ISSN: 0975-8585

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Comparative Assessment of Carbonic Sorbents' Capability to Purify Water Solutions from Ions of Lead and Copper.

Alexandr Ivanovich Vezentsev*, Lidia Fedotovna Goldovskaya-Peristaya, Pavel Viktorovich Sokolovskiy, Vladimir Alexandrovich Peristiy and Vladimir Dmitrievich Buhanov.

Belgorod National Research University, 308015, Russian Federation, Belgorod, 85 Pobedy St.

ABSTRACT

The work deals with exploring effectiveness of carbonic sorbents in purification of water solutions from ions of Pb^{2+} and Cu^{2+}. The authors analyzed sorption-active materials used for water purification and assessed their effectiveness. They explored and found characteristic relations of the process of sorption of ions Pb^{2+} and Cu^{2+} with charcoal and activated carbon.

Keywords: water purification, sorption, charcoal, activated carbon, heavy metals ions.

Corresponding author

ISSN: 0975-8585

INTRODUCTION

One of effective physico-chemical methods of water purification from different pollutants is sorption. Charcoal's capability to absorb substances from liquid medium is known since 1785 [1]. Nowadays carbonic sorbents (like silicate ones) are widely used for water purification from different contaminants [2 – 7]. Their advantage is not only in purification effectiveness, but also in economic feasibility in comparison with some synthetical sorbents.

Among very widespread and dangerous hydrosphere contaminants we can mention heavy metals, such as lead and copper. Using leaded petrol and copper-bearing toxic chemicals for many years led to accumulation of lead and copper correspondingly in soil and natural waters. Ions of Pb^{2+} and Cu^{2+}, getting into blood of warm blooded beings, including humans, cause formation of toxic products of biochemical reactions in the cells [8]. Lead has a negative impact mainly on nervous and cardiovascular system, and also on children's mental development. Excess of copper in a human's organism leads to Wilson's disease [8].

For more than 10 years the research team of general chemistry subdepartment of Belgorod State National Research University (NRU "BelSU") has been developing effective sorbents for purification of waste, industrial, natural and drink water from above mentioned pollutants, using for this purpose both mineral sorbents based on natural and modified aluminosilicates and based on products of pyrolysis and hydrothermal activation of waste of plant products and woodworking enterprises [9, 10].

During set up of experiment in coal's sorption capability we should take into consideration relations between main parameters of the process: adsorbent's concentration in suspension, adsorbent's dose, contact duration. Complex analysis of adsorbents for the purpose of revealing their practical applicability for water purification includes assessment of process kinetics and adsorption capacity (A_p). This work demonstrates capability of carbonic sorbents of different genesis to absorb ions Pb^{2+} and Cu^{2+}.

METHOD

As adsorbents we used charcoal obtained at the general chemistry subdepartment of NRU "BelSU" from birch wood scrap and pharmaceutical active carbon (Tabulettae Carbonis activati). The essence of the method of receiving charcoal lies in the following: birch scrap is put into a quartz glass flask and heat up without access of oxygen to the temperature of 400 – 450ºC, then isothermic time exposure is performed for 2 hours. Wood mineralization volatile products are brought to condensation system and condense on cooling into resinous products and water distillate. Residual gases (H_2, CO, low-molecular hydrocarbons) are burnt. After natural cooling to roam temperature obtained charcoal is unloaded. It is like a dark-coloured porous powder mixture.
For water purification we also used the commercial activated carbon in pills produced in Russia. A synonym: Carbolen.

Sorption of ions Pb^{2+} and Cu^{2+} was performed in static conditions under a constant temperature (20ºC) from standardized test solutions of corresponding salts: pf lead nitrate (II) and of copper sulphate pentahydrate (II) with metal ions concentration 5 mg/l. Amount of the sorbent equaled to 3 g for 50 ml of the solution. Mass ratio of the sorbate (Pb^{2+} or Cu^{2+}) to the sorbent equaled to 0.000083 : 1. The sorption process had been performing for 15, 30, 45, 60, 75, 90 minutes (6 replicate tets). For preparation of filtrate (after adsorption) and photometrical estimation of concentration of lead ions and copper ions in it we used a standard procedure with usage of photocolorimeter CPC (concentration photoelectric colorimeter) -3-01 and spectrophotometer Spekord – 50. Estimation of lead is based on its ions' interaction with plumbon, and in case of copper – with diethyldithiocarbamate.

MAIN PART

Results of the research of sorption capabilities of charcoal and activated carbon according to ions Pb^{2+} are shown in figure 1 and in table 1. Kinetic relations of lead ions sorption (figure 1 a) show that charcoal in the experiment allows to decrease these ions' concentration from 5 mg/l to 0.12 mg/l. Experiments proved that sorption of ions Pb^{2+} is the most intensive within the first 20 minutes of the process. At this time concentration of ions Pb^{2+} decreases to 1.15 mg/l in case of charcoal and to 0.35 mg/l in case of activated carbon. Sorption equilibrium with usage of charcoal and activated carbon is reached after exposure for seventy

ISSN: 0975-8585

five minutes. Sorption speed (figure 1 b) is maximum within the first 15 minutes of soprtion, then the sorption process becomes slower (difference between the speeds of these two stages is substantial and equals to 3.1 mg/l*min (curve 1) and 3.9 mg/l*min (curve 2)). Weight of adsorbed ions Pb^{2+} on activated carbon is higher by 9.2% in comparison with charcoal (figure 1 c).

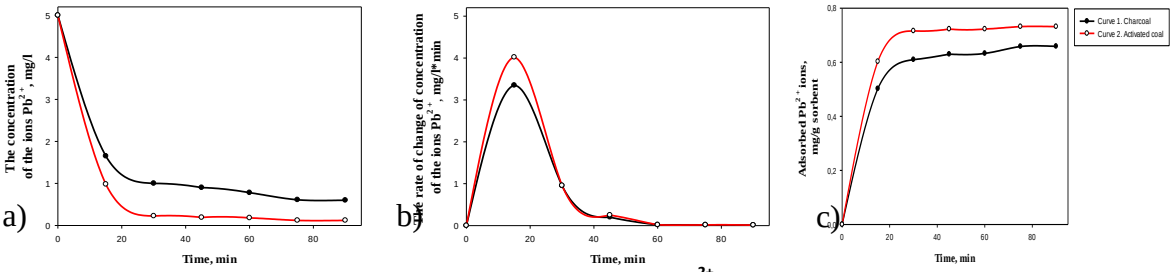

Figure 1 Characteristic relations of the process of sorption of ions Pb^{2+} with usage of charcoal and activated carbon: a) Kinetics of changes in concentration of ions Pb^{2+} in the standardized test solution; b) Speed of sorption of ions Pb^{2+} with the help of experimental sorbents; c) Dependence of weight of sorbed ions Pb^{2+} on sorbent's type and sorption duration.

Table 1 shows conditions of the process carrying out and sorption characteristics of charcoal and activated carbon in relation to ions Pb^{2+}.

Table 1: Sorption characteristics of charcoal and activated carbon in purification of water from ions Pb^{2+} ($V_{solution}$ = 50 ml, sorbent's weight 3 g, sorption duration 90 min)

Sorbent	Average speed of sorption		Sorption capacity, mg/g	Water purification effectiveness, mass. %
	mg/l*min	mmole/l*min		
Charcoal	0.0491	0.000236	0.074	88.4
Activated carbon	0.0542	0.000260	0.081	97.6

Data shown in table 1 testify that sorption of lead ions with activated carbon is quicker, its sorption capacity is higher and it allows to perform purification more effectively than charcoal. Effectiveness of purification of standardized test solution from ions Pb^{2+} with the help of charcoal in case of the specified ratio sorbate : sorbent is 88.4 mass.%, and in case of activated carbon – almost 97.6 mass.% (difference – 9.2 mass.%).
Results of sorption of ions Cu^{2+} with charcoal and activated carbon are shown in figure 2 and table 2.

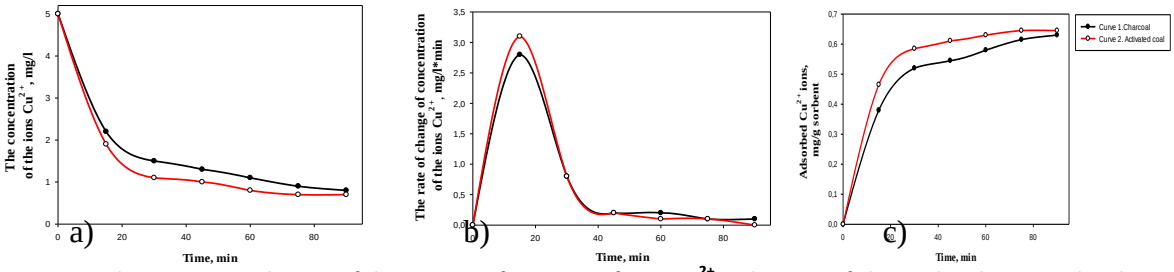

Figure 2 Characteristic relations of the process of sorption of ions Cu^{2+} with usage of charcoal and activated carbon: a) Kinetics of changes in concentration of ions Cu^{2+} in the standardized test solution; b) Speed of sorption of ions Cu^{2+} with the help of experimental sorbents; c) Dependence of weight of sorbed ions Cu^{2+} on sorbent's type and sorption duration.

Kinetic relations of sorption of copper ions (figure 2 a) show that charcoal in the experiment allows to decrease these ions concentration from 5 mg/l to 0.8 mg/l. Experiments demonstrated that sorption of ions Cu^{2+} is the most intensive within the first 20 minutes of the process. At the same time concentration of ions Cu^{2+} decreases to 1.3 mg/l in case of activated carbon and to 1.9 mg/l in case of charcoal. In the interval of 45 – 60 minutes during the exposure sorption processes intensify (the second and the following layers of the sorbent are filled), after the exposure for seventy five minutes a final equilibrium is reached. Sorption speed (figure 2 b) is maximum within the first 15 minutes, which is explained by a high speed of adsorption monolayer filling, then the sorption process becomes slower (difference between the speeds of these two stages is substantial and equals to 2.7 mg/l*min (curve 1) and 3.1 mg/l*min (curve 2)).

Weight of adsorbed ions Cu^{2+} on activated carbon is by 2% higher than in case of charcoal (figure 2 c). Table 2 shows experiment conditions and sorption characteristics of charcoal and activated carbon in relation to ions Cu^{2+}.

Table 2

Sorbent	Average speed of sorption		Sorption capacity, mg/g	Water purification effectiveness, mass. % mg/l*min
	mg/l*min	mmole/l*min		
Charcoal	0.0466	0.000729	0.070	84.0
Activated carbon	0.0477	0.000747	0.072	86.0

Sorption of both copper and lead with activated carbon is quicker, its sorption capacity is higher, and water purification is more effective than in the case of charcoal. However, this difference is not so substantial as in the case of lead.

CONCLUSION

Results showed that both charcoal and activated carbon purify water solutions from ions of copper and lead effectively. Effectiveness of purification of standardized test water solution from ions Pb^{2+} with charcoal under the specified ratio of sorbate : sorbent is 88.4 mass.%, and with activated carbon – 97.6 mass.%. Effectiveness of purification of standardized test water solution from ions Cu^{2+} with charcoal under the specified ratio of sorbate : sorbent is 84.0 mass.%, and with activated carbon – 86.0 mass.%. Considering that price of activated carbon is much (many times) higher than of charcoal, for purification of large volumes of waste, industrial and natural waters we may recommend practical usage of charcoal obtained without additional hydrothermal activation.

REFERENCES

[1] Volkov V.A., Volkov V.A., Vonsky E.V. Kuznetsova G.I., Moscow High School 1991;656 p.
[2] J.C.Moreno-Piraján and L. Giraldo, Review of Scientific Instruments 2005;76 (5): 1 – 8.
[3] S. Y. Zhang, O.Talu and D.T.Hayhurst, The Journal of Physical Chemistry, 1991;95(4):1722-1726.
[4] M.S.Sun, D.B.Shah, H.H.Xu and O.Talu. The Journal of Physical Chemistry 1998;102(1):1466-1473.
[5] J.H.Yun, D.K.Choi and S.H.Kim,. American Institute of Chemical Engineers Journal, 1998; 44(6):1344-1350.
[6] R.B.Rios, F.W.M.Silva, A.E.B.Torres, D.C.S.Azevedo and C.L. Cavalcante,. Chemical Activation, Adsorption 2009;15 (3):271-277.
[7] Gasangadzhieva A.G., Abdurakhmanov G.M., Gabibova P.I., Daniyalov P.M., Environmental protection in the oil and gas sector 2006;11: 77 - 79.
[8] Goldovskaya L.F., 2008 3rd edition. Moscow, Mir; BINOM. Laboratory of Knowledge, 295 p.
[9] Mulyutin V.V., Gelis V.M., Nekrasova N.A., Kononenko O.A., Vezentsev A.I., Volovicheva N.A., Korol'kova S.V, 2012. Radiochemistry, 54(1):. 75 – 78.
[10] A.N. Chulkov, V. I. Deineka, A. A. Tikhova, A.I.Vezentsev, L. A. Deineka,. Russian Journal of Physical Chemistry 2012; 86(3): 429 – 431.