

## Sorption of Amino Acids with Activated Carbon from Aqueous Solutions

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**Sorption of Amino Acids with Activated Carbon from Aqueous Solutions:** *The sorption of certain amino acids with synthetic carbonaceous sorbents from aqueous solutions was studied. It was found that sorption of amino acids depends on the chemistry of the sorbent surface, the pH of the equilibrium solution and the structure of the amino acid molecule.*

**Key words:** *sorption, amino acids, activated carbon, alanine, arginine, phenylalanine, tryptophan*

### INTRODUCTION

Amino acid exchange plays an important role in the human body. Any changes to it are one of the key indicators of the physical condition of the body as a whole or of its separate organs. Widely applied in recent years, sorption therapy (chemo- and enterosorption) with the use of activated carbon [5, 6] characterized by nonspecific sorption, involves the removal from the blood stream of toxic substances along with regular components, including amino acids, which leads to a redistribution in the composition of the latter.

In solving the tasks of amino acid removal from biological fluids (blood, lymph, plasma) with the use of sorption methods, the choice of sorbent is crucial. To this end, studies on the influence of sorbent nature on the sorption process in amino acid extraction from aqueous solutions are necessary.

### MATERIALS AND METHODS

The physicochemical characteristics of carbonaceous adsorbents and the ability to manage their porous structure have determined their essential role in working with biological environments [2, 3, 5]. It should be noted that existing literature data on the sorption of amino acids on carbon materials is not as numerous and rarely contains descriptions of the sorption capacity of certain industrial brands of activated carbon, the relationship between sorption extent and physical characteristics such as molecular weight, solubility, refractive index [9].

In the present study, an attempt to identify the specific adsorption interactions between the molecules of certain amino acids and the surface of carbon sorbents was made. For this purpose, the adsorption of amino acids with different structures on active carbons with both non-oxidized and oxidized surface was studied [1].

In order to explain the influence of molecule structure of amino acids on sorption extent, a study was conducted by means of simulant experiments with aqueous solutions of alanine, arginine, phenylalanine and tryptophan /Figure 1/ using activated carbon both with non-oxidized and oxidized surfaces at a pH 7,2, a temperature of 37°C, an adsorbent mass to solution volume ratio of 1:10 and a contact time of 60 min. Equilibrium concentrations were determined spectrophotometrically.

Sorption capacity was calculated using the following formula:

$$q = \frac{(C_0 - C_1) \cdot V}{P}, \quad (1)$$

q – sorption capacity, mg/g;

C<sub>0</sub> – initial solution concentration, mg/ml;

C<sub>1</sub> – current solution concentration, mg/ml;

V – solution volume, ml;

P – sorbent mass, g.

## RESULTS AND DISCUSSION

The adsorption isotherm of alanine is almost linear /Figure 1/. It is evident that the interaction of amino acid molecules with the carbon surface is very low. The sorption nature is probably determined by the presence of a carbon radical of short length at the  $\alpha$ -carbon atom, which leads to a low degree of dispersion interaction. This interaction is further weakened due to the significant energy of the hydrophilic interaction of carboxyl and amino groups in the alanine molecule with water molecules as a result of hydrogen bonding.

Increasing the length of hydrocarbon radicals leads to an increase in the energy of dispersion interaction of arginine molecules with the carbon surface. It is probably greater than the energy of interaction of hydrophilic groups with the solvent, as a result the sorption of arginine is greater than that of alanine and its isotherm has a slightly convex shape.

The change in electronic structure of the hydrophobic portion of the molecule (the presence of a phenyl radical  $C_6H_5$  in the molecule phenylalanine or a nitrogen-containing heterocycle in the molecule of tryptophan) determines the presence of a delocalized  $\pi$ -electron system. This leads to a decrease in the energy of interaction with the solvent (water) molecule and an increase in affinity to the carbon adsorbent surface.

Consequently, the adsorption isotherms of phenylalanine and tryptophan both have highly convex shapes even at low equilibrium concentrations, and the sorption capacity values using non-oxidized carbon substantially exceed the corresponding values for amino acids with aliphatic substituents and polar groups therein (alanine and arginine). Probably, in the case of adsorption of amino acids containing aromatic cycles, not only dispersion but also donor-acceptor interactions are present.

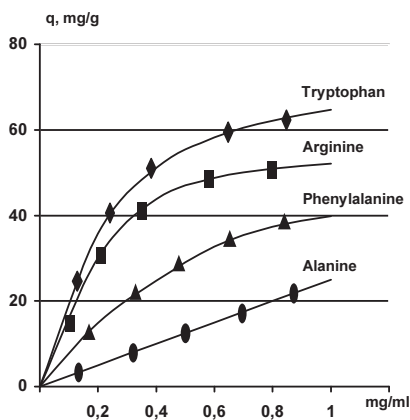


Fig. 1. Adsorption isotherms of amino acids at pH 7,2

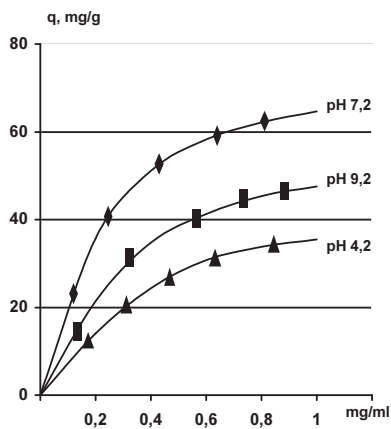


Fig. 2. Adsorption isotherms of tryptophan at pH 4,2; 7,2; 9,2

Sorption of amino acids depends not only on their molecular structure but also on the chemical nature of the adsorbent surface, as well as the pH value of the equilibrium solution. To assess the influence of these factors experimental sorptions of amino acids from aqueous solutions at a pH of respectively 4,2; 7,2; 9,2 with the participation of oxidized and non-oxidized active carbon were conducted /Figure 2/.

These pH values were selected as they are close to the range of pH values of biological fluids - with an acidic, neutral and alkaline character. It is acknowledged that amino acids in an acidic medium acquire a predominantly positive charge whereas in an alkaline one – a negative charge. This has a further impact on their sorption on active carbons, which, in electrolytic solutions have their own electrode potentials [7].

It is evident in Figure 2 that the adsorption of tryptophan is better in a neutral environment with non-oxidized active carbon. The change of pH in the acidic or alkaline area results in deterioration of the sorption.

The influence of acidity of the medium on tryptophan sorption is consistent with Andersen's rule [8], according to which activated carbon adsorbs non-ionized molecules better than their ionized forms.

Amino acids that are ampholytes are adsorbed better and faster in the isoelectric point. Evidently, the value of pH 7,2 is close to the isoelectric point of tryptophan.

It was found that sorption of tryptophan with oxidized carbon is weaker than that with non-oxidized carbon, and moreover, virtually independent of pH of the solution.

### CONCLUSIONS

The obtained adsorption isotherms of amino acids from individual solutions show that their sorption is largely determined by the chemistry of the sorbent surface and the pH of the equilibrium solution.

The data obtained indicate that the active carbons used in chemo- and enterosorption can have a corrective effect on the biochemical composition of biological fluids. An important factor is the marked adsorption by those sorbents of aromatics, sulfur-containing and basic amino acids, the accumulation of which in the human body is associated with certain diseases [4].

The redistribution of amino acid composition with the use of a specific adsorbent and pH of the medium, warrants a more differentiated approach to the indications and contraindications of sorption therapy in certain diseases.

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