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Original Contribution

STATIC SORPTION CAPACITY OF LYOPHILISED BLOOD PRODUCTS FOR BENZENE AND ITS DERIVATIVES

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ABSTRACT

Introduction: This report is a follow-up to results presented at an international scientific conference, *Technology, Security and Ecology*, held in Veliko Tarnovo, Bulgaria, on June 21, 2001. It was about the static sorption of three newly offered sorbents for gas masks. The purpose of this report is to study the sorption capacity of lyophilised blood products for benzene and its derivatives. Method: the static sorption of three newly offered sorbents has been investigated - lyophilised erythrocyte mass, lyophilised plasma proteins, lyophilised blood serum by exsiccator method. Results: The results are presented on **Table 1-5**. Conclusion: The newly offered absorbents have high sorption capacity.

Key words: sorbent, gas mask, lyophilisation

INTRODUCTION

This report is a further development of results that were reported at an international scientific conference *Technology, Security and Ecology*, held in Veliko Tarnovo on June 21, 2001 [1]

Gas masks were first used during the First World War to protect soldiers against poisonous gases. Apart from that they have been used in dealing with aftermath of industrial accidents, fires and natural disasters. The importance of gas masks has recently increased with the occurrence of terrorist attacks.

At present standard carbon catalyst K-5M is mainly used as absorbent in gas masks. However, it has a reduced capacity of absorbing some heavily poisonous gases.

The combination of carbon monoxide [2] and hydrogen cyanide [3, 4, 5] with blood haemoglobin causes heavy poisoning, which is often lethal. It has been found that haemoglobin [6] and plasma proteins [7] have a vast buffer capacity. They combine with acids and bases, including gases with acidic and basic characteristics.

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It has been shown that lyophilised blood products are hydroscopic and absorb water evaporations [8]. It can be thus concluded that they can absorb gases and evaporations of toxic chemical substances.

MATERIALS AND METHODS

1. Methods for receiving sorbents

Sheep blood, provided by the Institute of Communicable and Parasitic Diseases, Sofia, Bulgaria, was used.

1.1. Preparation of the blood:

Erythrocyte mass and plasma

Alsewer`s solution, modified by Bucantz should be used. It contains: 4,1 g glucose (Himsnab), 1,6 g sodium citrate (Himtex), 0,84 g sodium chloride (Himtex) and condensed distilled water, up to 200 ml. pH is treated by citric acid, so that its pH is brought to 6.1

The solution and the blood, ratio 1:1, are poured into a bank and then centrifuged for 20 minutes at 2000 revolutions per minute. The resulting two phases are then separated.

Blood serum

The blood is placed for one hour in a thermostat heater set at 37ºC. After that the

blood is left for 24 hours in a refrigerator to allow for coagulation. The liquid component is aspirated to a new tube and then centrifuged.

1.2. Refrigeration and vacuum sublimation dehydration of blood products.

T 616 Hochvacuum, DDR equipment was used.

Refrigeration is done at – 45 ºC (± 5 ºC) (it is preferable for the solution to be rotated while it freezes). After that the banks should be put into a sublimation chamber of the vacuum sublimation installation. When the temperatures of the products and the refrigerating chamber equalize the equipment is set to working mode – heating and vacuuming. The process of lyophilisation goes off automatically, at maximal working vacuum pressure of 10^{-1} Pa and final temperature of the substance of 36 ºC, ± 2 ºC. Depending on the quantity of the substance and the thickness of the frozen layer, the duration of sublimation dehydration is between 30 and 48 hours.

At the end of the process, the state of vacuum in the sublimation chamber is terminated by the introduction of dry inert gas (nitrogen). The lyophilised blood products are placed in airtight packs and labelled.

2. Testing of static sorption capacities of lyophilised blood products as regards benzene and its derivatives, under levels of pressure, equal to the pressure of their concentrated evaporations.

Sorbtives tested: nitrobenzene-''Reaktivul'', Bukurest; chlorobenzene-''Fluka'', benzene-''Merk'', toluene-''Fluka'', xylene- Technical school of industrial chemistry ''N. Zelinski'', Burgas.

The preparation of a mixture of air and evaporations of the tested substance is done directly in an exsiccator, by putting 50 ml of the tested substance in a Beherov`s glass, which is then put into an exsiccator. The temperature of the exsiccator is brought to 20 °C by putting it into a constant temperature water bath. When the liquid and the evaporations are in balance, weight measuring bottles, containing the sorbents that are being tested, are put into the exsiccator. Their mass should have previously been measured by Sartorius scales. At regular time intervals they are weighed and by calculating the difference in mass weight, the quantity of sorbed substance is found. Results are then recalculated in milligrams of sorbed substance per 1g of sorbent.

3. Statistic data processing

Variation analysis is used for statistic processing of quantity measurable indices. Data has been presented as an average arithmetic quantity of the values, measured in three separate experiments [9]. Results are taken into account only if the difference between the highest and the lowest value is 10% lower than the lowest value. Since all experiments are carried out in vitro, repetitiveness is very high.

RESULTS AND DISCUSSION

Results are presented on **Tables 1-5**:

Table 1 *Nitrobenzene sorption, milligrams of sorbed substance per 1g of sorbent*

Lyophilized sorbent			Time/hours
erythrocytes	plasma	serum	
31,598	62,499	51,948	3
60,939	114,576	97,395	6
83,509	140,616	123,367	9
99,308	161,448	136,353	12
115,107	171,864	142,846	15
142,191	192,696	162,325	26
167,018	213,528	188,297	38
182,817	232,320	201,283	50

Table 2 *Chlorobenzene sorption, milligrams of sorbed substance per 1g of sorbent*

Lyophilized sorbent			Time/hours
erythrocytes	plasma	serum	
38,680	61,538	41,237	3
90,898	102,560	72,156	6
110,238	128,200	97,926	9
127,644	148,712	113,388	12
129,578	158,968	123,696	15
143,116	189,736	159,774	26
154,738	211,342	159,774	38

Table 3 *Benzene sorption, milligrams of sorbed substance per 1g of sorbent*

Lyophilized sorbent			Time/hours
erythrocytes	plasma	serum	
16,444	96,000	70,420	3
53,756	128,000	98,588	6
69,988	152,000	105,600	9
75,764	168,000	112,672	12
92,872	176,000	119,774	15
112,424	184,000	133,798	26
126,88	192,000	147,882	38
136,919	192,000	147,882	50

Table 4 *Toluene sorption, milligrams of sorbed substance per 1g of sorbent*

Lyophilized sorbent			Time/hours
erythrocytes	plasma	serum	
20,360	43,712	27,396	3
32,576	76,496	34,245	6
40,720	76,496	41,094	9
48,864	87,424	47,943	12
69,224	131,136	68,490	24
85,512	142,064	102,735	48
97,728	152,992	130,131	60
114,016	163,920	136,980	72

Table 5 *Xylene sorption, milligrams of sorbed substance per 1g of sorbent*

Lyophilized sorbent			Time/hours
erythrocytes	plasma	serum	
22,630	56,818	43,010	3
33,936	79,527	60,928	6
45,248	102,249	68,096	9
50,914	106,036	71,680	12
56,560	109,823	71,680	15
72,114	109,823	82,432	27
73,528	109,823	75,264	32
82,012	109,823	82,432	51

On the basis of results from laboratory tests of lyophilised blood products and from already published sources on sorption mechanisms, assumptions can be made rather than assertions. Related literature review shows that evaporations of benzene [10, 11, 12], as well as of most of the other organic compounds are sorbed through physical sorption. Lyophilised blood products have great static sorption capacity for benzene and its derivatives. Research on the influence of moisture shows that the more it is increased, the more the specific surface of sorbents decreases [13]. The changes observed are

most probably related to the quantity of compounded water and, respectively, with the increase of the volume of macro-structural elements, on the account of the space between them and with the change in the solidity of the materials. It leads to the so-called swelling, whose mechanism of occurring can be either physical or chemical.

The process of absorbing toxic substances evaporations by lyophilised blood products is different from that of standard active carbon catalysts used in standard gas masks. The reasons for that are the lack of porous structure, the lack of active phases and most of all it is due to the fact that the process of swelling is of prime importance for absorbing toxic substance evaporations. Swelling is an osmotic process, during which the molecules of toxic substances are diffused into the lyophilised blood products.

The ability for swelling is not related to simple mechanical penetration of certain evaporations into the empty space between the different macro-structural elements of lyophilised blood products, but to inter-molecular interaction, as the respective macro-molecules attract and hold molecules from the solving substance. Due to that reason the process of swelling is always specific and lyophilised blood products do not absorb all toxic substance evaporations but only those whose molecules can participate into the process of solving of macro-molecules.

An important factor, influencing the capacity of absorbing evaporations is the presence of polarized functional groups in the macro-molecules of lyophilised blood products and their solving covers close surrounding. Their presence on the one hand decreases the level of swelling of lyophilised blood products, caused by evaporations of non-polarized substances and on the other hand, which is the common case, increases the level of swelling of polarized substances.

In this respect, the presence of residual moisture is very important. If there is no residual moisture, when coming into contact with the lyophilised blood products, evaporations occupy the empty space between macro-structural elements of lyophilised blood products. If the process of swelling occurs in that case, it is limited and slow.

Residual moisture can be either compounded or free. Compounded residual moisture does not have dissolving capacity but it is present in the solving cover around polarized functional groups and facilitated inclusion through hydrogen bonds, which respectively affects the process of swelling of the molecules of absorbed evaporations. The presence of free residual moisture helps penetration of evaporations of water-soluble toxic substances into the supra-molecular structures, as in the same time, intra-structural swelling is observed, which is accompanied by substantial increase of the volume of lyophilised blood products. Apart from that, the space between the macro-structural elements increases, the bonds between them grow weaker and if they become weaker than osmotic forces, swelling gradually changes to dissolving.

With respect to these theoretical facts, it is worth noticing that depending on the quantity of residual moisture, on the ratio between compounded and free moisture and on the nature of toxic substances, the process of their absorption by lyophilised blood products is either facilitated or hampered or it cannot occur at all.

The research on lyophilised blood products we have carried out so far, as well as the results we have obtained, do not allow for definitive conclusions about the mechanism of sorption in lyophilised blood products to be made.

CONCLUSIONS

Analysis of the results presented on **Tables 1-5** allow for the following conclusions to be drawn:

The sorbents tested showed high static sorption capacity. Static sorption capacity decreases in the following order: plasma, serum, and erythrocytes. During the first three hours plasma sorbs best, followed by serum and erythrocyte mass. Decrease in sorption capacity, when comparing benzene and its derivatives, is observed in the following order: nitrobenzene, chlorobenzene, benzene, toluene, xylene. The presence of one substitute in the benzene nucleus, an atom of chlorine or a nitro-group increases sorption capacity. The presence of methyl groups decreases sorption capacity. These compounds come in the same order, as regards their solubility in water. Only chlorobenzene is an exception, which is less soluble than benzene but on the other hand it has higher boiling temperature.

Experiment results show that lyophilised blood products have high sorption capacity and thus can be used in gas masks. What is more, benzene and its derivatives are sorbed in larger quantities than hydrocarbons hexane, cyclohexane, heptane and isooctane [14].

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