COMPARISON OF ADSORPTION PROPERTIES OF COAL-BASED ACTIVATED CARBONS PREPARED BY ALKALINE ACTIVATIONS

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The aim of the work is comparing the adsorption properties of activated carbons (ACs) prepared by thermal shock (TS) alkaline activation and conventional temperature-programmed (TP) alkaline activation.

The original coal samples were brown coal (B) and long-flame coal (D). The ACs were prepared as described in [1]. Adsorbates were phenol (Ph), 4-chlorophenol (CPh), methylene blue (MB) and lead cations being typical ecotoxicants. Adsorption capacities were defined by methods [2].

The kinetics of adsorption from aqueous solutions (25 °C) is more accurately approximated by the pseudo-second order model ($R^2 \geq 0.993$) than by the pseudo-first order model ($R^2 \leq 0.991$). Adsorption equilibria are reached in 2–4 hours, depending on the adsorbate nature. The adsorption rate is limited by the interaction of adsorbate molecules with surface adsorption centers, and not by diffusion into the AC porous structure. The initial rates were measured at the same initial concentration of 5 mmol/L and were the highest for the CPh adsorption (2.188–3.859 mmol/g·min), the lowest were for the MB adsorption (0.033–0.080 mmol/g·min). The AC equilibrium capacity is the largest for the CPh adsorption (2.419–4.359 mmol/g), the smallest is 0.354–1.097 mmol/g for the Pb(II) adsorption. Thermal shock increases this rate by 1.18–3.16 times and the equilibrium capacity by 1.13–2.08 times, depending on the adsorbate and the type of coal.

Adsorption isotherms for all adsorbates are approximated by the Langmuir ($R^2 = 0.981 – 0.994$) and Freundlich ($R^2 = 0.986–0.998$) models with close errors. The capacities ($A_{AD(L)}$) of saturated monolayer and Langmuir constants are given in the Table.

Table. The parameters of the Langmuir adsorption isotherms

Sample	$A_{AD(L)}$, mmol/g				$k_{AD(L)}$, L/mmol			
	Ph	CPh	MB	Pb(II)	Ph	CPh	MB	Pb(II)
AC(B)(TS)	2.965	3.514	1.337	0.933	1.76	7.67	1.28	0.82
AC(B)(TP)	1.850	2.560	1.139	0.447	3.63	5.75	0.30	0.52
AC(D)(TS)	4.187	4.484	1.296	1.458	0.66	22.30	1.45	0.76
AC(D)(TP)	2.967	3.952	1.278	0.921	0.33	22.14	0.31	0.54

Thermal shock has the greatest impact on initial adsorption rates and is influenced by the coal rank. Compared to AC(B), the AC(D) possesses higher adsorption capacities, more developed subnanoporous structure and 2 times higher yield. Since the surface areas of both carbons are almost equal, the long-flame coal-based carbon has a greater adsorption ability. The ACs prepared by thermal shock are more effective adsorbents for purification of aquatic environments from ecotoxicants.

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2. Sabierova V.A., Tamarkina Yu.V., Redko A.V., Kucherenko V.A. Adsorption properties of nanoporous carbon materials obtained by alkaline activation with thermal shock // Technologies and engineering. 2024. №4(21). P. 111–124.