

**IDENTIFICATION OF
CHROMATOGRAPHIC PARAMETERS
FOR BLISTER AGENTS IN THE
LOW DIESEL OIL
CONTAMINATION**

**HÓLYAGHÚZÓ HARCANYAGOK
GÁZKROMATOGRÁFIÁS
PARAMÉTEREINEK AZONOSÍTÁSA
ALACSONY
DÍZELOLAJSZENNYEZETTSÉG MELLETT**

NAGY Rudolf¹

Abstract

Thanks to the ongoing conflict in the Eastern region of Europe and the resulting confrontation between the great powers, the danger of a potential conflict involving the use of chemical weapons has also increased. After all, this is only one step away from organizing provocations intended to justify the use of chemical weapons and presenting them to the public in the media. So, in the new wars that broke out in the conflict zones of the world because of power struggles, there were more and more signs that the opposing parties were seriously considering the possibility of developments moving in this direction. In addition, terrorist organizations have already acquired the ability to produce this type of weapon. Thus, initiatives aiming at the development of high-sensitivity, fast analytical methods suitable for detecting these substances even from contaminated samples have received significant emphasis.

Keywords

warfare agents, diesel oil, GC, Lewisite, sulfur mustard

Absztrakt

Köszönhetően Európa keleti régiójában jelenleg is zajló konfliktusnak és az ennek nyomán fokozódó, a nagyhatalmak közötti szemben állásnak megnőtt a veszélye egy vegyifegyverek alkalmazásával végrehajtott esetleges összeütközés lehetőségének is. Hiszen ez már csak egy lépésre van a vegyi fegyverek bevetését igazolni szándékozó provokációk megszervezésétől és annak a közvélemény számára médiában történő tálalásától. Tehát a világ konfliktus övezeteiben a hatalmi viszályok nyomán kiobbantott újabb háborúkban egyre több jel utalt arra, hogy a szembenálló felek komolyan számolnak a fejlemények ilyen irányba történő elmozdulásának lehetőségével. Ráadásul e fegyverfajta előállításának képességére a már a terrorszervezetek is szert tettek. Így ismételten jelentős hangsúlyt kaptak az ezen anyagok akár szennyezett mintákból történő detektálására is alkalmas, nagy érzékenységgű, gyors elemző módszerek fejlesztését célzó kezdeményezések.

Kulcsszavak

mérgező harcanyag, diesel olaj, GC, Lewisite, kénmustár

¹ nagy.rudolf@uni-obuda.hu | ORCID: 0000-0001-5108-9728 | habil. senior lecturer, Óbuda University, Donát Bánki Faculty of Mechanical and Safety Engineering, Budapest, Hungary | habil. adjunktus, Óbudai Egyetem, Bánki Donát Gépész és Biztonságtudományi Mérnöki Kar

INTRODUCTION

Although in recent decades the confrontation between the states that were at the forefront of the development of intensive chemical weapons has begun to ease, today we can see the reawakening of the previous antagonisms. The confidence-building steps that started the disarmament processes that brought significant results at the time completely dissipated and were replaced by considerations ready to intensify the confrontation. In addition to creating tension, very disconcerting news is coming from the conflict zones, which suggests that not all actors wish to submit to the intention to limit the spread of chemical weapons. These unfavorable signs prompted me to publish the previously unpublished results of my experiments conducted in the early 90's in the framework of training at the military CBRN department. These results were indeed obtained in my previous experiments as part of my thesis, but the applied validated methodology also makes it possible to reproduce and compare them in today's researches. [1]

Similar to the desperate battles in the battlefield reports we have seen now, we have already seen in other conflict zones of the world, as a result of which a party hoped to seize the strategic initiative from the deployment of chemical weapons in more than one case. However, the initial use of surprise strikes with local targets always resulted in extensive mass deployments. Many toxic munitions thus released onto the battlefield can often claim their victims not only during the period of direct military conflict but also long after. As shown by the confirmed degenerative changes in the population caused by the massively applied vegetation-destroying toxic warfare agents after the Vietnam War. Of course, in this case, the dioxin left over from the preparation is held responsible as a substance that permanently pollutes the soil, which does not qualify as a chemical weapon according to international conventions. [2]

However, we also find similarly stable, long-lasting types of toxic warfare agents in a wide range of chemical weapons, such as, for example, blistering compounds, starting from sulfur mustard to nitrogen mustard and including phosgene oxime, as well as recipes made by combining them. Sulfur mustard and lewisite occupy a prominent place in this category. Both have been known since the beginnings of extensive battlefield chemical warfare in the First World War. [3]

This early realization, however, aroused the interest of the Spanish, Japanese, and Italian nationalist leaders who were reviving their colonialist aspirations, and wanted to offset the numerical superiority of the masses of the Moroccan, Manchurian, and Ethiopian national resistance. [4] [5]

Our experience since then has also shown that the applicability of blister agents is significantly affected by environmental conditions. However, the increased environmental stability of the chemical substances classified in the category of these munitions has given these compounds a particularly great military importance in terms of the capture of the troops located in the combat activity area affected by the chemical attack, causing a decrease in their military capability. In addition, we can count on possible pollution of this kind in the case of accidental emissions following attacks on chemical weapons manufacturing facilities. As a result, their so-called persistence is permanent, producing environmental pollution that appears long after the end of the military conflict. [6]

As a result of the discouraging experiences on the battlefield, they were not deployed during the Second World War, despite the considerable amount of stockpiled on

the European battlefields on both sides. However, certain contingents of the arsenal, which did not fulfill their purpose at the time, have retained their potential danger to this day, as shown by the example of the thousands of tons of munitions filled with war material sunk into the Baltic Sea. [7]

Similarly, easily identifiable pollution can be found on the training grounds serving as the scene of combat exercises carried out with sharp, toxic munitions. Due to the repeated pollution here for decades, zones indicating the enrichment of toxic munitions, which often show a significant concentration, can be found even down to the deeper layers of the soil, which can, by definition, also affect the surface waters. We have precisely developed procedures for the risk assessment of pollution causing environmental hazards in these areas. [8] [9]

Given that some of the toxic munitions and their decomposition products have a corrosive effect on the structural materials of the stored ammunition. The rate of even this structural damage is relatively low, but due to the typically long storage cycle, the corrosion process can lead to contamination caused by unexpected damage. Although these factors are indeed considered during the development of the military-technical parameters of the toxic munitions intended for use or of the recipes combined with their additives, as well as strict and regular inspections are required by military standards during long-term storage. [10]

The elaborated storage provisions are created by considering many factors. As can be deduced from the previous ones, the duration of storage of the blistering agents also depends on the possible technological impurities in them, i.e., the degree of purity of the product. In general, we can consider that the cleaner the munitions are, the longer they can be stored. Therefore, for example, in the case of technical sulfur mustard produced in countries that do not have the appropriate production technology, damage to the chemical warfare material may be more likely than if it were replaced with distilled sulfur mustard. By adding stabilizers, the storability of toxic warfare agents and their mixtures can be increased. Safe storability can be further enhanced by adding stabilizers, but even so, chemical weapons stockpiles are renewed after the cycle time determined by the manufacturer's quality inspections. Stocks of ammunition with an expired storage period are subject to review based on military-technical requirements, and non-compliant stocks are disposed of using special procedures. [11]

As it is well known, in such battlefield conditions, the weapons technology devices that make up chemical weapons are gradually exposed to changing environmental effects. Of course, despite the relevant military logistics regulations at resupply and temporary supply points aimed at serving combat activities, it cannot be ruled out that there may have been contamination from leakage. Not to mention the strikes on chemical munitions stocks in combat conditions, which can also contaminate those preparing to deploy the munitions themselves. [12]

Unused chemical weapons stockpiles destined for destruction pose additional challenges for highly toxic vesicular agents. The technologies developed for this carry the risk of exposure due to the disintegration of weapons materials, as well as munitions that may be released into the environment through possible technological disruptions. In this case, it is essential to use detection procedures that ensure adequate and continuous control. [13] [14]

However, it is not always so obvious to identify the presence of toxic warfare agents. This can primarily occur in environments where the toxic munitions may have been present in much lower concentrations, such as traces found on surfaces in contact with toxic munitions left over from the illicit trade of chemical weapons containing toxic munitions. [15] The hidden nature makes detection even more difficult if the use of toxic munitions must be justified in the investigation of the implementation of special secret service operations against terrorist organizations. [16]

However, even its occasional use in a covert or unrecognized manner on the battlefield or against the civilian population can often only be reconstructed from samples containing hard-to-identify remains. [17] Proof of this can be particularly important to validate possible war crimes. Credibility in such matters is a fundamental condition in the subsequent evidentiary procedure, where the fact of guilt can only be supported with irrefutable evidence. [18] In the case of war crimes that violate international law, it is possible to consider the factors of chemical degradation caused by the time lag in sampling that takes place long after the events, which in itself is a big challenge. [19, 20]

Not only these but the disturbing effects of pollution that can generally occur in the area affected by the fighting must also be faced during detection. Among these, the most frequently found pollutant components come from hydrocarbon derivatives. This is especially true when we consider that oil mists are popularly used on the battlefield to conceal enemy visual observation. During their settling, these dispersed fogs cover a large area of the battlefield. [21]

Therefore, the extremely important goal of this work is to determine the test parameters for gas chromatographic identification of sulfur mustard and lewisite blistering munitions, which enable their separation in the presence of hydrocarbon derivatives. Thanks to its high sensitivity and the fact that it can be easily reconstructed in the field, the gas chromatography method was chosen as the test method of choice in this study. The evaluated results in this way can be called up at any time and compared with the results of others. [22]

MATERIAL AND METHOD

During the training of chemical defense military officer students, the samples were based on the preparations of the mentioned compounds used in their chemical laboratory exercises for analytical reports, synthesized for training purposes by their own process. For the analysis of lewisite, the L-1 version was used. To determine the sulfur mustard, I worked using a distilled, highly pure product. This solvent is excellent at dissolving both the warfare agents and the diesel oil components used as contaminants in the test. For both substances, instead of the chemically pure state, I performed the measurements with their samples dissolved in an organic dichloromethane solvent. Test substances should be used at approximately 100-fold dilution to simulate low contamination. Adherence to the appropriate dilution ratio is important from the point of view of the effective evaluation of the peaks appearing in the chromatogram according to material components.

The use of the dichloromethane solvent during the measurements is justified by its low retention time and its applicability as an organic solvent proven in other tests. I simulated the oil spill with a mixture of the less volatile members of the saturated open-chain alkane series with 9-12 carbon atoms (nonane, decane, undecane, and dodecane). The use

of personal protective equipment was essential for the safety of the laboratory work, as well as the disinfection of the used equipment with a calcium hypochlorite solution after the measurement.

The use of personal protective equipment was essential for the safety of laboratory work, as was the decontamination of the instruments used with a calcium hypochlorite solution after the measurement was completed.

INSTRUMENTATION

I used an AMS Model-93 gas chromatograph for the determinations. This is a programmable, flame ionization detector equipped with a nitrogen carrier gas, and copper column, made in England. The 1.8 m long, 4 mm diameter separation column is filled with silicate material marked Chromosorb W-HP/100-120/, moistened with 4% SE-52 and 6% OV-210 separation fluid. The wetting fluid is chemically stable up to 300 °C. We can adjust the temperature of the column with an accuracy of ± 1 Co using a program. Thus, we had the opportunity to produce specific heat shocks. On the other hand, the temperature of the injector could be recorded electronically or manually with an accuracy of ± 50 Co. The syringe was a precision design, GL SGE (microfine) type.

With the help of the parameter adjustment system, it is possible to adjust the pressure of the gases coming from the gas tanks and to program the temperature of the injector and the column. The gas flow can be adjusted manually with an accuracy of ± 10 Pa. The H₂ and O₂ gas bottles are connected to the flame ionization detector, in the flame of which the tested sample is ionized. The instrument system used for the determination consists of the main components shown in Figure 1.

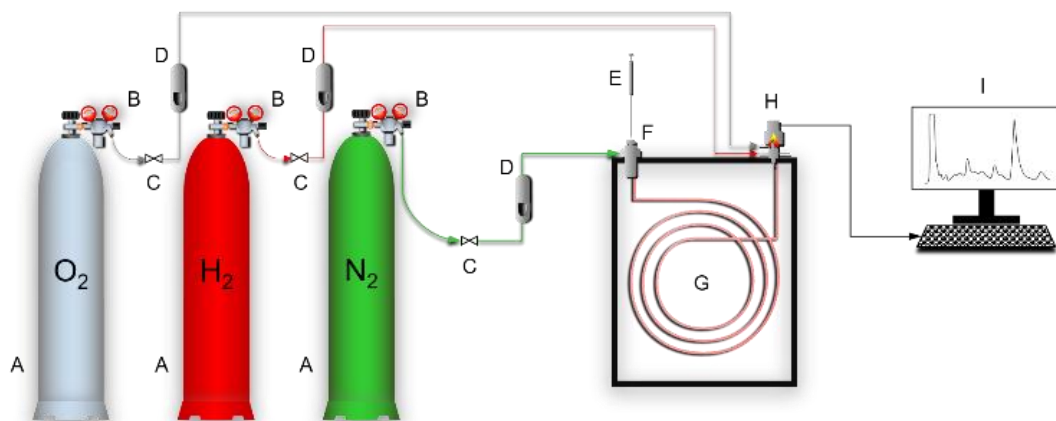


Figure 1: Schematic diagram of GC equipment

Source: Edited by the author

A – Gas Cylinders, B – Gas Regulators, C – Pressure Regulators, D – Flow Controllers, E – Syringe, F – Injector, G – Column, H – Detector; I – Display System

For all GC determinations, I used signal processing software connected to an IBM AT personal computer gas chromatography. The program supporting the evaluation of the signals from the gas chromatograph was the LabChrom software of Labinform Kft.

ANALYSIS

Blistering toxic agents retain their effect for a longer or shorter period on the surface of the materials that come into contact with them or by being absorbed into them. To identify the permanent presence of the toxic substances that cause chemical pollution, various technical procedures have been developed in accordance with the goals to be achieved based on the detection of chemical pollution. A fundamental distinction between these results from the evaluation of the presence of toxic substances. Based on this, two main categories can be distinguished: subjective and objective methods.

Using subjective methods, we establish the presence of toxic substances through indicators. In many cases, non-organizational chemical reconnaissance soldiers must establish the presence of toxic substances in battlefield conditions without special chemical expertise. The participants learn chemical protection knowledge for handling the reconnaissance devices used for this purpose within the framework of a simple course. This typically means methods using detection tubes or paper test strips that show a color change following sampling from the polluted air using hand pumps, as illustrated in the following Figure 2. To monitor the color change, the reaction between the reagent with a non-obscuring base color and applied to the adsorbent placed in the detection tubes and the toxic warfare agent during the color change forms the basis of the detection. [23]



*Figure 2: Examples of detection tubes (VFK-66)
Source: Compiled by the author.*

At the same time, it should be noted that the toxic munitions adsorbed in this way may also be suitable for determining exposure values by interposing gas chromatographic analysis following dissolution by the appropriate method. However, to carry out the analytical work, sampling and sample handling carried out with sufficient precision are required, for which it is necessary the involvement of properly trained personnel. [24]

Objective methods require more sophisticated training and involve procedures supported by advanced laboratory techniques. They can use all the techniques available in modern analytical laboratories [25] Gas chromatography techniques, which follow a technology supported by standardised sampling procedures, are a prominent tool in military field or mobile chemical defence laboratories. [26]

The methods used here, based on the requirements of rapid detection and control of the chemical situation, make it essential to have the results in the database, which are the

basis for a pre-laid comparison based on research. The optimization study of the GC parameters carried out during this research was intended to ensure the fulfillment of the mentioned goals.

CONCEPT FOR THE MEASUREMENT PROCEDURE

When determining the optimal parameters, I used members of the linear unsaturated alkane series with 12 carbon atoms, as I concluded from the literature data that the retention time of Lewisite and sulfur mustard falls within the range limited by the above-mentioned hydrocarbons [27] [28] [29]. At the beginning of the determination of the optimum, the starting parameters were planned to be set as follows:

- carrier gas pressure (N₂): 1.24×10^5 Pa
- column temperature: 250 °C
- injector temperature: 200 °C

In the future, I planned to reduce the column temperature by 50 °C, then adjust the values obtained by halving the temperature range. After determining the optimal temperature, I planned an increase or decrease of 1×10^3 Pa in the pressure of the carrier gas. I set the measurement execution time to 3 minutes, because the proper separation, and therefore the proper evaluation, can be achieved in this time by determining the optimal parameters. The other important factor that I considered when determining the duration of the measurement is that we need fast data provision during practical use.

RESULTS AND DISCUSSIONS

It is an important observation that real samples are often contaminated with diesel fuel due to the fuel of combat and motor vehicles and other pollution sources already mentioned. Therefore, it is necessary to base the tests based on the analysis of the mixed samples of the interfering gas oil components, using the experimental conditions given by the choice of the standard measurement parameters.

I optimized the parameters of the measurement by dissolving a volume of 0.15 ml of the mixture of paraffin of the linear unsaturated alkane series with carbon numbers C₉-C₁₂ used for the measurements in 5 ml of solvent. The volume injected was 0.3 µl each time. Examining the effectiveness of the separation of the n-alkane components on the chromatograms, I found that the column temperatures of 250 °C, 200 °C and 150 °C are not suitable for the separation of the components. While the measurements performed at 140 °C showed well-appreciable differentiated peaks. Having recorded the obtained value on the device, I started recording the chromatogram of the substances to be tested. I fixed the parameters of the optimization as 1.245×10^5 Pa in terms of N₂ gas pressure.

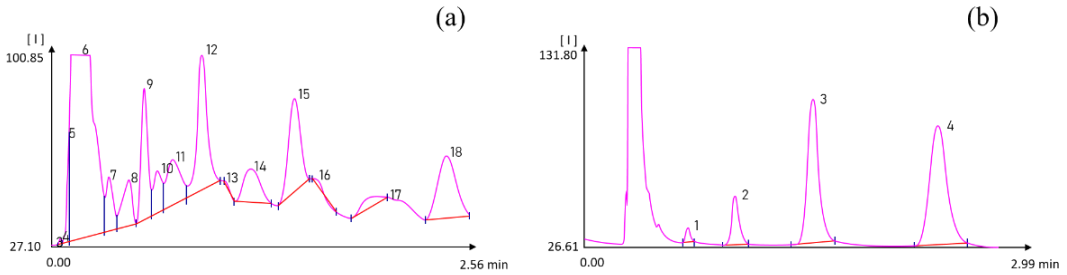


Figure 3: Chromatograms of diesel fuel matrix (a) and linear unsaturated alkanes standard (b)

N ^o	9.	12.	15.	18.
Component name	nonane	decane	undecane	dodecane
Retent.: (min)	0.69	1.00	1.52	2.36
Height: (I)	50.72188	52.81673	35.92736	23.72249
Rel.Hgt.: (%)	4.93	5.14	3.49	2.31
Integral: (min×I)	127.4935	207.4846	163.6285	165.2154
Rel.Int.: (%)	2.78	4.52	3.56	3.68
Int/Hgt.: (min)	2.514	3.928	4.554	6.965
Plate number:	1067	466	1287	1502

Table 1: Peak detection parameters of diesel fuel matrix (a)

N ^o	1.	2.	3.	4.
Component name	nonane	decane	undecane	dodecane
Retent.: (min)	0.696	1.011	1.528	2.368
Height: (I)	7.571232	25.89466	76.04636	63.08492
Rel.Hgt.: (%)	4.39	15.00	44.06	49.79
Integral: (min×I)	17.17122	89.91157	397.4881	500.2577
Rel.Int.: (%)	1.71	8.95	39.56	49.79
Int/Hgt.: (min)	2.268	3.472	5.227	7.930
Plate number:	1252	551	428	709

Table 2: Peak detection parameters of linear unsaturated alkanes (b)

Source: Compiled by the author.

The solvent identified by the number 6 in Figure 3(a) was not marked with a separate numerical value in the subsequent diagrams. Given that, thanks to its successful selection, it gave a signal producing an early elution without disturbing effects in the further stages of the analyses. By evaluating the characteristic peaks obtained from the data of the detected samples from diesel oil and appearing in the chromatograms of Figure 3(a), the retention times of pure n-alkanes, which are present in relatively large amounts and are also evaluated separately in Figure 3(b), are the four main diesel components, later, I performed the analysis of toxic munitions. The values obtained for the retention times of the peaks appearing in the mixture of the tested n-alkanes were obtained from the sample population as very close results that can also be read in Tables 1 and 2:

- Rfc₉= 0,689 min
- Rfc₁₀= 1.005 min

- $R_{fc11} = 1.522$ min
- $R_{fc12} = 2.361$ min

In order to record the basic values, I also carried out the pollution-free identification of Lewisite and sulfur mustard toxic munitions. In the volume composition of the solutions of the samples used here, the solvent was 0.5 μ l. For this, in the case of Lewisite, the stock solutions used in the samples were prepared by dissolving 0.06 μ l of t and then, leaving the amount of solvent unchanged, 0.09 μ l of sulfur mustard. In each case, 0.3 μ l of the solutions prepared in this way were injected per measurement.

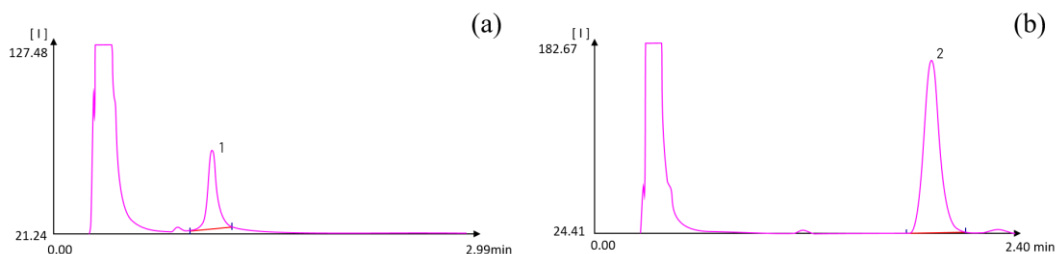


Figure 4: Chromatograms of Lewisite (a) and sulfur mustard (b) with solvent

N _o	1.	2.
Component name	Lewisite (L ₁)	Sulfur mustard (H)
Retent.: (min)	1.114	1.894
Height: (I)	43.88408	144.9692
Rel.Hgt.: (%)	100.00	100.00
Integral: (min×I)	199.7884	914.1168
Rel.Int.: (%)	100.00	100.00
Int/Hgt.: (min)	4.553	6.306
Plate number:	239	520

Table 3: Peak detection parameters of Lewisite (a) and Sulfur mustard (b)

Source: Compiled by the author.

Evaluating the previously illustrated chromatograms, we can identify the following retention times for Lewisite in Figure 4(a) and sulfur mustard in Figure 4(b) (see Table 3.):

- $R_{fL_1} = 1.097$ min
- $R_{fSM} = 1.897$ min

After taking the chromatogram of the pure components and determining their retention time, the mixed samples were identified.

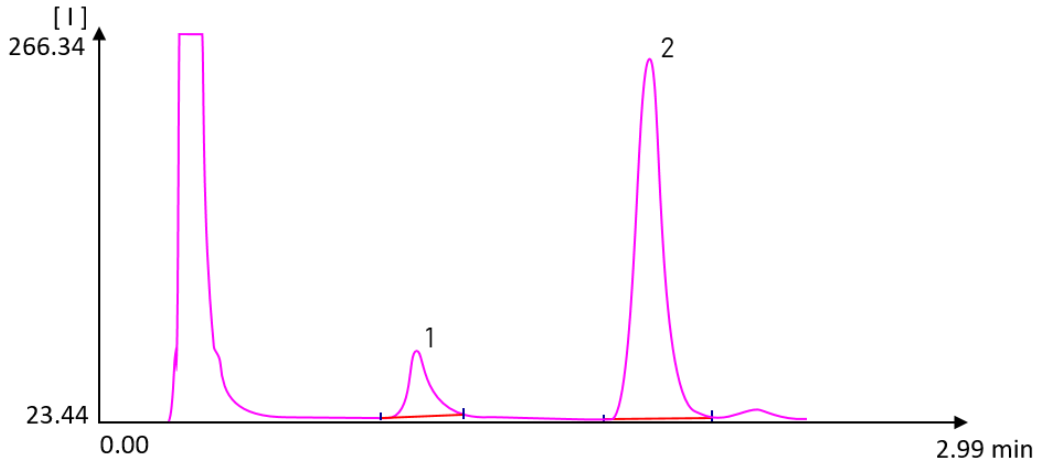


Figure 5: Chromatogram of Lewisite and sulfur mustard mixture

№	1.	2.
Component name	Lewisite (L ₁)	Sulfur mustard (H)
Retent.: (min)	1.098	1.894
Height: (I)	41.65199	228.7282
Rel.Hgt.: (%)	15.40	84.60
Integral: (min×I)	216.3628	1493.571
Rel.Int.: (%)	12.65	87.35
Int/Hgt.: (min)	5.195	6.530
Plate number:	242	414

Table 4: Peak detection parameters of Lewisite and Sulfur mustard mixture
Source: Compiled by the author.

The chromatogram in Figure 5 clearly shows sufficient undisturbed separation (Table 4.) even in the simultaneous presence of both toxic warfare agents, which predicts their separability in samples contaminated with diesel.

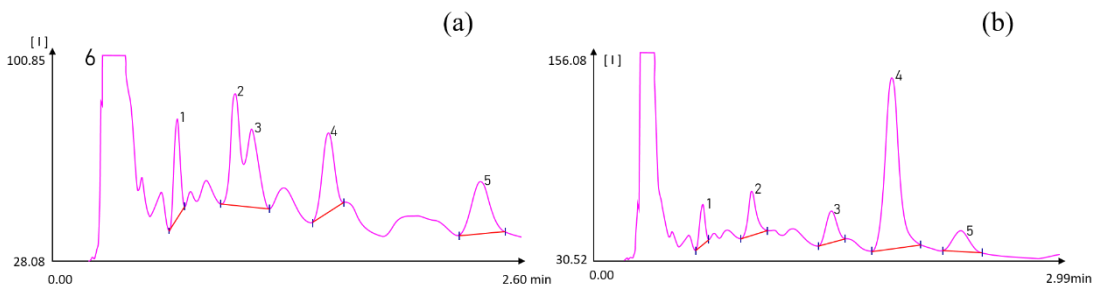


Figure 6: Chromatograms of Lewisite (a) and sulfur mustard (b) in diesel fuel matrix

№	1.	2.	3.	4.	5.
Component name	nonane	decane	Lewisite (L ₁)	undecane	dodecane
Retent.: (min)	0.681	1.002	1.097	1.523	2.373
Height: (I)	50.68088	57.03175	39.73513	40.05063	26.54458
Rel.Hgt.: (%)	23.68	26.64	18.56	18.71	12.40
Integral: (min×I)	117.2078	203.8490	190.6917	188.2663	190.4229
Rel.Int.: (%)	13.16	22.89	21.42	21.14	21.39
Int/Hgt.: (min)	2.313	3.574	4.799	4.701	7.174
Plate number:	1067	998	912	1199	1360

Table 5: Peak detection parameters of Lewisite in diesel fuel matrix (a)

№	1.	2.	3.	4.	5.
Component name	nonane	decane	undecane	Sulfur mustard (H)	dodecane
Retent.: (min)	0.694	1.011	1.522	1.906	2.362
Height: (I)	24.92676	27.11155	19.46072	103.5742	12.57546
Rel.Hgt.: (%)	13.28	14.45	10.37	55.20	6.70
Integral: (min×I)	56.48465	99.81961	89.19949	660.4343	93.24816
Rel.Int.: (%)	5.65	9.99	8.93	66.10	9.33
Int/Hgt.: (min)	2.266	3.682	4.584	6.376	7.415
Plate number:	1108	564	1335	579	1377

Table 6: Peak detection parameters of sulfur mustard in diesel fuel matrix (b)

Source: Compiled by the author.

The peaks of the diesel components can be clearly identified on the emerging chromatograms. The appearance of Lewisite is consistent with literature sources between C₁₀ and C₁₁ in Figure 6(a). However, Lewisite, which appears here as peak 3, can be isolated with sufficient certainty by evaluating the chromatogram. However, the elution of the C₁₀ component of the diesel occurring here somewhat masks the Lewisite, which is well reflected by the very close retention times of the two components (Table 5).

At the same time, sulfur mustard, consistent with its longer-lasting battlefield persistence identifiable from military literature data, appeared much later and was clearly discernible. As can be read from Figure 6(b), sulfur mustard was detected in the range between C₁₁ and C₁₂ diesel oil components. This presupposes that it provides a suitable basis for detection from diesel-contaminated samples even in lower relative quantitative conditions.

However, sulfur mustard and Lewisite are used in military practice as so-called viscous mustard for greater persistence and adhesion. I also examined their simultaneous detectability with the polluting diesel oil in a mixed sample.

Among the signals transmitted by the detector, the peak of sulfur mustard stood out because it was present in high purity and in relatively larger quantities than the diesel components. An important factor was also the fact that were the peak of sulfur mustard appeared, there is no peak from interfering diesel components.

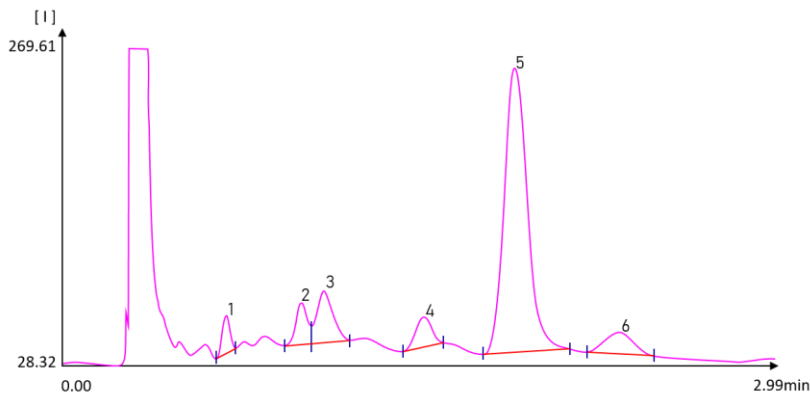


Figure 7: Chromatogram of Lewisite and sulfur mustard mixture in diesel fuel matrix

No	1.	2.	3.	4.	5.	6.
Component name	nonane	decane	Lewisite (L ₁)	undecane	Sulfur mustard (H)	dodecane
Retent.: (min)	0.683	1.001	1.097	1.516	1.897	2.344
Height: (I)	28.65878	31.41221	39.24110	22.66326	217.4166	16.49500
Rel.Hgt.: (%)	8.05	8.83	11.03	6.37	61.09	4.63
Integral: (min×I)	65.38900	108.3167	185.2154	105.4823	1413.764	130.8322
Rel.Int.: (%)	3.25	5.39	9.22	5.25	70.37	6.51
Int/Hgt.: (min)	2.282	3.448	4.720	4.654	6.503	7.932
Plate number:	1125	1256	725	1309	442	1088

Table 7: Peak detection parameters of Lewisite and sulfur mustard in diesel fuel matrix

Source: Compiled by the author.

In the final phase of the analysis of the samples, I examined the mixture of diesel Lewis and sulfur mustard. For the stock solution to be used as a sample, I dissolved 0.3 ml of gas oil, 0.15 ml of sulfur mustard, and 0.06 ml of Lewisite in 5 ml of solvent.

Figure 7 shows the chromatogram of the mixture of the examined blister-inducing toxic warfare agents in a diesel oil matrix. Evaluating the chromatogram, it can be established that, in line with military combat practice, the chromatogram is dominated by sulfur mustard, which is also quantitatively dominant in viscous mustard. In this case, too, Lewisite was eluted in the ranges between C₁₀ and C₁₁, while sulfur mustard was eluted in the ranges between C₁₁ and C₁₂ alkanes. According to the retention times that allow the identification of the individual components, I found that the detection peaks characteristic of the two investigated blister-inducing toxic munitions can be seen at the same time. Even then, Lewisite is still partially eluted with the C₁₀ component.

VALIDATION OF SIMULTANEOUS DETECTION

Simultaneous detection with C₉-C₁₂ alkanes found in diesel oil made it possible to use the retention times of Lewisite I and sulfur mustard to create comparability of the results obtained by determinations with various measurement parameters. For this purpose, based

on the retention times obtained with the same settings for C₉-C₁₂ linear unsaturated alkanes, I determined the Kováts retention time of Lewisite and sulfur mustard:

Kovats retention index of Lewisite (**I_{L1}**):

$$I_{L_1} = 100 \cdot n_{C_{10}} + 100 \cdot \frac{\lg \frac{Rf_{L_1}}{Rf_{C_{10}}}}{\lg \frac{Rf_{C_{11}}}{Rf_{C_{10}}}}$$

Where:

- $n_{C_{10}} = 10$
- $Rf_{L_1} = 1.097$ min
- $Rf_{C_{10}} = 1.005$ min
- $Rf_{C_{11}} = 1.522$ min

$$I_{L_1} = 100 \times 10 + 100 \times [\lg (1.097/1.005) / \lg (1.522/1.005)] = \mathbf{1021.10}$$

Kovats retention index of sulfur mustard (**I_{SM}**):

Where:

$$I_{SM} = 100 \cdot n_{C_{11}} + 100 \cdot \frac{\lg \frac{Rf_{SM}}{Rf_{C_{11}}}}{\lg \frac{Rf_{C_{12}}}{Rf_{C_{11}}}}$$

- $n_{C_{11}} = 11$
- $Rf_{SM} = 1.897$ min
- $Rf_{C_{11}} = 1.522$ min
- $Rf_{C_{12}} = 2.361$ min

$$I_{SM} = 100 \times 11 + 100 \times [\lg (1.897/1.522) / \lg (2.361/1.522)] = \mathbf{1150.16}$$

CONCLUSION

In modern chemical detection, a series of tools and chemical sets help us to perform the analysis of toxic munitions samples taken from the impact surface. However, the effectiveness of their tests to be carried out under field conditions is fundamentally influenced by the preliminary laboratory tests on which they are based.

However, during possible chemical disasters, the most important thing is quick identification in the field, because the time advantage they provide can save many lives through a successful analysis. In recent decades, almost all military chemical defenses, and at the civil emergency reconnaissance organization, model laboratory units equipped with modern equipment, including gas chromatographs, which are suitable for the detection of toxic warfare agents used in all chemical attacks, have been regularized. The data obtained because of such tests allow us to more accurately evaluate the degree of danger caused by various toxic warfare agents by researching in detail the disturbing effects of hydrocarbons present in samples contaminated with diesel oil. It should be noted that these tests are very

necessary, as the hydrocarbons present in individual samples can easily mask the signals from toxic warfare agents during tests performed with inappropriate parameter settings.

A basic requirement for these modern methods is that the results of the measurements can be reproduced in any laboratory. The deviations caused by the characteristics of individual gas chromatography devices can be eliminated by generating the Kováts reference data generated by me. The results presented here can therefore provide a suitable methodological basis for the separate rapid detection of Lewisite-1 and sulfur mustard diesel oil polluting hydrocarbon derivatives.

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