TECHNICAL NOTE

CRIMINALISTICS

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Comparison of New Ampac Bags and FireDebrisPAK® Bags as Packaging for Fire Debris Analysis

ABSTRACT: The FireDebrisPAK® bags that were produced by Kapak were considered to be one of the best containers for fire debris. Kapak bags were discontinued; however, from July 2010, Ampac is offering a new packaging material. The aim of the presented research was to compare the properties (durability, background interferences, and permeability) of Kapak bags and packaging material offered by Ampac. The analysis was conducted by passive adsorption from the headspace with subsequent thermal desorption and analysis by GC-MS. The results proved that the properties of the compared materials are similar. Their greatest advantage is that they are impermeable for components of flammable liquids, so there is no danger of losing analytes or cross-contamination. Their one significant drawback is that they should not be exposed to temperatures above 80°C. At this temperature, they become soft, their inner layer is compromised (becomes sticky), and they emit some volatile organic compounds. Among them, there are compounds that constitute the components of some of flammable liquids.

KEYWORDS: forensic science, microtraces, fire debris, containers, background interferences, permeability, Kapak, Ampac

Containers that are most often used as a packaging for fire debris are metal cans, glass jars, and plastic bags. Each of them has advantages and disadvantages (1,2). The advantages of plastic bags are that they are more convenient than solid containers, can accept larger pieces of evidence than cans or jars, and can easily be sealed at the site. The disadvantages of plastic bags that can be found enumerated in the literature are that they leak, are afflicted with background interferences, and can easily be pierced or torn by sharp items. FireDebrisPAK® bags that were produced by the American corporation Kapak (St. Louis Park, MN) were largely recognized as one of the best containers for the collection, storage, and analysis of fire debris samples because they were free of most of the disadvantages typical for other plastic bags. They had low level of background interferences, were durable and impermeable (3–5), and were used by many American and some European services and laboratories. Unfortunately, production of these bags was discontinued. Ampac—which has since taken over the Kapak company—is offering a new material as packaging for fire debris starting from July 2010. The question arises: does this new material have similar properties and qualities as FireDebrisPAK® bags.

The aim of this research was to compare FireDebrisPAK® bags with the new material offered by Ampac. The following properties were compared: durability and purity (background interferences) in various temperatures as well as impermeability (ability to retain vapors of ignitable liquids to prevent analyte loss and possible cross-contamination).

Materials and Methods

The compared materials were roll of plastic film provided by Ampac (St. Louis Park, MN), which were cut and thermally sealed to create bags, and FireDebrisPAK® bags, which were purchased before they were discontinued. Bags were thermally sealed using an impulse sealer (TISH-400; TEW, Taipei, Taiwan). The adsorption of analytes was conducted in passive mode by placing the tubes containing Tenax TA (Perkin Elmer, Waltham, MA), in the headspace of the samples.

During the adsorption process, bags were heated in a laboratory oven equipped with a thermostat (KBC G-65/250; PREMED, Warsaw, Poland). Adsorbed analytes were thermally desorbed using the Automated Thermal Desorber (Turbo Matrix ATD; Perkin Elmer) and analyzed using a gas chromatograph with a mass spectrometer (Auto System XL and Turbo Mass Gold; Perkin Elmer) (6,7). The chromatograph was equipped with DB5-MS column (30 m, i.d. 0.25 mm, film 0.5 μm; J&W Scientific, Folsom, CA). Analyses were conducted according to the following temperature program: 40°C hold for 10 min; increase 7°/min to 120°C; increase 15°/min to 300°C; and hold for 2 min. For experiments concerning the permeability of compared bags, a mixture of diesel fuel and gasoline (1:1 v/v) was used because it represents the range of compounds that are characteristic for most flammable liquids.

Background interferences and the durability of compared bags were checked for temperatures 70°C and 90°C.

In each of the two FireDebrisPAK® bags and the two Ampac bags, two adsorption tubes were placed; the bags were thermally sealed and placed inside the oven at a temperature of 70°C for 16 h. After cooling down, the tubes were taken out, and the adsorbed compounds were analyzed using the automated thermal desorber-gas

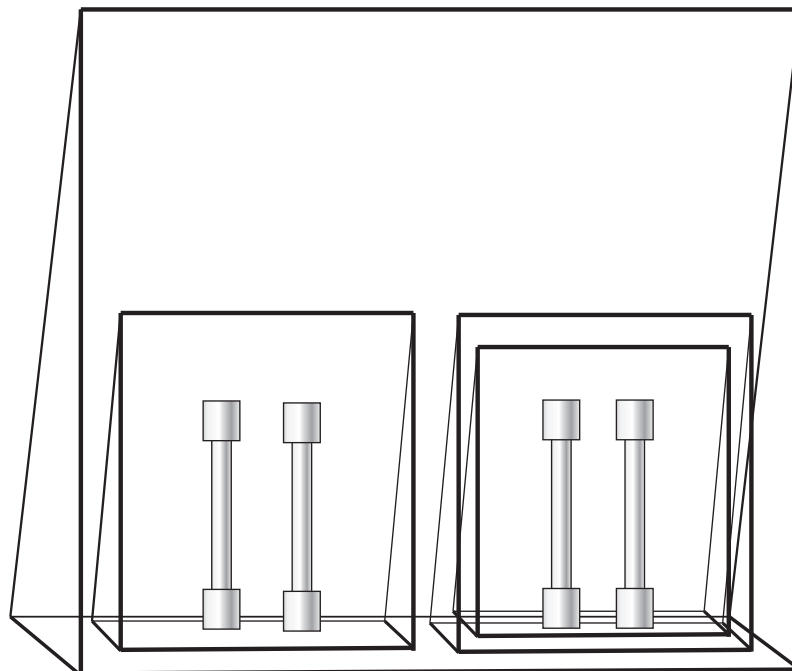[1]Institute of Forensic Research, Westerplatte 9, 31-033 Krakow, Poland.

FIG. 1—*Diagrams showing the experimental setup for permeability tests.*

chromatograph-mass spectrometer (ATD-GC-MS; Perkin Elmer) system. The working condition of the apparatus was controlled by analyzing control samples, as the first and the last in every series. Purity of the analytical system, and the adsorbent used, was monitored by analyzing blank samples—this is the adsorption tubes conditioned in the same way as the tubes, which were used for the analysis of the bags.

After the adsorption stage, the bags were inspected and compared to unused bags to check how the temperature influenced their properties.

The experiment for 90°C was carried out in a similar way.

To check whether components of flammable liquids can permeate through the single layer of examined bags (to escape from the tightly sealed bag) and to check whether it is possible for them to permeate through the double layer of examined bags (like in the case of cross-contamination), the following tests were conducted.

Two adsorption tubes were placed in an empty bag, which was then thermally sealed (set 1). Two other tubes were placed inside two bags, one inside another, both thermally sealed (set 2) (Fig. 1).
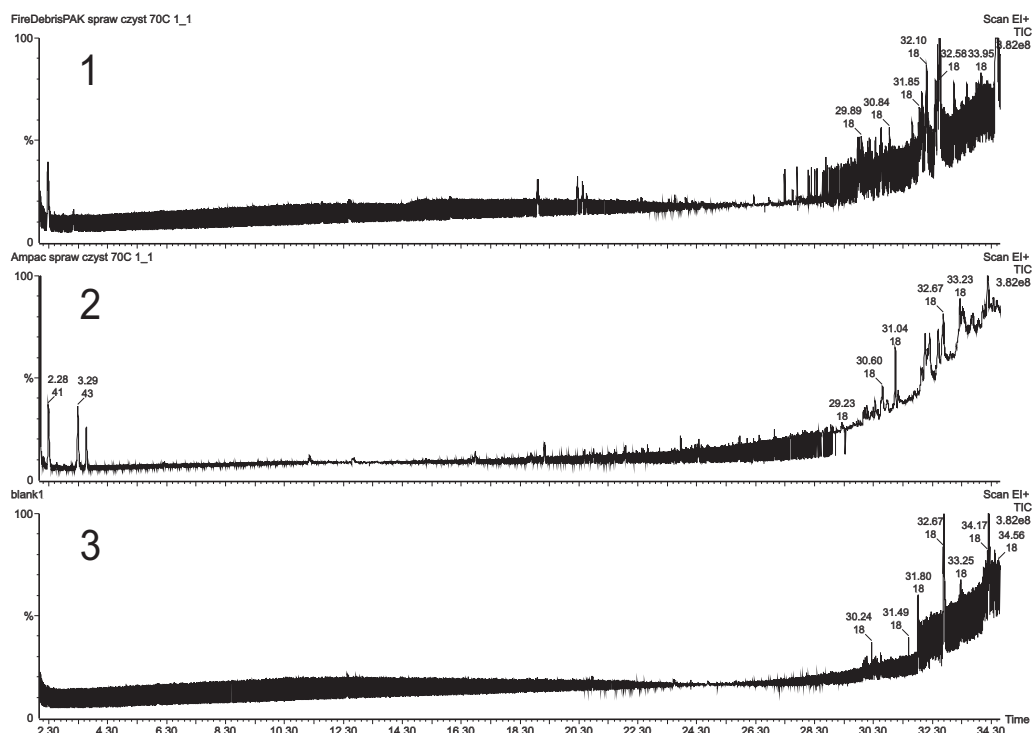

FIG. 2—*Representative chromatograms obtained as a result of experiments concerning background interferences at 70°C. 1 — FireDebrisPAK®, 2 — Ampac, and 3 — blank sample. Scale of y-axes for all three chromatograms is the same: 100% equals 3.82e8 (in number of counts).*

TABLE 1—*Volatile organic compounds emanating from FireDebrisPAK®*
bags and Ampac bags heated for 16 h at 70°C.

Retention Time (min)	FireDebrisPAK®	Ampac
2.32	3-Butenoic acid*	3-Butenoic acid
3.24	n.p.	2-Butanone
3.53	n.p.	Ethyl acetate

n.p., not present.

*Compounds were identified by searching through the computer libraries (Nist 98, Wiley 7).

Both sets were placed inside another bag, into which a 100-μL mixture of gasoline and diesel fuel was injected; the bag was immediately sealed and placed in the oven at 70°C. The experiment described above was conducted twice for the Ampac material and twice for FireDebrisPAK® bags. The results for "set 1" represent the potential loss of vapors from the material sealed in a bag. The results obtained for "set 2" represent the possibility of cross-contamination.

Additionally, a "comparison sample" was prepared: 1 μL of test mixture was injected into a bag with two adsorption tubes (this is only 1% of the amount used in the permeability test), the bag was sealed and placed in the oven heated to 70°C for 16 h. Adsorbed compounds were analyzed by ATD-GC-MS.

Results and Discussion

The analysis concerning background interferences provided four results (chromatograms) for each type of bag and temperature.

Obtained results are consistent; therefore, only exemplary chromatograms were presented for the figures.

The results for 70°C are similar for both kinds of bags—there are no background compounds that could interfere with flammable analysis. There is only one very small peak visible on chromatograms for FireDebrisPAK® (t_R = 2.3 min) and three very small peaks on chromatograms for Ampac (t_R = 2.3 min, t_R = 3.3 min, t_R = 3.6 min) (Fig. 2). Peaks were identified by searching computer libraries (Nist 98, Wiley 7). The peak on FireDebrisPAK® chromatograms was identified as 3-butenoic acid. The peaks on Ampac chromatograms were identified as 3-butenoic acid, 2-butanone, and ethyl acetate (Table 1). It should be emphasized that these peaks were so small that they would not be even noticed in real sample analysis.

Background interferences are much more intensive for adsorption conducted at 90°C (Fig. 3). Numerous peaks are present on chromatograms obtained for both kinds of bags (Table 2). Most of the compounds detected for FireDebrisPAK® and Ampac material are the same, although there are large quantitative differences. On the chromatogram for Ampac, the two largest signals are of 3-cyclohexene-1-carbonitrile and 2-ethyl-1-hexanal. For FireDebrisPAK®, these two signals are also present and belong among the largest ones, but equally intensive is a cluster of not completely resolved peaks of nonylphenol isomers. Mentioned peaks were marked in Fig. 3. Some of the detected compounds (highlighted in Table 2) are also components of some ignitable liquids. Nevertheless, their intensities are so low that they cannot interfere with the identification of flammable liquids in real fire debris samples. Most probably, on chromatograms obtained for real samples, they would not
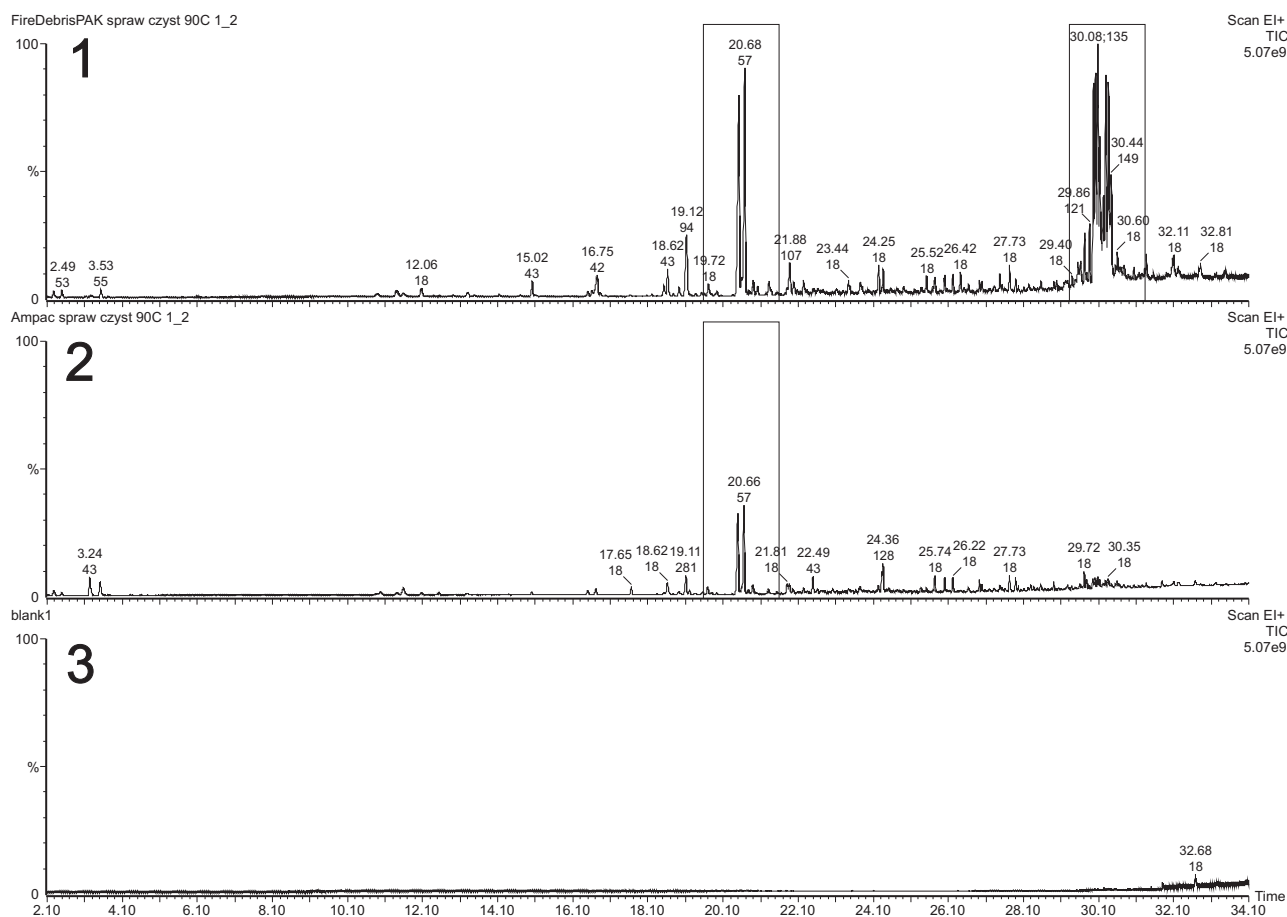

FIG. 3—*Representative chromatograms obtained as a result of experiments concerning background interferences at 90°C. 1 — FireDebrisPAK®, 2 — Ampac, and 3 — blank sample. Scale of y-axes for all three chromatograms is the same: 100% equals 5.07e9 (in number of counts).*

TABLE 2—*Volatile organic compounds emanating from FireDebrisPAK® bags and Ampac bags heated for 16 h at 90°C.*

Retention Time (min)	FireDebrisPAK®	Ampac
2.27	2-Methyl propane	2-Methyl propane
3.24	n.p.	2-Butanone
3.53	Ethyl acetate	Ethyl acetate
15.01	1-(Acetyloxy)-2-propanone	1-(Acetyloxy)-2-propanone
16.05	2-Methyl-2-cyclopenten-1-one	2-Methyl-2-cyclopenten-1-one
16.75	Dihydro-2(3H)-furanone	Dihydro-2(3H)-furanone
17.67	n.p.	Alpha pinene
18.60	3-Methyl-2-cyclopenten-1-one	3-Methyl-2-cyclopenten-1-one
19.11	Phenol	Phenol
20.50	3-Cyclohexene-1-carbonitrile	3-Cyclohexene-1-carbonitrile
20.71	2-Ethyl-1-hexanal	2-Ethyl-1-hexanal
21.92	2-Methylphenol	2-Methylphenol
24.20	2-Metoxy-4-methylphenol	2-Metoxy-4-methylphenol
24.40	Naphthalene	Naphthalene
25.51	2-Metoxy-4-ethylphenol	2-Metoxy-4-ethylphenol
25.75	1-Indanone	1-Indanone
26.01	2-Methyl naphthalene	2-Methyl naphthalene
26.20	1-Methyl naphthalene	1-Methyl naphthalene
26.42	2,6-Dimetoxyphenol	2,6-Dimetoxyphenol
27.70	1-Dodecanol	1-Dodecanol
27.93	Acenaphthylene	Acenaphthylene
29.73	Propenoic acid dodecyl ester	Propenoic acid dodecyl ester
29.86	Nonylphenol isomer	n.p.
29.95	Nonylphenol isomer	Nonylphenol isomer
30.00	Nonylphenol isomer	Nonylphenol isomer
30.08	Nonylphenol isomer	Nonylphenol isomer
30.13	Nonylphenol isomer	Nonylphenol isomer
30.24	Nonylphenol isomer	Nonylphenol isomer
30.30	Nonylphenol isomer	Nonylphenol isomer
30.36	Nonylphenol isomer	Nonylphenol isomer
30.44	Nonylphenol isomer	Nonylphenol isomer

Although most of compounds are the same for both kinds of bags, there are significant quantitative differences. Good examples of those are nonylphenol isomers, which are present in both kinds of bags but are much more abundant for FireDebrisPAK®.
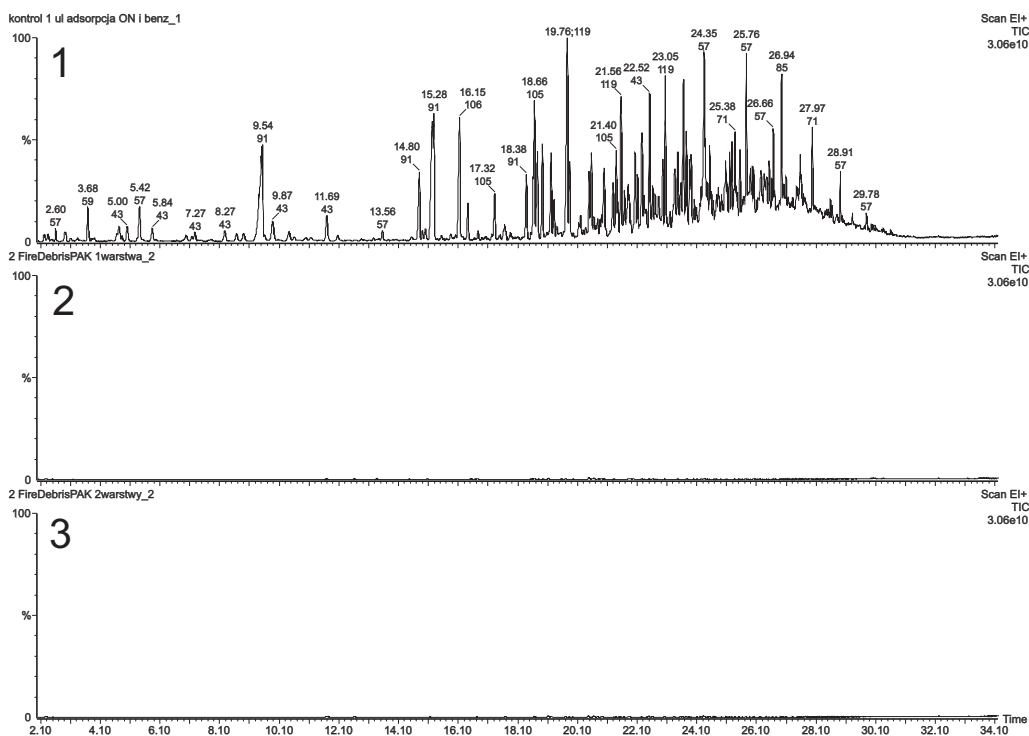

FIG. 4—*Representative chromatograms obtained as a result of permeability tests for FireDebrisPAK®. 1 — Analysis of 1 µL of test mixture, 2 — permeability of 100 µL of test mixture through one layer, and 3 — permeability of 100 µL of test mixture through two layers. Scale of y-axes for all three chromatograms is the same: 100% equals 3.06e10 (in number of counts).*

FIG. 5—*Representative chromatograms obtained as a result of permeability test for Ampac. 1 — analysis of 1 µL of test mixture, 2 — permeability of 100 µL of test mixture through one layer, and 3 — permeability of 100 µL of test mixture through two layers. Scale of y-axes for all three chromatograms is the same: 100% equals 3.06e10 (in number of counts).*
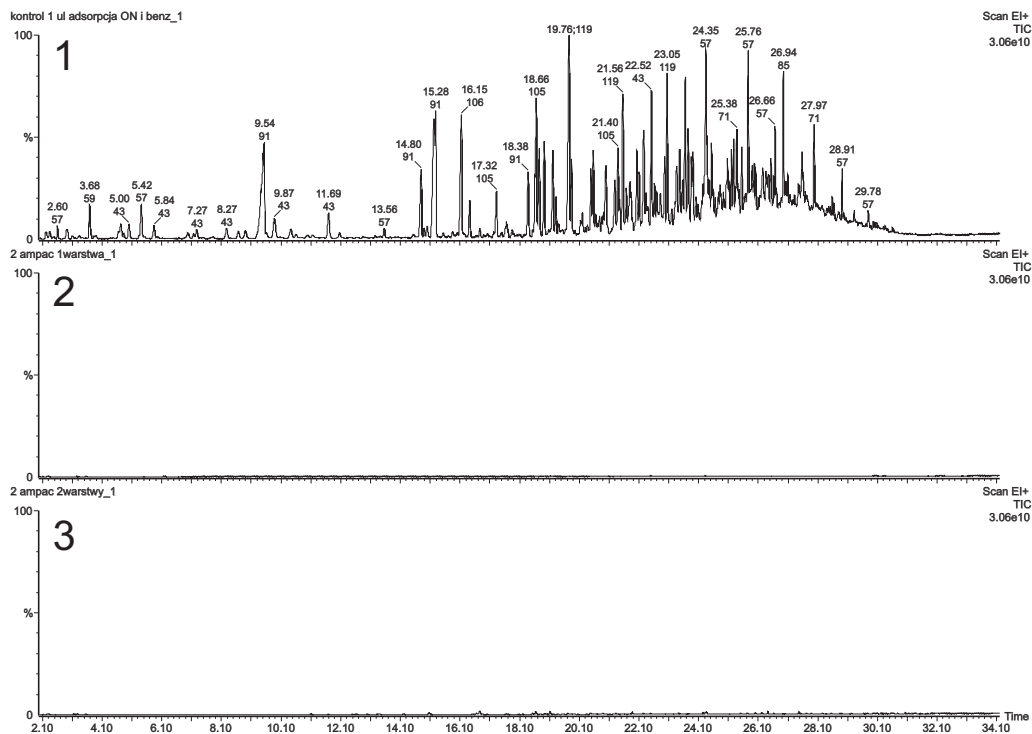
be even noticed. Mechanical properties of compared bags (rigidity, color, thickness) are the same and remained unchanged after heating at 70°C for 16 h. The situation is different after heating at 90°C. At 90°C, both kinds of bags become soft, their inner layer becomes sticky, and if both their sides stick to each other, they glue together. After cooling down, the material of both bags becomes more rigid than it was initially. Softening of the bags between the temperature range of 80–90°C may result in punctures or tears if there is a sharp object inside.

The experiments concerning the permeability of examined bags proved that their properties are the same, that is, they are impermeable for volatile organic compounds. Although a huge amount of flammable mixture was used in the test, none of its components permeate through either double or single layers of film.

In Figs 4 and 5, the following exemplary chromatograms were compared: the result of adsorption of 1 µL of test mixture that was used in the test (comparison sample) and results of analysis of the tubes that were separated from the 100 µL of this mixture by one and two layers of FireDebrisPAK® and Ampac material, respectively.

Conclusion

Ampac material has properties similar to FireDebrisPAK® bags, most probably because it is the same kind of laminated foil, so all previously published research results concerning the performance of FireDebrisPAK® bags apply also to Ampac bags (1–3). The slight differences in the profile of background interferences may be the result of aging as FireDebrisPAK® bags used in the tests were about 4 years old, or they are normal batch-to-batch differences. Some minor changes in technological processes also cannot be excluded.

Ampac bags should not be heated above 70–80°C, as in higher temperatures they become soft (they can be easily pierced or torn) and they emanate some volatile organic compounds. The great

advantage of the examined bags is that they are impregnable for volatile organic compounds: if the bags are sealed tightly, there is no danger of cross-contamination and losing analytes during sample storage.

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