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Effect of Temperature on Sorption and Strength Properties of Regenerated Activated Carbons †

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Abstract: Activated carbon (AC) is produced by either a physical or chemical activation process. It is used in various industries such as water treatment, air purification, and in the processes of clarification, liquid deodorization, and alcohol distillation. They are also used for the recovery of volatile compounds from post-production and waste gases, as well as the recovery of active substances in the pharmaceutical industry. They are also used in technological processes during the production of a number of pharmaceutical, biochemical, and chemical preparations. In order to restore the original physicochemical parameters of granular activated carbon (GAC), we must carry out a regeneration process at high temperature (600–850 °C). During the process, high-pressure steam and carbon dioxide are injected into the regeneration kiln. The conducted research focused on the effect of the temperature of the regeneration process on the sorption and strength parameters of the WG-12 activated carbon samples tested. The entire process was carried out in a laboratory tube kiln MTTF-1200 under identical conditions for both samples. The results showed that the effect of temperature on the regeneration process is very significant. In both cases, it was observed that, as the specified temperature was exceeded, the adsorption capacity and mechanical strength of the tested activated carbon decreased. The efficiency of the process also deteriorated.

Keywords: activated carbon (AC); granular activated carbon (GAC); water treatment; GAC regeneration; iodine number; mechanical strength

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1. Introduction

Activated carbon (AC) is a porous material with a large specific surface area and increased pore volume. The structure of activated carbon is a disordered system of pores with a diameter from less than one to several hundred nanometers [1–9]. AC is characterized by a large specific surface area (1000–3000 m^2/g) and a significant pore volume (even above 1 cm^3/g) [10,11]. The tested active carbon WG-12 is used in water-treatment processes, both in large water supply stations as well as in small filter and container installations [12,13]. Granular activated carbon (GAC) WG-12, due to its large specific surface area and well-developed pore structure, is highly effective in removing impurities from water. It is also used to dechlorinate water and improve its taste and smell.

2. Material and Methods

We collected two samples of GAC (WG-12) used in the water-treatment process (sample 1 and sample 2). The samples were not fundamentally different because the grain size, raw material, production technology, and physicochemical parameters of the two activated carbons were similar. The activated carbon was dried and analyzed to determine the degree of use. The results are presented in Table 1.

Table 1. The parameters of used activated carbons.

Activated Carbon	Iodine Number [mg/g]	Mechanical Strength [%]	Bulk Density [g/L]	Ash Content [%]	Volatile Parts Content [%]
Sample 1	757	95.8	501	12.3	19.7
Sample 2	732	94.7	498	10.1	22.3

The study consisted of reactivating two activated carbon samples using the same conditions in a laboratory kiln. The test rig consisted of a stationary dryer and a laboratory kiln. The prepared and standardized samples in the amount of 0.2 dm^3 were placed in a tube made of steel wire with a mesh 0.5 mm and were reactivated at 600 °C, 650 °C, 700 °C, 750 °C, 800 °C, and 850 °C for 20 min. The experiment was repeated three times to obtain reliable results, and the average values of the three trials were used for the results.

3. Results and Discussion

Table 2 presents obtained results of reactivated carbons.

Table 2. The parameters of reactivated carbons.

AC [Sample]	Process Temperature [°C]	Iodine Number [mg/g]	Mechanical Strength [%]	Bulk Density [g/L]	Ash Content [%]	Volatile Parts Content [%]
1	600	798	95.6	488	13.2	17.2
1	650	823	95.2	485	13.6	15.7
1	700	849	94.1	480	15.4	13.2
1	750	884	93.8	445	15.9	10.5
1	800	871	93.8	429	16.8	10.3
1	850	834	92.8	422	17.2	9.8
2	600	739	94.2	486	11.8	20.1
2	650	749	94.1	469	13.2	16.3
2	700	778	93.4	452	14.4	15.7
2	750	814	93.2	444	14.9	10.9
2	800	822	92.9	426	16.2	10.1
2	850	801	91.3	424	17.9	9.9

The results showed that both the activated carbon samples can be regenerated. It was observed that, as the process went on, the sorption capacity and the mechanical strength of the AC decreased. The highest reactivation factor was obtained for temperatures of 700 and 800 degrees, and the lowest for temperatures of 600 and 650 degrees.

4. Conclusions

1. The iodine number increases with increasing temperature (but only up to a certain point).
2. Mechanical strength increases with increasing temperature (but only up to a certain point, then decreases).
3. The efficiency of the regeneration process largely depends on the degree of use of the activated carbon and the content of volatile substances.

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