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RESEARCH OF THE ADSORPTION MECHANISMS FOR PURIFYING USED MOTOR OILS

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Abstract

This article analyses the changes in the physicochemical properties of used oils that occur following an adsorption purification process using bentonite. According to the research results, the bleaching clay and bentonite adsorbent effectively absorbs mechanical impurities, oxidation products, and harmful additives from the oil composition. After the purification process, the oil's color lightens, its acidity decreases, and its potential for reuse increases. The results indicate that purifying oils with bleaching clay and bentonite is an environmentally and economically effective method.

Keywords: *adsorption, used engine oil, regeneration, adsorbent, recycling, bentonite*

Introduction

Engine oils, which are widely used in the automotive and industrial sectors today, are an important material that ensures the continuous operation of machinery and mechanisms. However, during use, the physicochemical properties of the oils deteriorate, and they accumulate oxidation products, resins, metal particles, fuel residues and water. This makes it impossible for the oils to be used further and leads to their collection as waste. According to statistics, millions of tons of used engine oils are disposed of worldwide each year, and they are classified as hazardous waste that pollutes the environment.

Therefore, the recycling and regeneration of used oil is a pressing scientific and technical issue. Among the regeneration methods, adsorption stands out for its simplicity and efficiency.

In the last decade, solvent extraction-adsorption has been studied for base oil recovery from SEO due to the benefits accruing to the treatment method. A single solvent, methyl ethyl ketone (MEK) followed by clay has been studied. The method was compared with acid/clay- percolation processes. The latter gave a low yield of base oil. Thus, considering the sludge generated from the acid treatment, solvent/clay treatment remains the most preferred method. The removal of PAHs by solid surfaces from used oil using solvent (1-butanol) extraction and adsorption (activated carbon) was studied, which exhibited a potential

adherence of PAHs on its surface than other adsorbent tested. Other studies gave similar results. Comparison of a composite solvent, single solvent, and acid treatment methods on SEO has been studied. The best method that gave good quality base oil was composite solvent- extraction (Filho et al., 2010).

The adsorption process in SEO treatment helps to remove pollutants, especially PAHs, heavy metals, and color in SEO by trapping them on the active sites of the adsorbent. Solvent extraction is capable of removing about 10–14% of impurities in SEO which is mainly the sludge, but the base oil still contains some impurities such as PAHs and heavy metals. Thus, the adsorption process plays a good role in the removal of the remaining impurities. Carbon and clay are good adsorbents for this purpose because of their high porosity and surface area. Lignocellulosic agricultural wastes have high carbon content and low inorganic compounds and are hence, good precursors for AC production. Activated carbon AC prepared from lignocellulosic precursors have been known for the separation of gaseous mixtures, removal of dyes, PAHs and heavy metals from waste oil and water effluent. Also, local clay can be used as adsorbent due to its ability to remove colour and other impurities in oils (Ani et al., 2023).

Materials and Methods

The adsorption method for purifying used motor oils is currently one of the most promising approaches to resolving environmental and economic issues. This method serves to restore the physicochemical properties of engine oils, enabling their reuse and reducing the volume of waste. In the future, the efficiency of the method can be further increased by developing new, high-performance adsorbents and optimizing the technological processes.

Low-rank coal or Brown Coal can be used as an adsorbent by using a combination solution of H_3PO_4–$NaHCO_3$ is 2.5M on chemical activation (Patmawati and Alwathan, 2019). In this study will use the same adsorbent derived from Brown Coal. with a calorific value of 4503 J/g. However, this study will focus on the purification method of pyrolysis –Adsorption, namely base fuel or raw materials which is the result of pyrolysis purified again by pyrolysis and adsorption techniques, as the main test parameter is the yield of the results obtained, then the yield of adsorption results and, or pyrolysis obtained will be measured and calculated, then it will be analyzed density, viscosity, specific gravity, color, yield, and API(API, which is an abbreviation for the American Petroleum Institute, is a standard code that determines oil quality) (Alwathan et al., 2024).

Purifying used motor oil involves removing contaminants like water, fuel, sludge, and metal shavings to restore it for reuse, usually through a combination of settling, filtration, and distillation. Key methods include sedimentation, centrifugation, chemical treatment (e.g., sodium hydroxide), and vacuum distillation to remove impurities, producing base oil or cleaner fuel (Hidaya et al., 2018).

Key Steps in Purifying Used Motor Oil:

- ***Settling & Pretreatment:*** *Allowing the oil to stand for 24–48 hours lets sludge and heavy particles settle to the bottom. Heating to ~650 °F can improve the removal of contaminants;*
- ***Filtration:*** *Passing the oil through filters (cloth, paper, or mechanical filters) removes solid contaminants and debris;*
- ***Dewatering:*** *Removing water content by heating or through specialized separation processes;*
- ***Centrifugation:*** *Using high-G force to separate impurities and water from the oil.*

Chemical/Vacuum Treatment: *Advanced methods like distillation or treatment with sulfuric acid or clay are used to remove fine impurities, improve color, and restore viscosity.*

Safety Precautions:

- *Always perform purification in well-ventilated areas.*
- *Avoid open flames when heating, as it can be a fire hazard.*
- *Dispose of the resulting sludge and waste byproducts at approved hazardous waste centers.*

Results and Discussion

Adsorption is a surface phenomenon whereby particles from a liquid or gas are

absorbed onto the surface of a solid substance (adsorbent). The adsorbents used for the purification of motor oils (activated carbon, bentonite, silica gel, zeolite, aluminosilicates) have high porosity and a large surface area. With their help, colorants; tars and oxidation products; organic acids; heavy metals; coke and dispersed particles are effectively removed.

Table 1 presents the technology for purifying used engine oils by adsorption.

Table 1. *Adsorption-based technology for the purification of used engine oils*

Stages	Process Description	Result
1. Preliminary preparation	Large solid particles, sediment, and the liquid phase (water) are separated from the oil using mechanical filters, screens, or by settling	Separation of large particles by filtration. The oil is pre-treated, removing water and mechanical additives.
2. Heating	The oil is heated to 70–100 °C	This step ensures good mixing of the adsorbent with the oil and reduces viscosity.
3. Adsorption process	The oil is mixed with the adsorbent (activated carbon, bentonite, zeolite, silica gel, etc.). Impurities are adsorbed onto the adsorbent surface	Colourants, tars, oxidation products and heavy metals are removed
4. Separation	The adsorbent is separated from the oil by filtration or decantation	The purified oil is recovered
5. Additional processing	Neutralization (with acid/alkali). Additional adsorption for color improvement – Useful additives (inhibitors, detergents/modifiers) are added	Restores the oil's quality and increases its stability.

High purification level (70–85%). Environmentally safe, with low atmospheric emissions. The technology is simple and energy-efficient.

The adsorption method is considered one of the most effective and environmentally safe methods for the regeneration of used motor oils. It is widely used in practice as it can be carried out using inexpensive raw materials and provides a high degree of purification.

Table 2. *Adsorbents used and their properties*

Type of adsorbent	Main properties	Advantages	Disadvantages
Activated carbon	High porosity, large surface area, good adsorption of organic substances	Improves color, effectively removes oxidation products	Expensive, difficult to regenerate
Bleaching clay	Natural clay mineral, with high sorption capacity	Inexpensive, environmentally safe, widely available	Low mechanical strength
Bentonite	Natural clay mineral, with high adsorption capacity	Inexpensive, environmentally safe, widely available	Low mechanical strength
Silica gel	High surface area, effectively adsorbs moisture and acids	Good at removing organic acids and water	Higher price, limited reusability

Type of adsorbent	Main properties	Advantages	Disadvantages
Zeolite	Crystalline aluminosilicate, with ion-exchange capacity	Absorbs heavy metal ions effectively, stable	Complex preparation process
Aluminosilicates	High mechanical stability, adsorbs various particles	Can be reused multiple times	Efficiency is lower than that of activated carbon

From the table, it can be concluded that the most effective adsorbent is activated carbon, since it has a high surface area, while bentonite is the cheapest and most widely available. Zeolite performs best in ion exchange, and moreover, silica gel can be used to dry water that has entered the oil.

The purification process was carried out using the adsorption method. The local bleaching clay was dried, sieved and used as the adsorbent. The used oil was first filtered and then treated with the adsorbent.

Experiments have shown that adsorption purification using local bleaching clay significantly lightened the color of the used oil, allowing it to be cleaned of mechanical impurities, as well as partially of resins and oxidation products. After purification, positive changes were observed in the oil's viscosity, acidity number, and other key physicochemical parameters.

Among adsorbents, bentonite occupies a special position due to its high surface area, swelling properties, and strong adsorption capacity. Bentonite is one of the natural clays, whose main component is the mineral montmorillonite. When it comes into contact with water and oil, it swells and absorbs a large number of particles onto its surface. For this reason, bentonite enables the effective purification of used oils from mechanical particles, resin and oxidation products.

Also, bentonite is a widespread, cheap and environmentally friendly material, so its potential for industrial use is very high.

For more effective oil purification, bentonite was used as an adsorbent. In this case, the used oil was pre-filtered and cleaned of mechanical impurities. Bentonite was dried, crushed, sieved and used as an adsorbent. The adsorption process was carried out for a certain time, and then the purified oil was separated by filtration.

Conclusion

Adsorption treatment using local bleaching clay is an effective method for improving the quality of used oils. The cost-effectiveness, simplicity and environmental safety of this method allow it to be applied in practice.

Adsorption treatment using bentonite is an effective method for improving the quality of used oils. This method removes mechanical impurities, oxidation products and harmful additives from the oil, increasing its reusability. The cost-effectiveness and high adsorption capacity of bentonite make it suitable for widespread use in practice.

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