dial. The engine propels the dial, which in turn propels the pivot axis via the spring.

An example of a Brookfield rotational viscometer's schematic analogous viscosimetry principle is the fundamentals of a viscosimeter Brookfield Analog viscometer by Brookfield Brookfield viscometer, digital. The pivot cup is located underneath the main housing, and the lower end of the pivot pin protrudes through it. The dial or transducer revolves around the diamond tip within the pivot cup. The pivot point rests on this support and supports the pivot axis. The moveable link that the viscometer wheels are linked to is located at the bottom of the pivot axis. Stepping motors have taken the role of synchronous motors in digital gadgets. The torsion of the spring is transformed by a torque transducer into electrical tension, which the electronic card may subsequently turn into viscosity.

Techniques for measuring viscosity

The Brookfield viscometer is more effective when used with precise measuring methods, much like with another precision instrument. The user handbook that comes with each gadget outlines a step-by-step process. Here, we provide suggestions and guidance that have been gathered over 85 years by our clientele. They provide you with a strong starting point for researching more sophisticated procedures as well as the basis for a reliable viscosity measuring method. This also implies that another attribute, yield stress, which is the tension required to have a solid movement of materials like a liquid, would be interesting to look into. Even more resistance to the settling of suspended particles in a coating during storage would be offered by this solid-like behaviour. Over the years, a variety of mathematical models have been created to more accurately match data found in diverse materials. Based on the flow curve, the yield stress is estimated using the following equation the predicted yield stress in this instance is 17.2 dyn/cm2, which is presumably excellent for a paint that should be quite easy for a homeowner to brush onto a wall. Readers presumably observed that the data were collected at 20 °C whereas the data in other figures were collected at 25 °C. This was done on purpose so that we could educate our audience to always attempt to maintain their temperatures similar when comparing different coatings. This is because even a little temperature increase of 5 °C may drastically affect the viscosity of a particular substance at a certain shear rate.

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CHAPTER - 11

THE STIRRUP AND THE MOBILE

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Before using, carefully examine each cellphone. A wrong viscosity reading might be the result of anything that seems rusted or damaged enough to have altered its proportions. Since all mobile phones have a shiny polished appearance when they are new, every knock mark or other visible damage may indicate that it is time to replace the phone. The identical mobiles are provided in 316 series fibre glass reinforced or in a Teflon-coated variant if you have specific issues with vintage 300 series chrome-plated mobiles. There are further resources available. Remember that the mobile has the rightmost thread and that it has to be tightly fastened to the axis when you connect it to the viscometer. To avoid harming the gemstone point or the pivot support, slightly increase the coupling pin while mounting the mobile. Once the mobile has been secured, take care not to bang it against the measuring container's walls as this might cause the axis to get out of line [1]–[3].

We suggest positioning and submerging the mobile before mounting it on the viscometer. When confirming the measurement with mobiles 1 and 2, the calliper that comes with certain versions shields the mobile and affects the measurement. For measurements, the calliper must constantly be in place. On the measurement report, it should be noted whether it becomes essential or advantageous to use the viscometer alone. Callipers are only included with the LV and RV versions, please note. A calliper is not necessary for the cone/plane models, HA, and HB models. When adding accessories to the viscometer, the calliper is also not utilised.

Choosing a mobile device and speed

After confirming that you are using the appropriate type of viscometer, use the rover and speed recommended for taking a viscosity measurement following a given technique or standard. Trial and error is the best approach for selecting speed and rover when you need to take a certain measurement. Its objective is to show a figure between 10% and 100%. Keep in mind that when the figure gets closer to 100, the accuracy improves (see section 3.3.7). Choose a smaller rover and/or a slower pace if the number is more than 100. If the reading was much less than 10, choose a greater speed or rover, the other hand. The conversions chart (ruler of the rover/speed/model multipliers) included with each analogue model, or the AUTORANGE feature on digital models may be used to find the right rover/speed combination more quickly if an approximation of the fluid's viscosity is known. Selecting a mobility and speed combination whose min and max range boundaries the calculation is the objective [1], [3], [4].

In light of this, a different mobile and speed combination has to be used to conduct the measurement if the viscosity of a product to be studied is predicted to be 4000 cP. With some practice, choosing an appropriate rover/speed combination may just need a fast check at the conversion slider. It is recommended to utilise the same rover and speed combination while taking numerous measurements. If measurements need to be conducted at several speeds, choose a moving body that will provide results in the minimum and maximum ranges for each speed. This may result in measures of less than 10%, which can be ok provided one is aware of how inaccurate such measurements are. 3.3.4 Ship dimensions using a vessel with a diameter of 83 mm or more when doing tests with common Brookfield viscometers. Typically, a Griffin 600 ml low-size beaker is used as a container. The simplest approach when utilising smaller vessels is to note the vessel size on the measurement report and disregard any potential impacts on the calibration. There won't be a correlation issue if the same kind of container is utilised for all future tests. To account for the decision to use smaller containers, the viscometer may also be recalibrated. Another option is to think about using the SSA low-volume sample attachment.

There shouldn't be any air bubbles in the sample. By softly tapping the container on the table or by using an appropriate agitation or pumping mechanism, air may be expelled. The temperature of the sample must be stable and consistent. By measuring the temperature at several locations within the container, this may be verified. Before taking your measurement, confirm that the product, the mobile device, and the calliper are all at the same stable temperature. By swirling the substance before measurement, it is often possible to acquire temperature homogenization. But watch out that the product's viscosity isn't impacted by the earlier agitation. The conversion factors that are used to determine viscosity from measurements on a viscometer are not temperature-dependent. To keep the temperature where you want it, use a thermostatic bath. Use of the Thermosel attachment may be necessary for high-temperature readings (up to 300 ° C).

Immersion in mobile

The mobile must be dipped into the water up to the mark on the shaft's midsection. Inaccurate readings might result if this immersion depth is not followed. When the mobile device is submerged, the product sometimes changes its rheological structure. We advise placing the mobile at a location on the surface that will not be utilised for the measurement to prevent this behaviour. The mobile will then be positioned in the container's middle horizontally. Before connecting the mobile to the viscometer, this must be completed.

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CHAPTER - 12

CHECK THE VISCOSITY

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Check to make sure the viscometer is level and firmly fastened to the tripod before handling it. Attach the moveable to the viscometer after choosing a speed and mobile combination. Turn on the mobile's rotation and let it run until a steady measurement appears on the display. Be careful that occasional overruns could be seen once the mobile device starts to accelerate at a faster rate. An acceptable reading may be obtained using a variety of techniques. It is sometimes essential to wait up to five minutes before an apparent equilibrium is reached. Usually, it suffices to wait a few seconds for a steady reading to show up on the screen. A process that is easier to repeat involves setting a limit on how many times the mobile may rotate before the measurement is made. Depending on the speed employed, a certain sequence of revolutions may be completed at a variety of times [1]–[3].

Therefore, rather than overcounting the number of rotations, an alternate method involves allowing the mobile to turn for a certain amount of time. In rare instances, a balance cannot be achieved, and the measurement could instead keep bouncing back and forth between two values. This is often caused by the presence of an elastic constituent in the fluid. The fluid is presumably a time-dependent product and needs particular methods to be measured efficiently if the measurement rises or falls continuously. Even when equilibrium is established, the device's screen depiction of the internal spring's torsion percentage might change by 0.1 or 0.2%. Simply take the median number as an acceptable value in this situation. Larger fluctuations might be an indication of the aforementioned circumstances [4]–[6].

After obtaining a reliable % twist measurement, multiply that number by the conversion factor appropriate to the mobile and speed combination. Observation on conversion variables and measurement ranges: The viscosity value (in centipoise) may be calculated from the spring torsion % value using both factor and range. It is sufficient to multiply the reading of% read on the display by the conversion factor to get the viscosity measurement in centipoise. The measurement range is shown in place of the conversion factors for certain Brookfield accessories. It is equivalent to multiplying the conversion factor by 100. Simply divide the given measurement range by 100 to get the viscosity, then multiply the reading by this number.

Adjustment check

Users often worry about the accuracy and overall functionality of their viscometer. Here are some quick tests to confirm its mechanical functionality: The mobile may spin at the improper speed because of shifts in the wavelength of the mains power supply. As long as the frequency is consistent and the voltage variation is less than the +/- 10% figure shown on the manometers identification plate, the voltage fluctuation has no impact. The following signs of a bad power supply are also present: difficulties starting the motor, jerky spinning of the phone, substantial fluctuations of the dial marker, and inconsistent measurements on the lcd clock. The accuracy and consistency of the viscometer will be impacted by the deterioration of the pivoted tip and pivot bracket. You may evaluate the state of these components by performing the oscillation test listed below:

The viscometer must be level, have no connected moving parts, have its power switch turned off for analogue models, its power switch turned on and its motor switch turned off for digital viscometers.

1. Rotate the moveable coupling axis until there is a 5–10% torsion in the measuring pointer or digital display. When you release off, the axis will naturally revert to its starting position.
2. The pivot tip and pivot mounting are in excellent operating order if the pointer or led readout swings freely without jerking and resets to zero each time the test is run. If not, there may be a problem with the viscometer and maintenance may be necessary.
3. Though after hundreds of tens of flexes, we have never come across a spring composed of a beryllium/copper alloy that shows signs of wear or extensive usage. This makes it unnecessary to inspect the calibrated spring. Because analogue versions do not need zero adjustments, there is no need for an external adjustment knob. Some digital models now need zero adjustments to account for drifts brought on by an increase in the temperature of specific electronic components.
4. It is advised to apply calibration oil while doing a closing night check. The standard solution should be measured in the same manner as you would any other fluid. For this test, Brookfield viscosity knew concentration calibrated at +/- 1% worked best. It is not advised to utilise fluids besides the standard solutions since they may exhibit unexpected rheological behaviour.
5. The viscometer's performance may be deemed adequate if it passes each of the aforementioned tests. Refer to paragraph 3.5 if the device's accuracy or usage continues to raise questions.

Adjust the Brookfield Viscometer's settings

Using a low-size 600 ml beaker to obtain a measurement with the Brookfield viscometer is often not practicable. If the product transfer is discovered to be sloppy or if it takes a lengthy time, it could be advisable to use a different container. Users sometimes choose to use the viscometer without the yoke to save time by not having to clean it further. If reliable findings are to be obtained from any of these procedures, the instrument must be recalibrated. The steps below may be adequate if measurements were obtained under fresh circumstances but you want to construct a new reference point for the same product under old conditions:

Calculate the product's volume in both the old and new containers, as well as with or without the calliper. Verify that you're using the same mobile device and speed. Verify that the product is at the same temperature. Take note of the updated measurement. This is the updated benchmark that corresponds to your starting point. When the operator is not concerned with the centipoise value of the material, this approach might be utilised to build quality control procedures.

1. If a different container is to be used or if you no longer want to use the calliper, we advise the process below when your task needs to know the real centipoise value of the material:

2. Utilize a typical 600 ml low-size container to calculate the viscosity of a Newtonian fluid. For this, Brookfield standard oils are excellent. Carefully take this measurement; it will determine how accurate the outcome will be. Find the fluid's viscosity in centipoise by multiplying the viscometer measurement (%) by the relevant conversion factor.
3. Transfer the reference oil to the container that will be used for calibrating the viscometer. Remove the calliper if that's all you want to do and maintain the same container. Make sure the oil is always at the same temperature.

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