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Original Contribution

EFFECT OF INCREASED TEMPERATURE ON STATIC SORPTION CAPACITY OF LYOPHILISED BLOOD PRODUCTS

V. Ivanov[1], B. Popov[1], R. Nicolov[2], G. Arabadzhiev[3]

[1]Department of Chemistry and Biochemistry, Medical Faculty, Trakia University - Stara Zagora
[2]Institute of General and Inorganic Chemistry, Sofia, Bulgaria
[3] Department of Anaesthesiology and Intensive Care, Medical Faculty, University Hospital, Stara Zagora

ABSTRACT

Purpose: The purpose of this report is to find out the effect of increased temperature on sorption capacity of lyophilised blood products. Method: the static sorption of three newly offered sorbents was tested - lyophilised erythrocyte mass, lyophilised plasma proteins, lyophilised blood serum by exsiccator method. When sorbed evaporations reached maximum volume, temperature rose. After that sorption levels at different temperature levels were measured. Results: The most temperature-sensitive sorbent was plasma, followed by blood serum. Most temperature-sensitive desorption was that of benzene, followed by the desorptions of cyclohexane and hexane. Conclusion: At high temperature levels static sorption capacity decreases.

Key words: sorbent, gas mask, lyophilisation

INTRODUCTION

This report is a further development of results, that were reported at the scientific conference, “Technology, Security and Ecology" with international participation 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 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.

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

The main purpose of this article is to provide information on the effect of increased temperature on the sorption capacity of lyophilised blood products, which can be used as sorbents in gas masks.

MATERIALS AND METHODS

1. Methods for receiving sorbents

Sheep blood from vena jugularis externa, provided by the Institute of Communicable and Parasitic Diseases, Sofia, was used. Centrifuge T 23 (GDR) 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.

*** Correspondence to**: *Veselin Asenov Ivanov, Trakia University, Medical faculty, Department of Chemistry and Biochemistry, 11 Armeiska Str., Stara Zagora 6000, Bulgaria*
E-mail: veskoasenov@abv.bg

The solution and the blood from vena jugularis, ratio 1:1, were poured into a bank and then centrifuged at 300g for 20 min at a speed of 2000 revolutions per min. The two phases were then separated.

Blood serum

The blood was placed in a thermostat at 37ºC for an hour. After that the blood was placed for 24 h in a refrigerator to coagulate. The liquid component was aspirated and centrifuged.

1.2. Refrigeration and vacuum sublimation dehydration of blood products.

T 616 Hochvacuum, DDR equipment was used.

Solution was placed on a rotator and frozen at – 45ºC (± 5ºC). After that the banks were placed 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 36ºC, ± 2ºC. Depending on the quantity of the substance and the thickness of the frozen layer, the duration of sublimation dehydration is usually between 30 and 48 h.

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

2. Determining sorption capacity at different temperature levels.

2.1. Testing of static sorption capacities of lyophilised blood products under levels of pressure equal to the pressure of their concentrated evaporations at temperature 20°C.

Sorbtives tested: hexane, cyclohexane, benzene- ''Merk''

The preparation of a mixture of air and evaporations of the tested substance were done directly in an exsiccator: 50 ml of the tested substance was put in a Beherov`s glass, which was then placed in an exsiccator. The temperature of the exsiccator was brought to 20 °C by placing it in a constant temperature water bath. When the liquid and the evaporations equilibrated, weighing bottles of known masses, containing the sorbents that were being tested, were placed in the exsiccator. At regular time intervals they were weighed and by calculating the difference in mass weight, the quantity of sorbed substance was found. Results were recalculated in milligrams of sorbed substance per 1g of sorbent.

2.2. The changes in sorption capacity of saturated evaporations, at 20°C and increased temperature levels.

When sorption capacity reached its maximal saturation level, at 20°C, temperature increased by 5 degrees. One h later the sorption capacity was measured. After that the experiment continued by repeating the steps, gradually increasing the temperature by 5 degrees each time and measuring sorption capacity an h later, until the temperature reached 50 °C.

3. Statistic data processing

Variation analysis was used for statistic processing of quantity measurable indices. Data was presented as an average arithmetic quantity of the values, measured in three separate experiments [9]. Results were significant 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, repetitiveness was very high.

RESULTS AND DISCUSSION

Results are presented on Tables 1-4

On **Table 1** the maximal levels of sorption capacity, measured at 20°C are presented

The effect of increased temperature levels on sorption capacity

The effect of temperature was tested on the desorption of hexane, cyclohexane and benzene from lyophilised blood products, in the interval of 25°C - 50°C, for a period of 1 h. The compounds mentioned have been previously sorbed at 20°C. Results are presented on **Tables 2-4** in mg desorbed evaporations from 1g sorbent.

Table 1 *Maximal values of sorbing capacities in mg sorbed evaporations from 1g of sorbent, temperature 20 °C*

Lyophilised sorbent			***compound***
erythrocytes	*plasma*	*serum*	
142.824	194.025	160.472	hexane
135.408	184.338	137.795	cyclohexane
136.919	192.000	147.882	benzene

Table 2 *Desorption of hexane in mg desorbed evaporations from 1g of sorbent*

Lyophilised sorbent			***temperature, °C***
erythrocytes	*plasma*	*serum*	
1.082	1.243	2.059	25
2.164	2.487	4.114	30
3.246	3.731	6.172	35
6.492	4.795	12.344	40
12.984	9.590	15.430	45
16.230	24.875	24.688	50

Table 3 *Desorption of cyclohexane in mg of desorbed evaporations from 1g of sorbent*

Lyophilised sorbent			***temperature. °C***
erythrocytes	*plasma*	*serum*	
0.868	2.793	3.973	25
1.736	5.586	7.946	30
7.812	11.172	15.892	35
10.416	22.344	23.622	40
23.436	44.688	47.244	45
28.644	61.446	59.055	50

Table 4 *Desorption of benzene in mg of desorbed evaporations from 1g of sorbent*

Lyophilised sorbent			***temperature. °C***
erythrocytes	*plasma*	*serum*	
4.073	4.166	7.042	25
8.146	8.333	14.084	30
12.220	24.999	17.605	35
17.108	33.332	21.126	40
26.884	49.998	28.168	45
31.772	74.997	56.336	50

The sorbing capacity of the sorbents of different toxic substances are different. They depend on a number of factors, such as relative surface, size of pores, structure of the sorbent and the sorbing agent, mechanism of sorbing, temperature, saturation of evaporations, speed of flow of evaporations, moisture, duration of sorption. etc. [10, 11]. One of the most important factors is temperature.

In physical sorption, while increasing the temperature, the quantity of the sorbing substance decreases, as sorption is an exothermal process.

Haemo-sorption processes are usually characterized by high levels of activation energy and that is why the speed of such processes quickly slows down when temperature drops.

On the basis of our results and from published sources, assumptions can be made rather than assertions. Related literature review shows that evaporations of most organic compounds are sorbed through physical sorption [12, 13, 14]. Lyophilised blood products have great static sorption capacity for these compounds. Research on the influence of moisture shows that the more it is increased, the more the specific surface of sorbents decreases [10]. 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 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 than 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 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 study 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

The sorbents tested showed high static sorption capacity. Static sorption capacity decreases in the following order: plasma, serum, and erythrocytes. When temperature is increased, sorption capacities decrease. The most temperature-sensitive sorbent is plasma, followed by blood serum. Most temperature-sensitive desorption is that of benzene, followed by the desorptions of cyclohexane and hexane.

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