DETERMINATION OF ISOSTERIC ADSORPTION HEATS OF METHYLENE BLUE, VITAMIN B-12, OVALBUMIN AND BOVINE SERUM ALBUMIN (BSA) BY SYNTHETIC ACTIVE CARBONS OF SCS TYPE

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Introduction

Active carbons (AC) are well known as adsorbents in industry, biotechnology and medicine. Sorption detoxification during various grave diseases and poisonings become recently well known as a new rapidly developing field of modern medicine [1]. Adsorptive activity of AC against harmful and toxic substances with different molecular mass and nature determine the success of AC therapeutic usage. Adsorption of harmful and toxic substances from biologic fluids under extracorporeal detoxification (hemosorption) by AC occur in nonisothermal conditions. Temperature gradient is from patient's body temperature to surroundings one. So extracorporeal detoxification therapeutic effect depends on temperature too.

In the present work we have tried to investigate extracorporeal detoxification in system AC - model solution, study the temperature effect on adsorption by AC.

Experimental

AC of SCS type with regular spherical grains prepared from porous copolymers by pyrolysis and activation were used as adsorbents. We use carbons with equivalent pore radii 12 nm (SCS-3) and 24 nm (SCS-5). Physico-chemical and adsorptive characteristics of active (SCS-3, SCS-5), oxidized (SCS-3-o, SCS-5-o) and with immobilized BSA (SCS-3-BSA, SCS-5-BSA) were investigated (See table 1). As adsorbate we use water solutions of methylene blue (MB), vitamin B-12, ovalbumin and BSA. This number of substances differed by their nature and molecular mass (0.3-68 kD) simulate a harmful and toxic substances, which must be eliminated under extracorporeal detoxification.

Isotherms of adsorption determination by constant mass method under thermostated conditions; adsorbate concentration was determine by spectrometric data; pores distribution by their radii - by mercury porosimetry; sorptive pore volume (SPV) - by benzene vapor adsorption at 20 °C; specific surface area (SSA) - chromatographically by nitrogen thermal desorption; BSA was immobilized by water soluble carbodiimide method.

Table 1.

Sorbent	Pore size	SSA, sq.m/g	SPV, ccm/g
SCS-3		1130	1.20
SCS-3-o	12	800	1.00
SCS-3-BSA		300	0.90
SCS-5		1950	1.25
SCS-5-o	24	1350	1.20
SCS-5-BSA		550	0.80

Results and discussion

Figure 1 shows dependence of adsorption (isotherm) on temperature. This dependence is typical for all investigated by us adsorbents and adsorbates. Increasing of adsorption with increasing of temperature can be explained by activated character of adsorption because of similar dimension of adsorbate molecule and pore size [2,3]. Isotherms of adsorption can be described by $A=bC_{eq}^{n}$ equation and linearized in coordinates $\ln A$ - $\ln C_{eq}^{n}$.

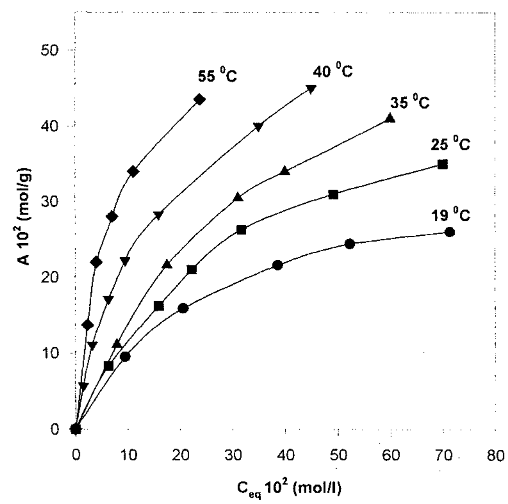

Figure 1. Isotherms of methylene blue adsorption by SCS-3 active carbons on different temperature.

Isosteric heat of adsorption (IHA) can be determined as educed heat in adsorption process of one mole of adsorbate under constant surface concentration of adsorbate. The equation for IHA can be given as:

$$\ln C_{eq} = - q_{st}/R \bullet (1/T) + \text{constant},$$

were C_{eq} - adsorbate equlibriun concentration, q_{st} - IHA, T - temperature. C_{eq} and T can be obtained from adsorption isotherms under the condition of A=constant. q_{st} can be determined as tgα in coordinates ln C_{eq} - 1/T (K). The results of calculations are shown in figures 2-4.

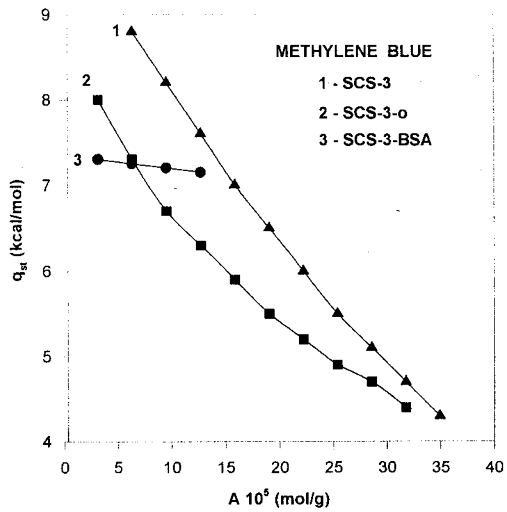

Figure 2. Dependence of IHA on surface covering.

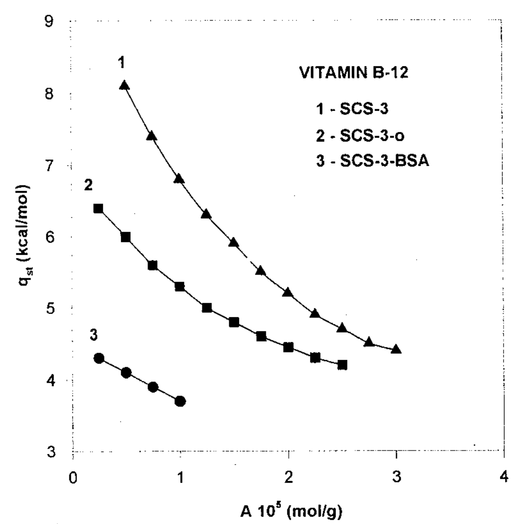

Figure 3. Dependence of IHA on surface covering.

IHA in the case of protein containing carbons, MB and vitamin B-12 (Fig. 2,3) practically independent on degree of surface covering. It can be explained by the SPV and SSA decreasing during BSA immobilization [4,5]. IHA decrease with increasing of degree of surface covering for active and oxidized adsorbents, methylene blue (Fig. 2), vitamin B-12 (fig. 3) and proteins (fig. 4).Changes in q_{st} correlate with molecular mass of sorbate and structure-sorptive characteristics of adsorbents.

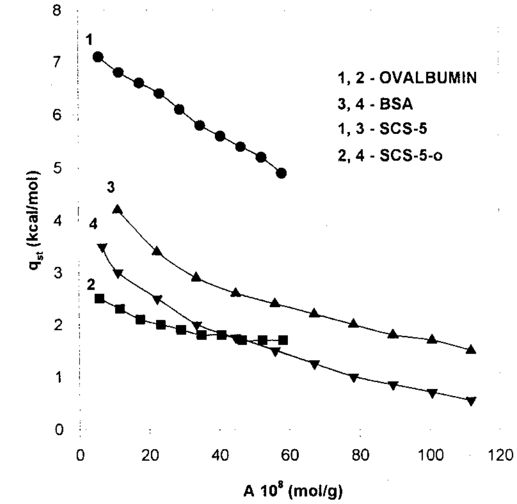

Figure 4. Dependence of IHA on surface covering.

Dependence of q_{st} on IHA for carbons of SCS-5 series, methylene blue and vitamin B-12 are similar one on Fig. 2,3; for carbons of SCS-3 series and proteins are similar to ones on Fig. 4.

Conclusions

Isotherms of adsorption of methylene blue, vitamin B-12, ovalbumin and BSA were determined for different adsorents of SCS-3 and SCS-5 series and temperatures. Isosteric heat of adsorption were calculated. The results of this work allowed to optimize development of sorbents for medical use and sorbtive processes for biotechnology and industry.

References

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