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THE INFLUENCE OF DECONTAMINATION MIXTURE OF ODS-4 ON CHEMICAL RESISTANCE OF THE GARMENTS FOR BODY SURFACE ISOLATIVE PROTECTION OF THE CZECH ARMED FORCES CHEMICAL CORPS SPECIALISTS

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***Abstract**: Providing effective isolative protection of the Czech Armed Forces Chemical Corps´ specialist is long-term, developed and perspective problems. In current time established protective garments designated for hermetical body surface protection of the Czech Armed Forces Chemical Corps´ specialist are constructively solved with the employment of a mixture based on a butyl-rubber polymeric mixture both-sided coated on a polymeric fabric. Effective protection of a body surface has to be guaranteed for the whole time of usage of a protective garment, thus after performed repeated decontamination. The paper deals with influences of decontamination mixtures ODS-4 on the isolative protective foil used for production of anti-gas protective garment marked as OPCH-05 which is established as the garment for specialists´ body surface protection.*

Keywords: Butyl-rubber polymeric mixture, garments of body surface isolative protection, decontamination, decontamination mixture, breakthrough time

1. Introduction

Czech Republic´s obligations towards North Atlantic Treaty Organization are legislatively defined in security and strategic documents of the Czech Republic. The Czech Armed Forces (CAF) Chemical Corps´ (CCs) specialists are permanently detached to the consequence management, for example to removing consequences of Chemical Warfare Agents (CWAs) or leakage of Toxic Industrial Chemicals (TICs) with the help of decontamination. Fulfillment of these tasks has clearly aims to minimize the effects of these compounds, including industrial pollutants on manpower and resources. Based on the definition and specification of security threats it is still necessary to study the protective properties of individual protection means in order to ensure quality protection of body surface of specialists. Getting real and credible data on the impact of toxic substances on the barrier materials consisting of butyl-rubber lead researchers and specialists to develop test methods leading to precise specifications for the improvement and advancement of quality of isolative protection of specialists not only in relation to the CWAs, but also TICs. They are an integral part of the chemical industry in all countries of the world and a part of decontamination mixtures [1-3].

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2. Theoretical part

Chemical specialists use their isolative means of body surface protection while they fulfil specific tasks within their professional activities. The protective properties of this group of garments are characterized with the help of breakthrough time (BTT) in the CAF. In the case of the isolative garment BTT is deemed as the period of time during which the material reliably protects against liquid or gaseous phase of CWAs. This time can be defined as the time either from covering of the particular amount of the liquid CWA (TIC) or from the beginning of the effect of gases of CWAs or TICs on the facial side of the isolative material to its permeation in the form of gas on the back side in the determinate amount [4,5].

The NBC Defence Institute of the University of Defence´ specialists deal with determination of the chemical resistivity of barrier materials used in anti-gas protection for a long time. From the published statement it is evident that the chemical resistance of used butyl-rubber polymeric mixture expressed with BTT has its significant limits just in relation to the liquid organic TICs, which are an essential part of the established decontamination mixtures in the CAF [6-10]. General awareness of this deficiency has become a challenge for the implementation of experimental work to clearly define the effects of decontamination liquid mixtures on anti-gas garment of OPCH-05. While performing specific tasks by specialists of the CAF CCs it cannot be expected that the probability of contact decontamination mixtures and chemical protective clothing OPCH-05 is minimal or none. Otherwise, you can talk about the result of contact with a potential impact on the structure of the isolative protective film comprised of a linear amorphous non-cross linked or slightly cross linked polymeric material based on butyl-rubber. It is known that butyl-rubber has distinctly non-polar properties.

For determination of effects of decontamination mixtures whose destructive effects on the isolative foil has not been studied to this time, the method and methodology of MIKROTEST have been used [11-13]. The sulfur mustard [bis(2-chloroethyl) sulfide] is traditionally used for testing constructive materials of individual protective equipment. This CWA is relatively simple with its chemical structure and from the group of persistent CWA is the less toxic. It is relatively available and it has a small molar volume in the comparison with other persistent CWAs.

3. Used chemicals and materials

3.1 Used chemicals

For study of the chemical resistance of the isolative protective foil the decontamination mixture ODS-4 has been used. This mixture is designated for removing CWAs and radioactive compounds from the surfaces of military vehicles. Basic data about it is summarized in the table 1. Selected properties of components which are its parts are introduced in the table 2.

Table 1 Basic data decontamination mixture ODS-4

Mixture	Content	Consumption [$dm^3.m^{-2}$]	Time of application on the surface [min]	Application
ODS-4	3% of detergent LINKA 1,2 % NaOH, in water	0,5	5	Line way
	0,15% of detergent LINKA 1, 0, 1% NaOH, in water	2,5	-	Brush way

Table 2 Survey and specification of used chemicals

Name of the chemical	*Specification, clearance*	*Producer*
Bis(2-chlorethyl)sulfide sulfur mustard	92,7 % distilled	VOP 072 Zemianské Kostoľany, SK
Detergent LINKA 1	14 % alcylarylsulfonan 2-aminoethanole 2% nonylfenolpolyglycolether 40% difosfate tetrasodium 18,7% Na_2CO_3 2,6% SiO_2 22,7% Na_2SO_4 . 10 H_2O	Rakona Rakovník, ČR
Sodium hydroxide	p.a.	Penta Ltd Praha, CR

3.2. Used material

Basic polymeric material that has been used to the construction of garment for specialists OPCH-05 consists on isolative protective textile of TP-RUB-001-06, polyamide textile both-sided with coating from the butyl-rubber (Rubena, public limited corporation, Hradec Králové, Czech Republic). The final product it means OPCH-05 is completed by the ECOPROTECT, Ltd, Zlín, Czech Republic. Used polymeric material has not been modified.

For making samples of isolative protective foil of a stamping die (MARBACH - CR, limited company, Brno, Czech Republic) and a manual hydraulic press (Polymertest, Zlín, CZ) have been used. The thickness of samples has been measured with the help of a quick thickness meter MITUTOYO, type C112BS (Mitutoyo Corporation, Kawasaki, Japan). Decontamination mixture has been dosed with the help with Pasteur´s pipette (volume 3 ml, Merci, CR) and triturated with the help of school paintbrush (Spokar, Spojené kartáčovny, joint-stock company, Pelhřimov, CR). After each decontamination cycle pictures of the surface of the isolative protective foil have been made with the help of USB microscope DigiMicro 2.0 Scale (Drahtlose Nachrichtentechnik, GmbH, Ditzenbach, Germany).

4. Working procedures

Test samples (size 6,5 x 6,5 cm) have been cut from the protective textile with the help of the cutter and the hydraulic press. Samples have been cut in two versions, thus the protective foil without a seam and with the seam. All samples have been marked for their better identification. The thickness has been measured in the middle of samples with the accuracy of 3 decimal places with the help of the quick thickness meter. Values have been recorded. From areal samples of tested material 10 sets of 10 samples has been chosen I order to have samples with approximately same thickness. Samples have been wiped with ethanol in order to remove mechanical impurity and grease. Samples have been located on the filtration paper to create 10 sets of 10 samples. Two milliliters of the decontamination mixture have been dosed to the middle of each sample within common laboratory temperature. The volume of the mixture has been immediately sliced with circle movements of the school paintbrush on the whole area of the sample (42 cm^2). The decontamination mixture has worked for 15 minutes. The surface of samples has been wetted with enough cover of decontamination mixture for the whole time. The amount of the mixture has been chosen in order to keep humidity of the whole area of the sample for the whole test.

After expiration of determined time samples have been three times wiped in a beaker and put on filtration paper for drying within common laboratory temperature. After approximately 3 hours has been performed next, thus the second decontamination cycle, however, the number of contaminated sets has been reduced. Two sets of samples have been prepared in one day in this way. The total number of decontamination cycles was 10. It means that for preparation of all sets consists of 100 samples 5 days were needed. This approach has come from consideration that double decontamination of used isolative anti-gas garments would be performed in the scope of the CAF CCs decontamination units which can be operationally deployed twice a day. In practice it means that the decontamination of garments would be performed twice always after completion of working activities.

Ten samples of has been cut from the material with the seam and butyl-rubber cover. Samples have been wiped with ethanol. The material has been subjugated in the same conditions as in the case of areal material. Only mechanical or chemical damages, change of the color, peel off of the cover and so on have been observed. Samples has not been tested on the change of resistivity because no from used methods is able measure samples which is typical by its shape inhomogeneity. Moreover, in the scope of sewn samples of material with the cover of seams it is possible to assume significant dereferences concerning resistivity against CWAs from the reason of their appreciable inhomogeneity. From this reason measurement of resistivity against CWAs would not provide results which would be possible to compare each other.

In the scope of areal samples the breakthrough time after determinate decontamination cycles has been measured. This one has been measured with the help of MIKROTEST method within that the chloramide CNITI-8 [*N*-chloro-*N*-(2-tolyl)benzamide] reacts with the sulfur mustard within releasing of hydrogen chloride. This one subsequently changes an alkali form of acidobasic indicator on acid one. In the case of MIKROTEST method thus the red form of Kongo red color on blue one with the way of azohydrazono tautometry.

The breakthrough time has been for comparison measured also within the samples which have not been decontaminated. The selection of samples has been performed in accordance with the same principles as by 10 sets designated for decontamination in order to have samples with the same thickness. All measurements of breakthrough times have been measured within 30 °C.

5. Results of the examination and discussion

At the beginning of the test samples have embodied light green coloration and samples cut from those parts of the garment with the seam light green and grey green coloration which has been declared by the producer (figure 1). On the figure 1 at the left part there is a visible texture of polyamide textile and at the right part there is visible polymeric coating. Generally it is presumed that the seam cam cause untightness of the garment and that is why it is equipped with stronger coating in order to prevent permeation of toxic compounds through relatively inhomogeneous connection of two and more parts of the anti-gas garment.

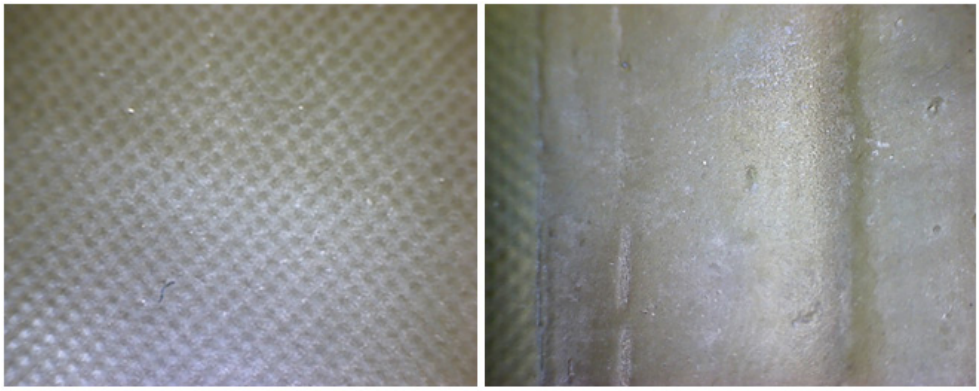

Figure 1: Foil pf OPCH-05 at the beginning of testing (at right there is the sample with the seam)

In accordance with above introduced procedure decontamination mixture ODS-4 has been dosed on samples of tested isolative foil. The time of effect of the decontamination mixture has been chose in the length of 15 minutes. No change on the surface of the tested isolative foil has been observed after performing the 1st till the 3rd decontamination cycle. This state is visible in the figure 2. On the right figure there is possible to observe an interface of the transfer of tested isolative foil and the polymeric coating of the seam (the left third of the figure).

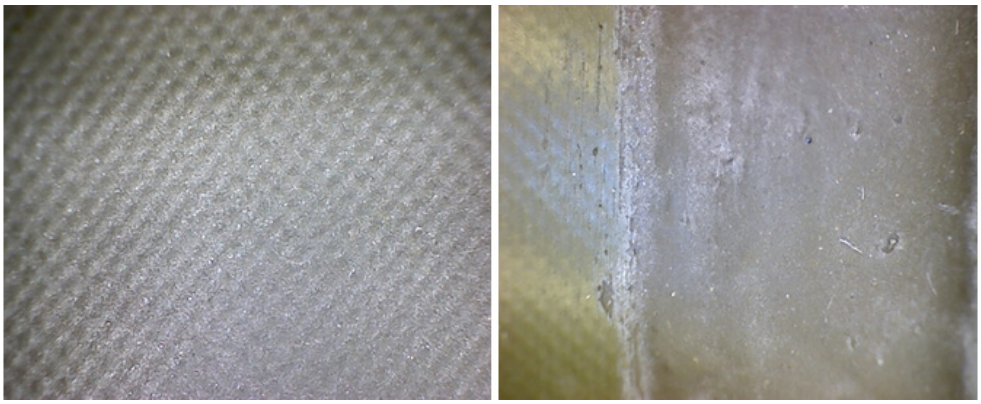

Figure 2: Foil OPCH-05 after three decontamination cycles performed with ODS-4 (light isolative foil, right the seam after the effect of the decontamination mixture)

No change on the surface of the tested isolative foil has been observed after performing the 3rd till the 6th decontamination cycle. It is possible to claim that based on figures made with the help of USB microscope there are no visible no destructive effects on the surface of the isolative foil which is perceptible from the figure 3.

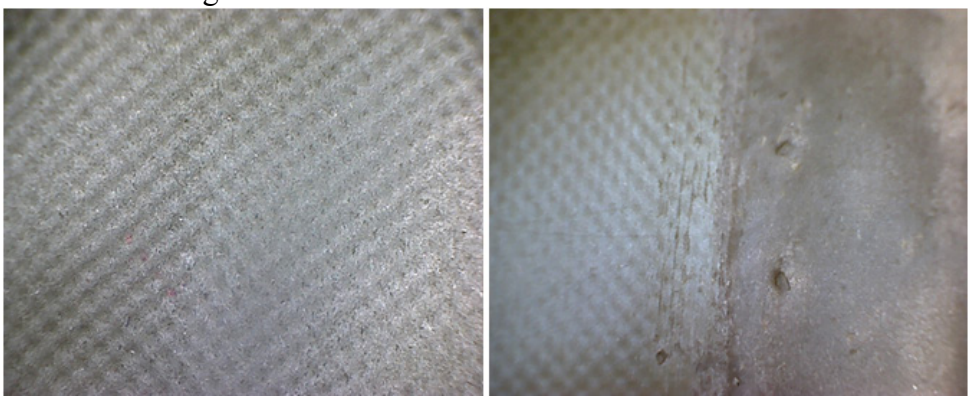

Figure 3: Foil OPCH-05 after three decontamination cycles performed with ODS-4 (light isolative foil, right the seam after the effect of the decontamination mixture)

After completing the 7th till the 10th decontamination cycle samples of the tested isolative foil have embodied tiny erosion of their surface. This state could be caused with mechanical effects of the paintbrush within coating decontamination mixture mainly on the surface of the foil without the seam (figure 4). It has been observed that just from the 6th decontamination cycle the surface of the tested isolative foil was smoother on the touch. This finding can be connected with the fact that after repeated coating of the decontamination mixture on the surface of tested material has come to surface homogenization of samples with the effects of the paintbrush. Furthermore it is possible to assume that on the surface of samples have remained rests of detergent which was not completely removed after rinse. Its presence on the surface could fill surface pores and thus to smooth the surface with unification of surface structure.

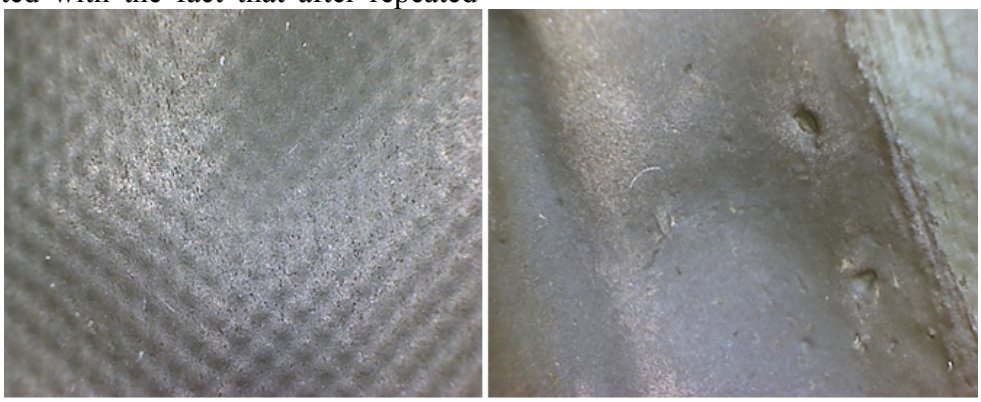

Figure 4: Foil OPCH-05 after ten decontamination cycles performed with ODS-4 (light isolative foil, right the seam after the effect of the decontamination mixture)

Negligible influence of decontamination mixture ODS-4 on protective properties of tested isolative protective foil has shown itself even after performed test with MIKROTEST method. The rate of dependence of the BTT on the number of decontamination cycle is visible from the chart 5. The value of BTT of the clear sample is approximately 399 minutes. This time is declared by the producer and has been confirmed with MIKROTEST method in the framework of performed experiment. The values of BTTs after performing the 1st till 10th decontamination cycle moved in the scope from 400 till 460 minutes. Based on linear analysis of measured values of BTTs it is possible to observe mild increase of BTT in connection with the number of performed decontamination cycles. This increase could be caused with gradual creation of the layer of detergent ALFA or reaction waste production originated from mutual incidence of detergent ALFA with the polymeric layer which could cleave on the surface of samples. It is possible to assume that after next decontamination cycles has come to further increase of the thickness and thus to increase of the thickness of samples. These changes had probably the consequence that the difference between BTT measured after the 1st and 10th decontamination cycle is 20 minutes, thus approximately 4,5 %. Regarding this finding it is possible to state that the change of BTT is minimal after 10 decontamination cycles and that it is not possible to claim that the effect of the decontamination mixture positively or negatively influence the change of BTT still better that comes to its mild increase. Based on consideration of appearance of samples of tested material and their orientation consideration from the mechanical and usable properties point of view it is possible to state that samples were more homogenous of their surface and that decontamination mixture ODS-4 does not influence usable properties of tested material.

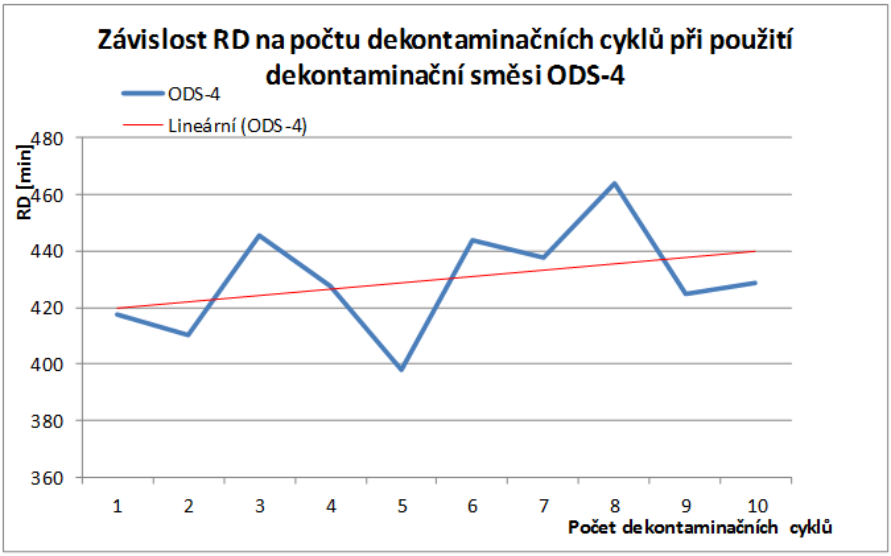

Figure 5: Rate of dependence of change of BTT of tested material of the isolative protective foil OPCH-05 after repeated decontamination with decontamination mixture ODS-4

6. Conclusions

Providing high level of the CAF CCs´ specialist protection against the effect of toxic compounds which fall into the category of CWAs and TICs is one from basic presumptions for fulfilment of sophisticated tasks. One from typical tasks which are in a sponsorship of the CAF CCs is performing of thorough decontamination with the employment of liquid decontamination mixtures which are established in its armament. Regarding heterogeneousness of composition of single decontamination mixtures it is necessary to devote an effort to study potential effects of established mixtures on the change of protective properties of isolative protective garment of the CAF CCs specialists.

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