Ползуновский вестник. 2026. № 2. С. 235–238.
Polzunovskiy vestnik. 2026;2: 235–238.

Научная статья
2.6.13 – Процессы и аппараты химических технологий (технические науки)
УДК 628.16.081.32
doi: 10.25712/ASTU.2072-8921.2026.02.033 EDN: VULSJO

ВЛИЯНИЕ АКТИВИРОВАННОГО УГЛЯ НА МИНЕРАЛЬНЫЙ СОСТАВ ОБРАБОТАННОГО ВОДНОГО РАСТВОРА

Биляль Саад Таха [1], Андрей Сергеевич Алексеев [2], Джубари Мохаммед Кадер [3], Надежда Вячеславовна Алексеева [4]

[1, 4] Тамбовский государственный технический университет, Тамбов, Россия
[2] Тамбовский государственный университет им. Державина, Тамбов, Россия
[3] Кафедра технологий топливно-энергетического машиностроения, инженерия нефтегазовых технологий – Киркук, Северный технический университет, Мосул, Ирак
[1, 2, 3, 4] bilalsaad_t@yahoo.com

Аннотация. *Активированный уголь (АУ) является неполярным материалом с высокой молекулярной адсорбционной способностью. Благодаря большой площади поверхности, микропористой структуре, адсорбционной эффективности и пригодности к вторичной переработке, он подходит для использования с различными материалами для адсорбции органических загрязнителей в сточных водах с различными уровнями концентрации. В статье обсуждается уровень минерализации двух распространенных видов активированного угля: березовой древесины и скорлупы кокосового ореха. Результат показывает, что максимальная электропроводность водного раствора после контакта с активированным углем на основе березы составила 978 мкСм/см, а кокоса – 98 мкСм/см. Это указывает на то, что активированный уголь на основе березы имеет более высокое содержание минералов, чем активированный уголь на основе кокоса.*

Ключевые слова: *активированный уголь, электропроводность, время, концентрация, соль.*

Благодарности: *автор выражает признательность коллегам за помощь, благодарность за финансовую поддержку исследования.*

Для цитирования: Таха Б. С., Алексеев А. С., Джубари М. К., Алексеева Н. В. Влияние активированного угля на минеральный состав обработанного водного раствора // Ползуновский вестник. 2026. № 2, С. 235–238. doi: 10.25712/ASTU.2072-8921.2026.02.033. EDN: https://elibrary.ru/VULSJO.

Original article

INFLUENCE OF ACTIVATED CARBON ON MINERAL COMPOSITION OF TREATED AQUEOUS SOLUTION

Bilal Saad Taha [1], Andrey S. Alekseev [2], Mohammed Qader Gubari [3], Nadezda V. Alekseeva [4]

[1, 4] Tambov State Technical University, Tambov, Russian Federation
[2] Derzhavin Tambov State University, Tambov, Russian Federation
[3] Fuel and Energy Engineering Technologies Department, Oil and Gas Technologies Engineering – Kirkuk, Northern Technical University, Mosul, Iraq
[1, 2, 3, 4] bilalsaad_t@yahoo.com

Abstract. *Activated carbon (AC) is a nonpolar material with a high molecular adsorption capacity. Due to its large specific surface area, microporous structure, adsorption efficiency, and reusability, it is suitable for application with various materials for the adsorption of organic contaminants from wastewater with different concentration levels. This study discusses the mineralization level of two common types of activated carbon derived from birch wood and coconut shell. The results demonstrated that the maximum electrical conductivity of the aqueous solution after contact with birch-based activated carbon reached 978 μS/cm, whereas for coconut-based activated carbon it was 98 μS/cm. These findings indicate that birch-based activated carbon contains a higher mineral content compared to coconut-based activated carbon.*

Keywords: *Activated carbon, Electrical conductivity, Time, Concentration, Salt.*

Acknowledgements*: the author expresses gratitude to colleagues for their help, thanks for the financial support of the research.*

For citation: Taha, B. S., Alekseev, A. S., Gubari, M. Q. & Alekseeva, N. V. (2026). Influence of activated carbon on mineral composition of treated aqueous solution. *Polzunovskiy vestnik*, (2), 235-238. (In Russ). doi: 10/25712/ASTU.2072-8921.2026.02.033. EDN: https: //elibrary.ru/VULSJO.

INTRODUCTION

Activated carbon (AC) consists of three distinct components: single-layer carbon with a crystalline lattice, graphite microcrystals, and amorphous carbon, with graphite microcrystals constituting the major fraction of activated carbon [1]. One of the most effective strategies for wood waste management involves the production of activated carbon with a uniform pore size distribution and a large specific surface area through the addition of chemical agents to carbonaceous char, which can be efficiently used for the removal of chemical contaminants from wastewater [2].

Methods of chemical activation of carbonaceous raw materials are highly effective for the production of microporous carbon materials. These methods are based on the introduction of chemical additives into the precursor material, followed by carbonization in an inert atmosphere or in the presence of a gaseous oxidizing agent. Chemical promoters such as $ZnCl_2$, Al_2O_3, H_3PO_4, carbonates, and alkali metals are commonly employed as activating agents [3]. Activated carbon can be produced from biomass through thermal treatment either by direct activation or direct carbonization, or by preliminary carbonization of biomass followed by activation of the resulting biochar into activated carbon [4]. Chemical activation reduces the energy consumption required for raw material activation while simultaneously increasing the specific surface area of the final product [5].

Birch-based activated carbon is widely used for drinking water purification as well as in water treatment processes involving natural water sources [6]. On the other hand, coconut shell is one of the most commonly used raw materials worldwide for the production of activated carbon [7]. The production of activated carbon is aimed at obtaining materials with desired pore volume, specific surface area, and pore size distribution characteristics [4]. Activated sorbents derived from birch wood and coconut shell possess highly porous surfaces. The pore size ranges from 2 to 30 nm for birch wood–based activated carbon and from 2 to 10 nm for coconut shell–based activated carbon [8]. Coconut shell is considered an important precursor for activated carbon production because the resulting material exhibits a high micropore content, low ash content, and high reactivity [9]. For example, it is effectively applied in the catalytic oxidation of hydrogen sulfide to elemental sulfur or in water dechlorination through the redox reaction: $Cl_2 + C \rightarrow C–O + Cl^-$.

On the other hand, chemical activation leads to an increase in the content of chemical components in activated carbon, which may subsequently leach into aqueous solutions upon contact with the adsorbent. Du-ring the application of activated carbon in water treatment processes, organic water-soluble compounds are removed from the solution; simultaneously, organic components are adsorbed onto the sorbent, while water-soluble inorganic components may migrate from the activated carbon into the solution. The aim of this study is to evaluate the mineralization level of solutions in contact with activated carbon, assessed through changes in electrical conductivity. This parameter may depend on the characteristics of the activated carbon (mass fraction, particle size and shape, and pore geometry) as well as on the properties of the electrolyte (type of dissolved component, concentration, temperature, and acidity).

The mechanisms of electric current transfer in these systems differ significantly: electronic conduction occurs within the activated carbon, whereas ionic conduction takes place in the electrolyte [11]. Therefore, activated carbon represents a solid material lacking ionic conductivity and can be considered a dielectric within the heterogeneous system under investigation. An exception arises at high activated carbon concentrations, where particle agglomerates may form conductive pathways between the electrodes. However, in systems with low activated carbon concentrations (less than 15 wt.%), such agglomeration is unlikely, and electrical conduction occurs predominantly through ionic transport. Under these conditions, the ion transport pathway becomes longer, resulting in a decrease in the electrical conductivity of the suspension [12].

MATERIALS AND CHEMICALS

Activated Carbon Used

Two types of industrial activated carbon were employed in this study:

1. Activated carbon from birch BAC-A.
2. Activated carbon from coconut shells CAC.

The industrial crushed activated carbon served as the primary source material for this study, with its characteristics presented in Table 1 (parameters as specified by the manufacturer). Samples with a particle size of 1–1.5 mm were selected for each carbon type for experimental purposes. The bulk density of each material was determined gravimetrically.

Distilled water with an electrical conductivity of 4 μS/cm at a room temperature of 21 °C was used in the experimental investigations and for washing the activated carbon granules.

The mineralization level was determined by conductometric analysis based on changes in the electrical conductivity of the contacting water. Electrical conductivity measurements of the aqueous solution were performed using an HM Digital COM-100 conductivity meter. Each measurement was repeated multiple times, and the mean value of the measured parameter was calculated.

The pH of water in contact with the activated carbon was measured using an HM Digital PH-200 pH meter.

Powdered activated carbon (both birch wood-based and coconut shell-based) was produced by grinding prewashed crushed activated carbon in a laboratory mill. The resulting powder was subsequently dispersed in either an aqueous sodium chloride solution or distilled water to prepare a suspension.

Table 1 – Characteristics of the activated carbon used
Таблица 1 – Характеристики используемого активированного угля

Parameter	Type of Activated Carbon	
	Birch wood BAC-A GOST 6217-74	Coconut TU 20.14.71-001-2009357701-2023
parameters declared by the manufacturer		
Type of coal	Crushed	
Particle size	1.0–3.6 mm	0.4–1.7 mm
Adsorption activity for iodine, not less	60 %	60%
Bulk density, not more	240 g/dm^3	500 g/dm^3
Ash mass fraction, not more than	6 %	3%
Measured parameters		
Particle size	1.0–1.5 mm	1.0–1.5 mm
Bulk density	210 g/dm^3	700 g/dm^3

METHOD

In the first stage of the study, the change in the mineralization level of water in contact with granular activated carbon was evaluated. For this purpose, 25 g of the carbon sample was immersed in 250 mL of distilled water and agitated for a defined period of 24 hours, after which the water was filtered and the carbon was replenished with fresh distilled water (250 mL). The degree of mineralization was assessed by measuring the electrical conductivity of the filtered water. The experiment was terminated upon reaching a constant electrical conductivity level as a function of contact time, after which the spent granular activated carbon was filtered and dried for subsequent analyses.

The second stage of the study aimed to determine the effect of powdered activated carbon concentration on the electrical conductivity of the suspension. Distilled water and aqueous sodium chloride solutions at concentrations of 2.5 and 5 g/L were used as electrolytes, to which varying amounts of powdered activated carbon (0.5, 1.0, 1.5, and 2.0 g) were added, yielding corresponding concentrations of 0.5, 1.0, 1.5, and 2.0 g/L.

During the suspension experiments, powder particles were maintained in a suspended state by continuous magnetic stirring at 300 rpm, resulting in a mean particle velocity of 0.2 m/s within the container. The particle sedimentation velocity, calculated on the basis of the mean powder particle size and system parameters according to Stokes' law for the laminar flow regime ($Ar < 36$), was determined to be 2.3 mm/s for birch wood-based powder and 0.7 mm/s for coconut shell-based powder.

RESULTS AND DISCUSSION

For systematic presentation and discussion, the results were organized into two sections as outlined below.

In all experiments, the granular activated carbon concentration was maintained at 100 g/L. During the experiment, the activated carbon was agitated using a magnetic stirrer; at defined time intervals, the carbon was filtered and the electrical conductivity of the resulting solution was measured. The obtained results are presented in Figure 1.

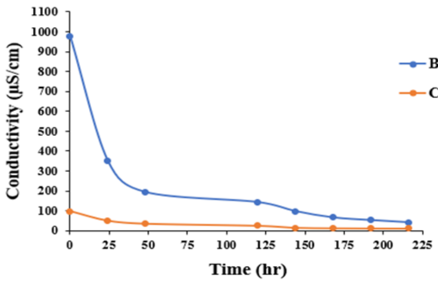

Figure 1 – Electrical conductivity of water in contact with activated carbon depending on the contact time

Рисунок 1 – Электропроводность воды при контакте с активированным углем в зависимости от времени контакта

As shown in Figure 1, the electrical conductivity of the solution in contact with birch wood-based activated carbon powder is higher than that of the coconut shell-based activated carbon solution, owing to the greater salt content in birch wood-based activated carbon compared to its coconut shell-based counterpart. Furthermore, the electrical conductivity of the solution following treatment with coconut shell-based activated carbon can be considered to exhibit negligible variation over time. Accordingly, throughout the entire experiment, the following quantities of soluble salts were leached from crushed activated carbon with a particle size of 1–1.5 mm into water, expressed as sodium chloride equivalent:

- Birch wood-based activated carbon: 0.01 g NaCl/g activated carbon.
- Coconut shell-based activated carbon: 0.001 g NaCl/g activated carbon.

The residual electrical conductivity of the aqueous solution saturated with powdered activated carbon was determined to be 41.6 µS/cm for birch wood-based carbon and 10.2 µS/cm for coconut shell-based carbon.

Effect of Dispersed Activated Carbon Powder on the Electrical Conductivity of the Suspension

The powder obtained from washed crushed activated carbon was used for dispersion purposes. The electrical conductivity of suspensions containing both types of activated carbon, free of mineral impurities, was investigated. In this experiment, quantities of (0.1, 0.5, 1, 1.5, and 2) g of activated carbon were added to (2.5 and 5) g/L NaCl solutions for a contact period of 20 minutes. The results are presented in Figure 2 below.

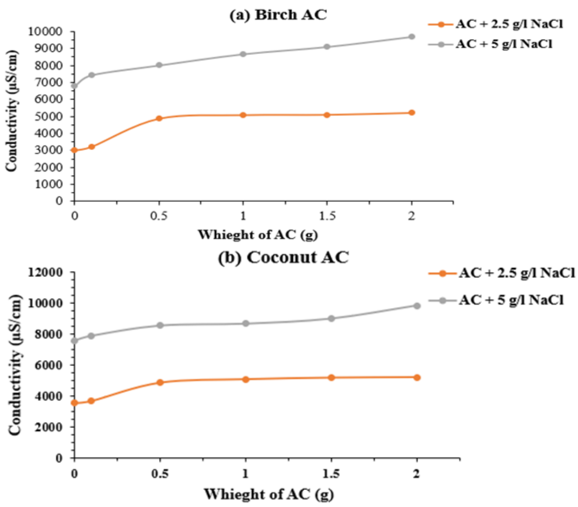

Figure 2 – Comparison of the conductivity of suspensions containing two types of salt-free activated carbon, with the addition of different masses of activated carbon to (2.5 and 5) g/l NaCl

Рисунок 2 – Сравнение электропроводности суспензий, содержащих два типа активированного угля, не содержащего соли, с добавлением активированного угля различной массы к (2,5 и 5) г/л NaCl

Figure 2 presents a comparison of the electrical conductivity of suspensions containing the two types of washed activated carbon. Varying quantities of activated carbon were added to 2.5 and 5 g/L NaCl solutions: birch wood-based activated carbon (Fig. 2(a)) and coconut shell-based activated carbon (Fig. 2(b)). It is evident that the electrical conductivity increases with increasing activated carbon concentration in the solution.

According to classical suspension conductivity theory [13], at low volume fractions of the dispersed phase that does not participate in electrical current transmission, the electrical conductivity of the suspension decreases with increasing solid-phase concentration. However, the experimental data demonstrated an increase in electrical conductivity, which can be attributed to the presence of residual water-soluble components in the activated carbon powder that are released into the solution upon dispersion, resulting in a conductivity increase that outweighs the expected decrease. In addition to mineral salts, the powder particles may contain water-soluble acids or alkaline compounds that can influence the pH of the solution. Figure 3 illustrates the dependence of suspension acidity on the quantity of dispersed powder.

Birch wood-based activated carbon induces a greater shift in suspension pH than coconut shell-based activated carbon. The pattern of pH variation is consistent across both carbon types, with the suspension acidity shifting toward higher pH values, indicating the presence of alkaline components in the activated carbon. These experimental findings are in agreement with data reported in the literature, according to which an increased alkaline content in the precursor mixture is required to enhance the specific surface area and pore volume of carbon materials produced by thermal decomposition [6]. Furthermore, coconut shell-based activated carbon is characterized by a high carbon content and low inorganic matter content [10], which is consistent with the lower electrical conductivity of its contacting solution compared to that of birch wood-based activated carbon.

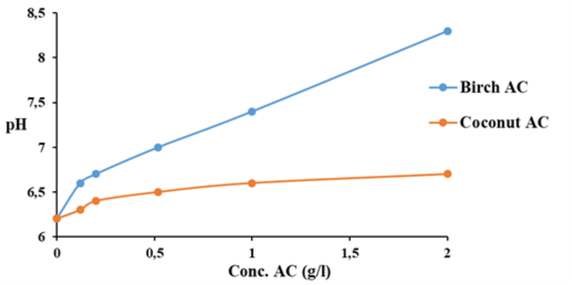

Figure 3 – Change in suspension acidity depending on the concentration of activated carbon powder of birch AC and coconut AC

Рисунок 3 – Изменение кислотности суспензии в зависимости от концентрации порошка активированного угля березового и кокосового

CONCLUSION

Birch wood-based and coconut shell-based activated carbons are among the most widely used carbonaceous adsorbents for the purification of water and aqueous solutions, owing to their large surface area and well-developed porous structure. Upon contact with aqueous solutions, these carbons preferentially adsorb organic water-soluble components. The present study demonstrated that the interaction of aqueous solutions with activated carbon can lead to an increase in the mineralization level of the solution, attributable to the mineral constituents present within the activated carbon matrix. The results indicate that birch wood-based activated carbon elevates the mineralization level of the contacting solution to a greater extent than coconut shell-based activated carbon. In both cases, the pH of the contacting solutions shifts toward higher values.

Overall, the findings demonstrate that plant-derived activated carbon can alter the mineralization level of a solution upon contact, through the transfer of mineral components from the activated carbon phase into the solution. The results obtained may be applied in the design and optimization of water treatment processes employing adsorption units with activated carbon, enabling the prediction of the mineralization level of the treated water. They may also be utilized in the modeling of processes involving low-concentration water-carbon suspensions for the estimation of the electrical conductivity of the suspensions employed.

REFERENCES

1. Jiang, C., Cui, S., Han, Q., Li, P., Zhang, Q., Song, J. & Li, M. (2019). Study on application of activated carbon in water treatment. In IOP conference series: Earth and environmental science (Vol. 237, No. 2, p. 022049). IOP Publishing.

2. Babel, K., Janasiak, D. & Jurewicz, K. (2012). Electrochemical hydrogen storage in activated carbons with different pore structures derived from certain lignocellulose materials. Carbon, 50(14), 5017-5026.

3. Chesnokova, N.V., Mikovab, N.M., Ivanov, I.P. and Kuznetsova, B.N. (2014). Synthesis of Carbon Sorbents by Chemical Modification of Fossil Coals and Plant Biomass. Journal of Siberian Federal University. Chemistry (7) 1 (2014 7). 42-53.

4. Bergna, D., Varila, T., Romar, H. & Lassi, U. (2018). Comparison of the properties of activated carbons produced in one-stage and two-stage processes. C, 4(3), 41.

5. Kushwaha, S., Sreelatha, G. & Padmaja, P. (2013). Physical and chemical modified forms of palm shell: preparation, characterization and preliminary assessment as adsorbents. Journal of Porous Materials, 20, 21-36.

6. Кузнецов, Б.Н., Чесноков, Н.В., Цыганова, С.И., Микова, Н.М., Иванов, И.П. & Иванченко, Н.М. (2016). Пористые углеродные материалы, полученные химической активацией древесины березы. Химия твердого топлива, (1), 25-25.

7. Syna, N. & Valix, M. (2003). Modelling of gold (I) cyanide adsorption based on the properties of activated bagasse. Minerals Engineering, 16(5), 421-427.

8. Kishibaev, K.K., Tokpaev, R.R., Atchabarova, A.A., Efremov, S.A., Voropaeva, N.L., Fernández-Sanjurjo, M.J. & Karpachev, V.V. (2016). Activated carbons of varied nature in recovery of gold. Russian Journal of Applied Chemistry, 89, 381-387.

9. Azari, B.L.H., Wicaksono, T., Damayanti, J.F. & Azari, D.F.H. (2021). The Study of The Electrical Conductivity and Activation Energy on Conductive Polymer Materials. Computational and Experimental Research In Materials and Renewable Energy, 4(2), 71-79.

10. Barroso Bogeat, A. (2021). Understanding and tuning the electrical conductivity of activated carbon: a state-of-the-art review. Critical Reviews in Solid State and Materials Sciences, 46(1), 1-37.

11. Volfkovich, Y.M., Mikhalin, A.A., Rychagov, A.Y. [et al.]. Activated Carbons as Nanoporous Electron-Ion-Exchangers. Russ J Electrochem 56, 869-882 (2020). https://doi.org/10.1134/S1023193520100122.

12. Электропроводность электролитов-суспензий системы NaF-AlF3-CaF2-Al2O3 Бакин К.Б., Симакова О.Н., Поляков П.В., Михалев Ю.Г., Симаков Д.А., Гусев А.О. / Journal of Siberian Federal University. Engineering & Technologies 2 (2011 4). 162-169.

13. Духин, С.С. Электропроводность и электрокинетические свойства дисперсных систем. Киев : Изд-во «Наукова думка», 1976. 248 с.

Information about the authors

B.S. Taha - PhD student of the Department of «Technological processes, apparatuses and technosphere safety» of the Tambov State Technical University.

A.S. Alekseev - student of the Department of «Chemistry» of the Derzhavin Tambov State University.

M.Q. Gubari - Ph.D. of Engineering Sciences, lecturer of the Fuel and Energy Engineering Technologies Department, Oil and Gas Technologies Engineering - Kirkuk, Northern Technical University.

N.V. Alekseeva - Candidate of Technical Sciences, Associate Professor of the Department of «Technological processes, apparatuses and technosphere safety» of the Tambov State Technical University.

Авторы заявляют об отсутствии конфликта интересов.

The authors declare that there is no conflict of interest.

Статья поступила в редакцию 17 декабря 2025; одобрена после рецензирования 24 апреля 2026; принята к публикации 18 мая 2026.

The article was received by the editorial board on 17 Dec 2025; approved after editing on 24 Apr 2026; accepted for publication on 18 May 2026.