UOT 34:343.1 Cinayət mühakimə icraatı

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PETROLEUM-BASED OILS: COMPOSITION, TYPES, PROPERTIES, AND RESEARCH METHODS

Keywords: Petroleum, properties, viscosity, devices, methodology, Environment, composition of Petroleum-based oils.

Petroleum-based oils are primarily composed of hydrocarbons—organic compounds consisting solely of hydrogen and carbon atoms. These hydrocarbons are categorized into:

Paraffins (Alkanes) - saturated hydrocarbons with straight or branched chains, contributing to the oil's stability and low volatility.

Naphthenes (Cycloalkanes) - saturated hydrocarbons with ring structures, enhancing the oil's solvency properties.

Aromatics - unsaturated hydrocarbons with ring structures, providing high energy content but can be less stable and more reactive.

In addition to hydrocarbons, petroleum-based oils contain heteroatom compounds such as sulfur, nitrogen, and oxygen, as well as trace metals like iron, nickel, vanadium, and chromium. These constituents can influence the oil's performance, stability, and environmental impact.

Petroleum-based oils are classified based on their intended use and composition:

Lubricating Oils - designed to reduce friction between moving parts in machinery and engines.

Motor Oils - used in internal combustion engines, formulated to withstand high temperatures and pressures.

Carburetor Oils - specialized oils for carburetor systems, ensuring smooth operation and preventing corrosion

Aviation Oils - engine oils formulated for aircraft engines, meeting stringent performance and safety standards.

Fuel Oils - utilized as fuels in various applications.

Diesel Fuels - used in diesel engines, characterized by higher energy content and efficiency.

Jet Fuels - specialized fuels for jet engines, formulated to operate at high altitudes and temperatures.

Industrial Oils - employed in manufacturing processes, including cutting oils, hydraulic oils, and transformer oils.

Petroleum-based oils are integral to various industries, serving as lubricants, fuels, and raw materials for chemical products. A comprehensive understanding of their physical and chemical properties is essential for optimizing their applications and ensuring sustainability.

The physical properties of petroleum-based oils are crucial for their performance in various applications:

Viscosity - Determines the oil's resistance to flow and its ability to form a lubricating film. High viscosity oils are thicker and provide better lubrication under high-load conditions.

Density - Indicates the oil's molecular weight and composition. It affects the oil's buoyancy and behavior in aquatic environments.

Flash Point - The temperature at which the oil can vaporize to form an ignitable mixture in air. A higher flash point indicates greater fire safety.

Pour Point - The lowest temperature at which the oil remains fluid, affecting its performance in cold conditions.

Oxidation Stability - Resistance to chemical degradation when exposed to oxygen, influencing the oil's service life.

To analyze and characterize petroleum-based oils, several research methods and analytical devices are employed:

Chromatographic Techniques:

- Gas Chromatography (GC) - Separates and analyzes volatile compounds in oils, aiding in the identification of hydrocarbon types.

- High-Performance Liquid Chromatography (HPLC) - used for non-volatile compounds, such as additives and oxidation products.

Spectroscopic Methods

Infrared (IR) Spectroscopy - identifies functional groups and chemical bonds within oil molecules.

Mass Spectrometry (MS) - determines molecular weights and structures of compounds, providing detailed compositional analysis.

Elemental Analysis

Inductively Coupled Plasma (ICP) Spectroscopy - detects trace metals and heteroatoms, which can affect oil performance and stability.

Thermal Stability Testing

Thermogravimetric Analysis (TGA) - measures weight changes under controlled heating, indicating thermal stability and degradation patterns.

The petroleum-based nature of an oil can be identified through:

Hydrocarbon Profile - a predominance of alkanes, cycloalkanes, and aromatic hydrocarbons.

Elemental Composition - presence of sulfur, nitrogen, oxygen, and trace metals. Physical Properties.

Density and Viscosity - indicative of the oil's molecular structure and purity.

Flash Point - reflects the oil's volatility and safety characteristics.

Chromatographic Techniques - chromatography is a key research method for separating and analyzing complex mixtures in petroleum-based oils. This method helps in identifying the different hydrocarbons present in the oils, such as paraffins, naphthenes, and aromatics.

Gas Chromatography (GC) - GC is widely used for analyzing volatile components of petroleum-based oils. It works by vaporizing the oil sample and passing it through a chromatographic column, where the components are separated based on their molecular size and affinity for the column material. For example, the ASTM D-3328 standard is commonly used to evaluate the hydrocarbon composition in lubricants and motor oils. GC allows for precise identification of the hydrocarbons, which helps in understanding the oil's lubricating properties.

High-Performance Liquid Chromatography (HPLC) - this technique is useful for analyzing non-volatile compounds in oils, such as additives and oxidation products. HPLC provides detailed information on the molecular composition of oils, aiding in the optimization of formulations to meet specific performance criteria.

Spectroscopic Methods - spectroscopic techniques are employed to analyze the molecular structure and functional groups present in petroleum-based oils. These methods help identify impurities, oxidation by-products, and other chemical characteristics that influence the oil's performance.

Infrared (IR) Spectroscopy - IR spectroscopy is used to detect functional groups such as carbonyl, hydroxyl, and alkyl groups in oils. By measuring the absorption of infrared light at specific wavelengths, IR provides insights into the chemical structure and purity of the oil. The ASTM D-3414 standard is often referenced when using IR spectroscopy for analyzing lubricants.

Mass Spectrometry (MS) - Mass spectrometry, especially when coupled with GC (GCMS), is a highly sensitive technique used to identify and quantify the molecular weight and structure of compounds in oils. This method is essential for understanding the composition of oils, particularly when investigating complex additives or contaminants.

Viscosity and Rheological Testing - viscosity is one of the most important physical properties of petroleum-based oils, as it directly influences the oil's ability to lubricate and protect engine components.

Viscometry - viscosity is typically measured using viscometers, which can operate under varying temperature and shear conditions. The

ASTM D445 standard outlines the procedure for determining kinematic viscosity, which is crucial for evaluating motor oils and other lubricants.

Rheological Testing - rheology examines the flow behavior of oils under stress and strain, providing insights into their performance in real-world applications, such as high-pressure engine systems.

Elemental Analysis - elemental analysis helps determine the concentration of specific elements, such as sulfur, nitrogen, and metals, in petroleum-based oils. These elements can significantly impact oil performance, especially in terms of oxidation stability and corrosion resistance.

Sulfur Content Analysis - the sulfur content in oils is crucial because sulfur compounds can lead to the formation of acidic by-products, which degrade the oil's performance and damage engine components. Low-sulfur oils are preferred in aviation and automotive applications to reduce emissions and prevent engine corrosion.

Metal Content Analysis - the presence of metals, such as copper or iron, can indicate contamination or degradation of the oil. Inductively Coupled Plasma (ICP) spectroscopy is commonly used for metal analysis in oils.

Thermal stability is an essential characteristic of petroleum-based oils, especially for high-performance engines and industrial applications.

Flash Point Testing - the flash point of an oil is the lowest temperature at which it produces enough vapor to ignite in the presence of an open flame. This property is important for ensuring the safety and performance of oils, especially in hightemperature environments. ASTM D92 and ASTM D93 standards are used to determine the flash point of lubricants and oils.

Thermal Oxidation Stability Testing - this method assesses the oil's ability to resist degradation at high temperatures, simulating the conditions under which oils are used in engines and industrial machinery. Oils with higher oxidation stability tend to have longer service lives and reduced sludge formation.

Chromatography and Spectroscopy Instruments

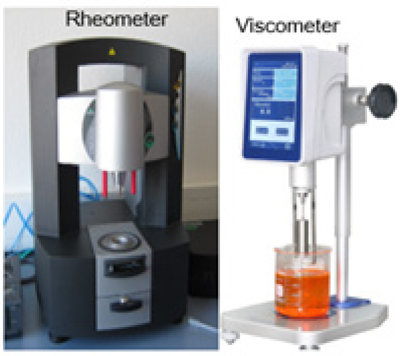
- Gas Chromatograph (GC): A GC device equipped with a flame ionization detector (FID) or mass spectrometer (MS) is used for hydrocarbon analysis. It provides detailed information about the oil's composition, including the identification of individual hydrocarbons.

HPLC Systems (HPLC) devices are equipped with UV/Vis detectors, refractive index detectors, or fluorescence detectors to analyze the non-volatile compounds in oils.

Fourier Transform Infrared (FTIR) Spectrometer are used to perform IR spectroscopy and can quickly identify functional groups in oils. This device is valuable for quality control and ensuring that the oils meet specified performance standards.

Inductively Coupled Plasma (ICP) Spectrometer is used for elemental analysis, particularly for detecting trace metals in oils. ICP spectrometers are highly sensitive and can detect metal contamination at very low concentrations.

Rheometer - measures the flow properties of petroleum-based oils under controlled stress and temperature conditions. It is used to evaluate the lubricating characteristics and ensure that the oils meet the required specifications for various applications



Rotational Viscometer - this device measures the viscosity of oils under different shear rates and temperatures. It is particularly useful for assessing the performance of oils in machinery where variable operating conditions are common.

Flash Point Apparatus - devices such as the Cleveland Open Cup (COC) tester and Pensky-Martens Closed Cup (PMCC) tester are commonly used to determine the flash point of petroleum-based oils. These devices are critical for ensuring that the oils are safe for use in high-temperature environments.

Thermogravimetric Analyzer (TGA) - this instrument is used to measure the weight loss of oils as they are heated, which helps assess their thermal stability and degradation rates.

Accurate characterization of petroleum-based oils is essential for understanding their properties, optimizing their applications, and ensuring environmental safety. Various analytical methods are employed to determine the composition of these oils, each providing unique insights into their chemical makeup.

Several advanced analytical methods are utilized to determine the composition of petroleum-based oils:

Gas Chromatography-Mass Spectrometry (GC-MS) - this technique separates and identifies volatile and semi-volatile compounds within oil samples. It is particularly effective for detecting hydrocarbons, including alkanes, cycloalkanes, and aromatic compounds. GC-MS is widely used for environmental analysis of fuel oils, as it can detect major hydrocarbon components in air and water samples.

Fourier Transform Infrared Spectroscopy (FTIR) - FTIR analyzes the absorption of infrared light by oil molecules, providing information about functional groups and molecular structures. It is useful for identifying polar compounds and assessing the degree of unsaturation in hydrocarbons. FTIR spectra can be used to predict properties such as the Research Octane Number (RON) of fuels, aiding in fuel quality assessment.

High-Performance Liquid Chromatography (HPLC) - HPLC is employed to separate and quantify non-volatile compounds, including additives and degradation products. It is particularly useful for analyzing polar compounds that are not amenable to GC analysis.

Inductively Coupled Plasma Mass Spectrometry (ICP-MS) - ICP-MS detects trace metals and heteroatoms (such as sulfur, nitrogen, and oxygen) in oil samples. The presence of these elements can influence the oil's performance and environmental impact.

Saturate, Aromatic, Resin, and Asphaltene (SARA) Analysis - this method divides crude oil components based on their polarity and solubility. The SARA analysis provides insights into the distribution of hydrocarbons and is essential for understanding the oil's behavior during refining and its suitability for various applications.

Assessing whether two oils are identical involves a comprehensive analysis of their physical and chemical properties. Even oils that meet the same specifications may exhibit subtle differences due to variations in their composition and performance characteristics.

To determine if two oils are identical, several analytical methods can be employed:

Gas Chromatography-Mass Spectrometry (GC-MS) - this technique separates and identifies individual compounds within the oils, providing a detailed profile of their chemical composition. It is particularly effective for detecting hydrocarbons and additives.

Fourier Transform Infrared Spectroscopy (FTIR) - analyzes the absorption of infrared light by oil molecules, revealing information about functional groups and molecular structures. This method is useful for identifying polar compounds and assessing the degree of unsaturation in hydrocarbons.

Viscosity Measurement - comparing the kinematic viscosity of both oils at specific temperatures can indicate differences in flow characteristics. Significant variations may suggest differences in molecular structure or the presence of additives.

Density Determination - measuring the density of each oil can provide insights into their molecular composition. Differences in density may indicate variations in the types and proportions of hydrocarbons present.

Pour Point and Cloud Point Analysis - determining the pour point (the lowest temperature at which the oil remains fluid) and cloud point (the temperature at which wax crystals begin to form) can reveal differences in the oil's low-temperature performance.

Utilizing statistical methods and specialized databases can enhance the comparison process:

Principal Component Analysis (PCA) - can reduce the dimensionality of complex datasets, highlighting the most significant variables that contribute to the variance in oil composition. This aids in identifying patterns and correlations within the data.

Petroleomics Databases - provide comprehensive information on the molecular composition of crude oils, including data on heteroatom classes and compound types. These resources are invaluable for researchers and industry professionals seeking to understand the chemical diversity of petroleum-based oils.

Understanding the composition of oils is crucial for assessing their environmental impact and ensuring compliance with regulatory standards:

Gas Chromatography Mass Spectrometr

FT-IR Spectrometr

Environmental Toxicity - the presence of certain hydrocarbons and heteroatoms can influence the toxicity of oil spills. Analytical methods that determine the concentration of these components are essential for environmental risk assessments.

Regulatory Compliance - accurate compositional analysis is necessary for compliance with environmental regulations governing oil spills and emissions. Methods such as GC-MS and FTIR are commonly used to monitor and report the composition of petroleum products in various matrices.

In this article, we have explored the intricate physical and chemical properties of petroleum-based oils, emphasizing their significance in various applications and environmental considerations. Understanding these properties is crucial for optimizing oil usage, ensuring environmental safety, and complying with regulatory standards.

The analysis of petroleum-based oils involves advanced techniques such as Gas Chromatography-Mass Spectrometry (GC-MS), Fourier Transform Infrared Spectroscopy (FTIR), and High-Performance Liquid Chromatography (HPLC). These methods provide detailed insights into the chemical composition of oils, enabling the identification of hydrocarbons, additives, and trace elements. For instance, GC-MS is particularly effective for detecting hydrocarbons, including alkanes, cycloalkanes, and aromatic compounds, which are essential for environmental analysis of fuel oils.

Statistical analyses, such as Principal Component Analysis (PCA), are employed to interpret complex datasets, highlighting significant variables that contribute to the variance in oil composition. This approach aids in identifying patterns and correlations within the data, enhancing the understanding of oil properties. Furthermore, specialized databases like the Petroleomics Database offer comprehensive information on the molecular composition of crude oils, including data on heteroatom classes and compound types. These resources are invaluable for researchers and industry professionals seeking to understand the chemical diversity of petroleum-based oils.

In conclusion, the determination of the composition of petroleum-based oils is a multifaceted process that requires a combination of sophisticated analytical techniques, statistical analyses, and specialized databases. This comprehensive approach is essential for understanding the properties of these oils, optimizing their applications, and mitigating their environmental impact.

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NEFT ƏSASLI YAĞLAR: TƏRKİBİ, NÖVLƏRİ, XASSƏLƏRİ VƏ TƏDQİQAT ÜSULLARI

XÜLASƏ

Neft əsaslı yağlar sürtünməni azaltmaq, avadanlıqları qorumaq və istiliyi yaymaq qabiliyyətinə görə sənaye və texnoloji tətbiqlərdə mühüm komponentlərdir. Bu məqalədə neft əsaslı yağların, o cümlədən sürtkü, motor, aviasiya və karbüratör yağlarının tərkibi, növləri və xassələri araşdırılır. O, oksidləşmə sabitliyi və karbohidrogen tərkibi kimi kimyəvi xüsusiyyətlərlə yanaşı, özlülük, alovlanma və tökülmə nöqtələri kimi əsas fiziki xüsusiyyətləri vurğulayır. Bu yağların qiymətləndirilməsi üçün qabaqcıl tədqiqat metodları, o cümlədən FTIR spektroskopiyası, qaz xromatoqrafiyası və istilik analizi müzakirə olunur. Bundan əlavə, neft əsaslı maddələrin müəyyən edilməsi və neft nümunələri arasında oxşarlığın müəyyən edilməsi üçün meyarlar verilmişdir. Bu hərtərəfli icmal neft əsaslı yağların və müxtəlif sənaye sahələrində onların performansını və etibarlılığını təmin etmək üçün istifadə edilən analitik üsulların əhəmiyyətini vurğulayır.

PETROL BAZLI YAĞLAR: BILEŞIMI, ÇEŞITLERI, ÖZELLIKLERI VE ARAŞTIRMA YÖNTEMLERI

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ÖZET

Petrol bazlı yağlar sürtünmeyi azaltma, ekipmanı koruma ve ısıyı dağıtma özellikleri nedeniyle endüstriyel ve teknolojik uygulamalarda kritik bileşenlerdir. Bu makale, yağlama, motor, havacılık ve karbüratör yağları dahil olmak üzere petrol bazlı yağların bileşimini, türlerini ve özelliklerini araştırmaktadır. Oksidasyon stabilitesi ve hidrokarbon bileşimi gibi kimyasal özelliklerin yanı sıra viskozite, parlama noktası ve akma noktası gibi temel fiziksel özellikleri vurgular. Bu yağların değerlendirilmesi için FTIR spektroskopisi, gaz kromatografisi ve termal analiz gibi ileri araştırma yöntemleri tartışılmaktadır. Ek olarak, petrol bazlı kökenlerin belirlenmesi ve petrol örnekleri arasındaki benzerliğin belirlenmesine yönelik kriterler de özetlenmektedir. Bu kapsamlı genel bakış, petrol bazlı yağların öneminin ve çeşitli endüstrilerde performanslarını ve güvenilirliklerini sağlamak için kullanılan analitik tekniklerin altını çizmektedir.