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Original Contribution

INVESTIGATION OF STATIC SORPTION CAPACITY OF LYOPHILISED BLOOD PRODUCTS FOR SOME HALOGENHYDROCARBONS

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ABSTRACT

Purpose: The purpose of this report is to find out the sorption capacity of lyophilised blood products for halogenhydrocarbons. Method: the static sorption of three newly offered sorbents was studied based on the following parameters: lyophilised erythrocyte mass, lyophilised plasma proteins, lyophilised blood serum, using the exsiccator process. Results: Static sorption capacity decreases in the following order: plasma, serum, erythrocytes. Decrease in sorption capacity, when comparing halogenated derivatives, is observed in the following order: chloroform, carbon tetrachloride, dichloroethane, trichloroethane. Conclusion: The newly offered absorbents have high sorption capacity.

Key words: sorbent, gas mask, lyophilisation

INTRODUCTION

This report is further development of results, that were reported at the international scientific conference, "Technology, Security and Ecology", 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. But it only has a reduced capacity of absorbing some highly poisonous gases.

The combination of carbon monoxide [2] and hydrogen cyanide [3,4,5] with blood haemoglobin causes serious poisoning, which is often lethal. It has been shown 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.

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

MATERIALS AND METHODS

1. Methods for procuring sorbents

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

1.1. Preparation of the blood

Erythrocyte mass and plasma

Alsewer`s solution, modified by Bucantz was 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 was attained by treating with citric acid until a pH level of 6.1 was reached.

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

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Blood serum

The blood was placed in a container with thermostat at 37ºC for an hour. After that the blood was left in a refrigerator for 24 hours for coagulation to take place. The liquid component was decanted and the residue centrifuged.

1.2. Refrigeration and vacuum sublimation dehydration of blood products

T 616 Hochvacuum, DDR equipment was used.

Refrigeration was done at – 45 ºC (± 5ºC) (it is preferable for the solution to be rotated while it freezes. After that the banks were put in a sublimation chamber of the vacuum sublimation installation. When the temperatures of the products and the refrigerating chamber equalized the equipment was 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 was between 30 and 48 hours.

At the end of the process, the state of vacuum in the sublimation chamber was terminated by the introduction of dry inert gas (nitrogen). The lyophilised blood products were then packed in airtight containers and labelled.

2. Testing of static sorption capacities of lyophilised blood products for halogen hydrocarbons, under levels of pressure equal to the pressure of their concentrated evaporations

Sorbtives tested: chloroform (Himtex), carbon tetrachloride (Himtex), dichloroethane (Merk), trichloroethane (Merk).

The preparation of a mixture of air and vapours of the tested substance was done directly in an exsiccator: 50 ml of the tested substance was put into a Beherov`s glass, which was then put into an exsiccator. The temperature of the exsiccator was brought to 20 °C by putting it into a constant temperature water bath. When the liquid and the vapours were in equilibrium, weighing bottles, whose masses had been known using the Sartorius scales and now containing the sorbents that were being tested, were put into the exsiccator. At regular intervals they were weighed and, by calculating the difference in mass weight, the quantity of sorbed substance was obtained. Results were then recalculated in milligrams of sorbed substance per 1g of sorbent.

3. Statistic data processing

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

RESULTS AND DISCUSSION

Results are presented on **Tables 1-4.**

Our results and those obtained from published sources enable us to make the following assumptions. Related literature review shows that carbon tetrachloride vapours [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 hydrocarbon halogen-derivatives. Research on the influence of moisture shows that the more it is increased, the more the specific surface of sorbents decreases [13].

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

Lyophilised sorbent			***Time/hours***
erythrocytes	*plasma*	*serum*	
150,366	229,152	222,846	3
150,366	234,360	228,560	6
166,194	239,568	239,988	9
187,290	255,192	251,416	12
216,316	260,400	245,702	15
374,596	333,312	331,412	27
319,922	406,244	399,980	32
342,940	432,264	405,694	51

Table 2.*Carbon tetrachloride sorption, milligrams of sorbed substance per 1g of sorbent*

Lyophilised sorbent			***Time/hours***
erythrocytes	*plasma*	*serum*	
41,237	129,032	81,871	3
49,464	145,152	93,552	6
63,891	169,344	111,093	9
74,196	177,408	122,787	12
113,355	217,728	163,716	24
129,843	225,792	175,41	36
146,331	241,920	187,104	48
164,948	241,920	198,830	72

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

Lyophilised sorbent			***Time/hours***
erythrocytes	*plasma*	*serum*	
38,955	66,326	42,246	3
38,955	102,040	61,024	6
46,746	132,652	89,186	9
41,149	147,958	93,880	12
38,955	153,060	107,962	15
54,537	198,978	168,984	27
49,349	193,876	150,208	32
62,337	193,876	173,678	51

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

Lyophilised sorbent			***Time/hours***
erythrocytes	*plasma*	*serum*	
39,924	80,503	61,611	3
43,912	93,214	61,611	6
51,896	102,48	71,085	9
59,880	118,636	80,563	12
67,864	127,110	85,303	15
95,808	156,763	118,475	27
95,508	118,475	137,431	32
123,752	173,717	170,616	51

The changes observed were most probably related to the quantity of compounded water and respectively, with the increase of the volume of macro-structural elements, on 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 occurrence can be either physical or chemical.

The process of absorbing vapours of toxic substances 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, is due to the fact that the process of swelling is of prime importance for absorbing toxic substance vapours. 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 vapours 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. Because of that the process of swelling is always specific and lyophilised blood products do not absorb all toxic substance vapours but only those whose molecules can participate in the process of solving of macro-molecules.

An important factor, influencing the capacity of absorbing vapours is the presence of polarized functional groups in the macro-molecules of lyophilised blood products and their solving covers close surrounding. Their presence on 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, vapours 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 facilitates inclusion through hydrogen bonds, which 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 received, do not allow for definitive conclusions about the mechanism of sorption in lyophilised blood products to be made.

CONCLUSIONS

The sorbents tested showed high static sorption capacity. Static sorption capacity decreases in the following order: plasma, serum, erythrocytes. During the first three hours plasma sorbs best, followed by serum and erythrocyte mass. Decrease in sorption capacity, when comparing halogenated derivatives, is observed in the following order: chloroform, carbon tetrachloride, dichloroethane, trichloroethane and is dependent on their solubility in water, not only on their molecular mass and temperature of boiling [14]. Compounds, which dissolve better sorb better. What is more, halogenhydrocarbons are sorbed in larger quantities than the hydrocarbons hexane, cyclohexane, heptane and isooktane [15].

Experimental results show that lyophilised blood products have high sorption capacity and thus can be used in gas masks.

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