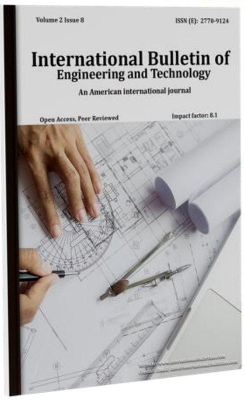

DEVELOPING HIGHLY ENERGY-EFFICIENT METHODS TO MAKE ACTIVATED CARBON FROM WOOD.

G.M.Bekturdiev
PhD (DSc), Associate Professor
Tashkent Institute of Chemical Technology
Ortiqboy Turdikulov
Master's student
Behzod Turdikulov

https://doi.org/10.5281/zenodo.17893478

Abstract. This study identifies the distinctive compositional and property-related characteristics of locally sourced walnut wood, evaluating its suitability as a raw material for producing highly energy-efficient activated adsorbents. The colloidal and physicochemical parameters of activated carbons derived from walnut wood were examined, along with their adsorption performance in the deep purification of water–alcohol mixtures. Research was conducted on the trunks of several tree species growing in Uzbekistan, assessing their potential as adsorbent precursors. Experimental results demonstrated that walnut wood—due to its high density and well-developed porosity—fulfills the necessary requirements for adsorption applications. Key properties such as porosity, moisture content, ash content, and adsorption capacity were analyzed. Based on these findings, a set of promising raw materials suitable for adsorbent production was identified.

Key words. Walnut, wood, adsorbent, carbon.

With industrial growth and the rising demand for adsorbents, exploring diverse raw material sources and developing adsorbents derived from them has become increasingly significant. Producing adsorbents from locally available materials and expanding their application—not only for treating industrial waste water of complex compositions but also in the food sector, such as refining fruit juices and purifying water–alcohol solutions from harmful impurities like fuel oils, aldehydes, methyl acetate, and ethyl acetate—offers substantial economic advantages for Uzbekistan.

Carbon adsorbents are products of heat treatment of plants and their residues at high temperatures (400-900°C) without oxygen and without air in a chamber. Sources of carbon: bark, crowns, sawdust, shavings and other organs of trees, stems and stalks of fruits, stems of legumes and cereals, as well as weeds. These sources are not used in the national economy. However, they can be processed to obtain dispersed or granular adsorbents that can be used in the food, pharmaceutical, chemical and other industries, in the safety of the population, in environmental protection and water protection. The selection of raw materials and their reserves for the production of adsorbents is an important task. The properties of adsorbents obtained from various plants, in particular from the coals of cherries and apples, were studied and recommended for the treatment of industrial wastewater.

Given the importance of the problem of obtaining activated carbon from local raw materials and continuing ongoing research, we set ourselves the task of obtaining carbon sorbents based on walnut wood, which also represents the flora of Uzbekistan. Walnut wood mainly meets the requirements for the production of adsorbents studied by the authors, which is due to its strength, moisture resistance, and density. One of the key priorities in advancing modern adsorption technologies for removing harmful substances is the development of new, cost-effective, and highly efficient adsorbents. The growing need to address wastewater discharge and reuse—particularly in light of the republic's limited freshwater resources—defines stringent requirements for the adsorbents used. Consequently, creating new types of adsorbents from locally available raw materials and implementing them in practice has become an urgent challenge in industrial wastewater treatment.

The production of activated carbon adsorbents in this study followed a specific sequence. Various raw materials were examined for their chemical composition, physicochemical properties, and structural characteristics, after which suitable precursors were selected. These materials were then carbonized at temperatures ranging from 400°C to 900°C. For each thermally activated carbon sample, ash content, moisture content (determined by drying), and acetone porosity were measured. The composition of the carbon precursor, along with the conditions of activation, largely determines the resulting adsorbent's properties.

Given the limited coal reserves in the republic, plant-based raw materials are essential sources for producing adsorbents. During oxygen-free thermal decomposition, the pores of hydrocarbon materials open, enabling them to absorb a wide range of gaseous and liquid substances, extracts, and solution mixtures. Since many industries cannot independently supply themselves with high-quality adsorbents—and not all can rely on imported activated carbon—meeting national industrial demand has become an important scientific task in modern physical and colloidal chemistry.

Drying sawdust at 130–160°C leads to a reduction in mass by 25–27%, or approximately 1.365–1.360 times, due to the loss of free moisture and certain volatile elements such as chlorine and iodine. The wood from the studied fruit trees contains 12 key elements, along with an additional 17–18 macro- and microelements including boron, rubidium, silicon, lead, molybdenum, chromium, cobalt, nickel, potassium, and copper. Among the analyzed woods, walnut exhibits the following composition: 47.0–49.5% cellulose, 12–15% pentosans, 21–23.5% lignin, and 11.8% extractives, with 0.6–1.0% ash and about 10% hot-water-soluble substances. In comparison, local maple wood contains 50.5% cellulose, 25.0% pentosans, 23.0% lignin, 0.6% ash, and roughly 1.0% hot-water-soluble components.

Walnut wood contains various inorganic salts. When these salts are taken as 100%, approximately 45% consist of calcium carbonate, while about 15% are potassium carbonate. All plant materials subjected to high-temperature treatment in the absence of air form charcoal. When these materials undergo chemical processing prior to heat treatment, the result is activated carbon. All plant materials subjected to high-temperature treatment in the absence of air are converted into charcoal. When these woods undergo chemical processing prior to heat treatment, activated carbon is produced. In this study, washed and dried sawdust was pyrolyzed. During the pyrolysis of sawdust in the presence of intense water vapor, a portion of the material combusts, while the majority—approximately 30–35%—is transformed into charcoal. Charcoal samples obtained from different tree species were washed with water, dried at 130–160°C, and demonstrated the following carbon yields: apricot – 25.41%, peach – 25.94%, cherry – 24.61%, cherry (second sample) – 24.76%, maple – 26.08%, birch – 26.40%, and walnut – 25.26%.

The influence of heat treatment on the physical properties of fruit and non-fruit hardwoods was examined by heating them in an airtight container within a furnace at 400–900°C, completely isolating the material from air and oxygen. It was observed that within this temperature range, moisture content decreased by 1.0–1.5%, adsorbent yield declined by 1–

4%, the average overall yield dropped by 3–5%, and mechanical strength was reduced by 4–6%. It was observed that for fruit-tree woods, moisture and ash content vary only slightly, whereas the yield decreases and the strength of the resulting coal adsorbent changes over a much wider range. Among all samples, the adsorbent derived from walnut wood demonstrated the highest strength as well as stable yield at 900°C. Peach-wood adsorbent followed in performance, although it began to lose mass at temperatures above 900°C. At 950°C and higher, a significant portion of the activated carbon combusted, causing a sharp decline in mechanical strength.

An additional idea was to use heat generated by a microwave oven, since such heating can also drive moisture out of wood and potentially open pores. For this purpose, adsorbent samples previously heat-treated at 400°C were selected. However, the study of thermomagnetic activation showed that this temperature is insufficient to fully open micropores; the surface mesopores also do not expand adequately and cannot release moisture from the capillary channels. Because ash content did not change significantly, it was excluded from the analysis. The capillary diameters of these mesopores are smaller than the sizes of water and solute molecules moving through the wood channels. A clear inverse relationship was identified between the yield of activated carbons and the density (relative weight) of the tree bark. The measured densities were as follows: apricot – 772 kg/m^3, peach – 760 kg/m^3, walnut – 680 kg/m^3, cherry – 600 kg/m^3, maple – 500 kg/m^3, and birch – 650 kg/m^3. With the exception of chinar and walnut, all of the studied trees contain sugary sap, which contributes to higher bark density. The corresponding trends in density and activated carbon yield can be summarized in the following order:

By density: apricot < peach < cherry < sweet cherry < birch < maple < walnut
By yield: apricot < peach < cherry < sweet cherry < birch < maple < walnut

Conclusions

As a result of studying the raw material base for adsorbent production in Uzbekistan, the initial chemical composition and physicochemical properties of walnut tree waste—including branches, sticks, and chips—were analyzed after activation. To evaluate the suitability of these wood materials as raw materials and adsorbents, key physicochemical parameters were measured, including moisture content, ash content, porosity, pore volume, benzene activity, particle size distribution, bulk density, and mechanical strength.A relationship between the density of the wood and the yield of activated carbon was established. The observed sequence is as follows:

By density: apricot < peach < cherry < birch < maple < walnut
By yield: apricot < peach < cherry < birch < maple < walnut

Used adverbs:

1.Панченков Г.М., Лебедов В.П. Химическая кинетика и катализ. М. МГУ.2001, 551с.
2.Каталитическая переработка углеводородного сырья/ А.С. Султанов, А.К. Хасанов, А.С. Сафаев и др./ вып. 2, М. 1995 с.3-14.
3.Бреслоу Р. Механизмы органических реакций. М. Мир. 2008. 280с.
4. И.И. КУЛАКОВА, Г.В. ЛИСИЧКИН.Каталитическая химия.
5.Ройтер В.А. Голодец Г.И. Введение в теории кинетики и катализа. Киев. 2001.
6.Методы исследования катализаторов и каталитических реакций. Новосибирск, «Наука» 2001. 152с.

7.Галимов Ж.Ф., Дубинина Г.Г., Масагутов Р.М. Методы анализа катализаторов нефтепереработки. М. «Химия», 1993, 191с.Бремер Г., Вендландт К.-П. Введение в гетерогенный катализ. М. «Мир», 1991