ADSORPTION OF LOW MOLECULAR SOLUTES OF BIOLOGICAL IMPORTANCE ON POLYMER-PYROLYSED CARBONS

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Introduction

Haemoperfusion over activated carbons, AC is a common procedure for the treatment of acute poisonings and organ failure [1]. However, efficiency of this procedure is limited and it is used to a much lesser extent than other extracorporeal methods such as dialysis. In haemoperfusion, direct contact of blood with AC surface is avoided by using adsorbents coated with a semipermeable membrane coating. Such a coating makes AC more haemocompatible but, on the other hand, imposes strict limitations on AC-haemoperfusion. Firstly, the membrane coating virtually cuts off solutes of middle and high molecular mass and, secondly, the overall process becomes diffusion controlled implying longer duration of treatment, usually 6-12 hours, which, in its turn, puts higher demand to the haemocompatibility of an adsorbent column and auxiliary devices, etc. This circle can be broken by creating AC with haemocompatibility comparable to that of coated AC. This problem is not as insoluble as it may seem. In fact, those AC which are in current use for haemoperfusion, have never been specifically designed for medical purposes. Alternatively, it was suggested to introduce polymer-pyrolysed AC designed according to the medical regulations [2]. In this work adsorption of some solutes by a series of polymer-pyrolysed AC has been studied.

Experimental

PA carbons were made from a phenol-formaldehyde resin synthesised in the presence of aniline (molar ratio phenol/aniline = 9:1). The resin was carbonised by a step pyrolysis in the temperature range 350-950°C and steam activated at 850-875°C. SCN AC was synthesised by a step pyrolysis of a vinylpyridine-divinylbenzene copolymer at 350-900°C and further steam activation at 950-1000°C. Some characteristics of PA and SCN carbons are given in Table 1. Both initial resins were mesoporous, and the final AC also retained a narrow mesopore size distribution characteristic of the starting materials. PA carbons have an average mesopore radius 19 nm, and that of SCN carbons is 35 nm. AC BDH and RBXS were purchased from BDH, UK and Norit, The Netherlands, respectively. The bulk density of BDH carbon was 0.58 g/cm^3, the bulk density of Norit RBXS carbon was 0.47 g/cm^3. Cholestyramine resin, CA - a strong anion exchanger containing quaternary nitrogen, and other chemicals were purchased from Sigma, USA.

Table 1. Some characteristics of PA and SCN carbons.

Code	Activation parameters			Bulk density, g/cm^3
	T, °C	Burn-off, %	Duration, min	
PA-10	850	11.4	120	0.39
PA-20	875	20.5	120	0.37
PA-30	875	28.5	180	0.34
PA-40	875	40.1	340	0.32
PA-50	875	49.0	435	0.29
SCN-1	950	60.0	240	0.54
SCN-2	1000	83.3	360	0.26

Adsorption experiments were carried out by shaking 0.05 g AC with 10 mL solution for 24 hours at 37°C. Solute concentration was determined spectrophotometrically. Solutions of methylene blue (molecular mass 374 D), sodium salicylate (160 D) or vitamin B_{12} (1355 D) were prepared in a phosphate buffer, pH 7.4. Bilirubin (585 D) does not dissolve in this buffer and it was dissolved in a 0.1M phosphate buffer, pH 9.2.

Results and Discussion

Figures 1 to 4 show the results of adsorption experiments. With exception of bilirubin, for all the other solutes both SCN samples and highly activated PA samples had adsorption capacity which significantly exceeded adsorption capacity of commercial carbons. The biggest difference was in the case of vitamin B_{12}. Its relatively large molecules cannot penetrate narrow micropores, whereas SCN and PA carbons have mesopores accessible to this solute. Adsorption of bilirubin is a special case. This metabolite has to be removed from the organism of patients with liver disease. Cholestyramine has high affinity for bilirubin, completely removing it from a 20 mg% solution. Unfortunately, CA is a toxic substance itself and cannot be used for medical treatment. From the shape of adsorption isotherms it occurs that neither SCN nor PA carbons demonstrate high affinity to bilirubin (Fig. 4). However, due to the well developed porous structure, these AC adsorb substantial amount of bilirubin which makes them prospective for further investigation.

Taking into account that polymer-pyrolysed AC are mechanically strong and their porous structure can be

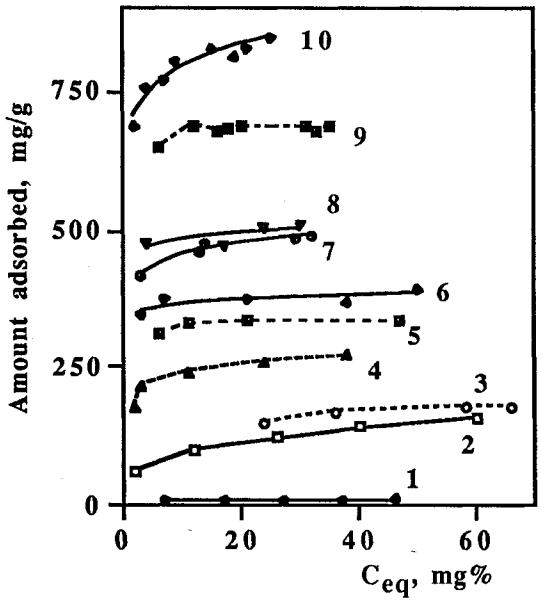

Fig. 1. Adsorption isotherms of methylene blue. 1 - CA, 2 - Norit RBXS, 3 - BDH, 4 - PA-10, 5 - PA-20, 6 - PA-30, 7 - PA-40, 8 - PA-50, 9 - SCN1, 10 - SCN2.

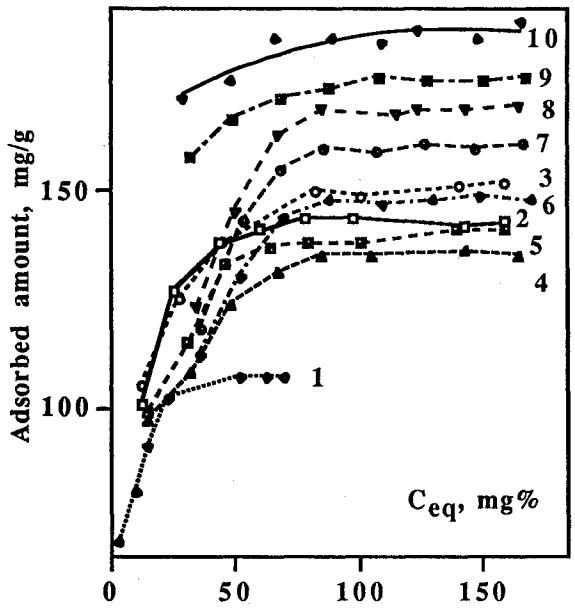

Fig. 2. Adsorption isotherms of sodium salicylate. 1- CA, 2 - Norit RBXS, 3 - BDH, 4 - PA-10, 5 - PA-20, 6 - PA-30, 7 - PA-40, 8 - PA-50, 9 - SCN1, 10 - SCN2.

varied in a wide range of pore size, these materials have a great potential for medical use. It is important that they have high adsorption capacity for middle molecules (vittamin B_{12}) which are not removed by coated AC.

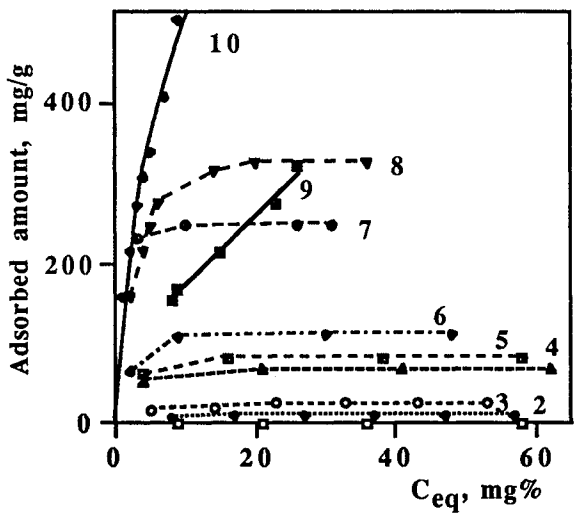

Fig. 3. Adsorption isotherms of vitamin B_{12}. Numbers correspond to the same carbons as in Fig. 1 and Fig. 2. Cholestyramine did not adsorb vitamin B_{12}.

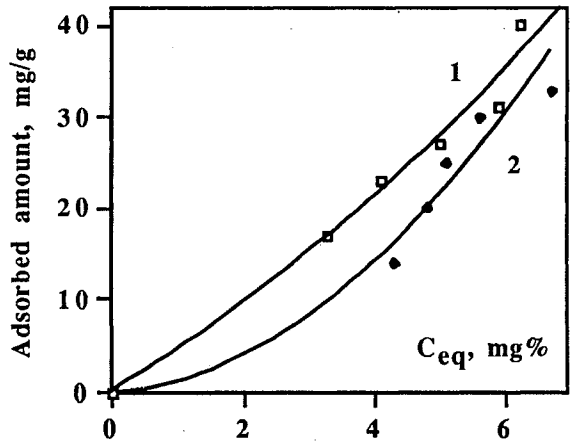

Fig. 4. Adsorption isotherms of bilirubin. 1 - PA-50, 2 - SCN2.

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