An Evaluation of a New Film for Air Sampling Bags Used in Industrial Hygiene and Ambient Air Sampling

Linda S. Coyne, SKC Inc., 863 Valley View Road, Eighty Four, PA 15330

ABSTRACT

Air sampling bags are used in a variety of applications in industrial hygiene and ambient air sampling. Bags are an inexpensive and simple option for collecting single or multiple component mixtures and for the calibration of direct-reading and laboratory instruments. One drawback to using bags for sample collection is that bag materials can outgas and confound analytical measurements of the bag contents. Tedlar®, for example, has been shown to outgas phenol and dimethyl acetamide. Other potential issues include bag and compound incompatibility and loss of sample integrity during extended storage.

This paper will investigate the ability of the new SKC SamplePro® FlexFilm to provide improved properties for sample collection as compared to Tedlar film. Stability tests were performed using gases from several classes of compounds. Bag contents were analyzed at 1, 2, 3, and 4-day intervals using direct-injection into a gas chromatograph with flame ionization detection (GC/FID). Bag outgassing was tested by filling the bags with air and analyzing the bag contents by Gas Chromatography with Mass Spectrometry (GC/MS).

The data show that the total VOCs outgassed from SKC FlexFilm were 877 µg/m^3 compared to 2730 µg/m^3 for Tedlar. Storage studies indicate that 21 test gases have recoveries greater than 80% after 2-day storage in bags made from the new film. Many of the test gases were stable for 7 days.

In conclusion, the new film was found to be suitable as an air sampling bag. It offers the advantage of lower VOC background and long holding times for many compounds when compared to Tedlar film bags. FlexFilm provides a new option for sample collection using sample bags in industrial hygiene and ambient air applications.

Bag Study

Four different films were tested in this study: Tedlar (polyvinyl fluoride), FluoroFilm (copolymer of tetrafluoroethylene and hexafluoropropylene), SamplePro FlexFilm, and Kynar Flex® (hexafluoropropylene-vinylidene fluoride copolymer).

One-liter bags were tested with both polypropylene and stainless steel fittings. Known concentrations were prepared by first filling each bag with a known volume of air and then injecting various chemicals. Chemicals were tested singly in each bag so that the effect of each chemical could be tested. Each bag was allowed to equilibrate for 20 minutes prior to analysis. A sample of the air from each bag was then injected into a gas chromatograph. The bags were stored for a minimum of 3 days at ambient temperatures of 72 F (22 C).

Tedlar and FlexFilm were tested for background as these bags are used for ambient air studies. Bags constructed of each material were sent to various laboratories and analyzed by GC/MS.

Compounds with boiling points greater than 250 F (121 C) should not be used in bags. The loss of a compound from a bag must be less than 20% over a 72-hour storage time at temperatures above 32 F (2 C). These guidelines are stated in EPA Method 0040 entitled "Sampling of Principal Organic Hazardous Constituents from Combustion Sources using Tedlar Bags."

Physical Properties of Test Films

Film	Thickness (mil)	Specific Gravity	Tensile (psi)	Melting point (F)
PVF	2.0	1.71	8000	400-450
FluoroFilm FEP	2.0	2.15	2500	518
FlexFilm	3.0	1.34	6000	158
Kynar Flex PVDF	3.0	1.78	5210	310-320

General Permeability Properties of FlexFilm vs. Tedlar

Property	SamplePro FlexFilm	Tedlar
Water vapor transmission	13.5 g/m^{2}d	9-57 g/m^{2}d
Oxygen	52.5 cc/m^{2}d	49.6 cc/m^{2}d
Carbon dioxide	171 cc/m^{2}d	172.1 cc/m^{2}d

Background of FlexFilm vs. Tedlar VOCs and Sulfur Compounds — µg/m^3

Bag film	H_2S	Carbonyl sulfide	Carbon disulfide	Total VOCs
SamplePro FlexFilm	120	290	18.0	972
Tedlar	ND	20.0	16.6	2675

ND = Not detected

Stability of VOCs in Tedlar Bags % Recovery

Compound	Day 1	Day 2	Day 3	Day 6
Acrylonitrile	81.1	72.8	63.5	NT
Benzene	100	100	107	103
2-Butanone	98.5	102	103	100
Ethyl acetate	100	101.5	101	101
Ethylene	103	103	101	96.1
Isopropyl alcohol	97.5	89.5	88.3	77.6
Methylene chloride	101	100	92.7	88.9
Propylene	104	98.0	99.3	94.7
Tetrahydrofuran	92	89.5	88.3	80.8
Toluene	103	94.8	82.4	75.5
Trichloroethylene	94.5	98.6	90.3	80.8

NT — Not tested on this day of the study

Stability of VOCs in FlexFilm Bags % Recovery

Compound	Day 1	Day 2	Day 3	Day 4	Day 5
Acetone	96.7	88.9	NT	88.5	86.1
Acetonitrile	69	55.1	NT	NT	36.7
Benzene	96.0	95.2	NT	85.5	NT
2-Butanone	96.2	95.8	NT	80.6	79.5
1,2-Dichloroethane	91.5	82.9	NT	80.0	NT
Ethyl acetate	94.9	95.4	NT	82.8	82.6
Ethylene	104	100	NT	99.6	NT
Heptane	96.7	106	NT	89.0	89.2
Isopropyl alcohol	99.1	91.7	NT	100	98.9
Methylene chloride	93.2	87.2	NT	77.8	NT
Perchloroethylene	94.8	84.9	80.6	NT	NT
Tetrahydrofuran	96.7	93.6	93.4	NT	NT
Toluene	102	92.9	NT	81.7	71.5
Trichloroethylene	92.4	82.9	NT	78.8	77.7
2,2,4-Trimethylpentane	100	97.9	97.9	NT	NT
p-Xylene	85.9	82.7	78.1	NT	NT

NT — Not tested on this day of the study

Stability of VOCs in FluoroFilm Bags % Recovery

Compound	Day 1	Day 2	Day 3	Day 4
Benzene	90.7	83.6	77.6	NT
2-Butanone	90.4	81.8	73.6	65.1
Ethyl acetate	87.2	76.7	64.5	56.3
Heptane	92.3	96.9	81.8	78.0
Isopropyl alcohol	103	100.7	94.3	95.0
Methylene chloride	75.0	77.0	49.1	41.0
Tetrahydrofuran	88.8	80.1	81.7	76.1
Toluene	72.0	74.1	44.3	34.6
Trichloroethylene	64.6	50.95	35.2	28.7

NT — Not tested on this day of the study

Stability of VOCs in Kynar Flex Bags % Recovery

Chemical	Day 1	Day 2	Day 3	Day 4
Benzene	79.3	71.1	69.4	NT
2-Butanone	71.4	58.7	51.5	NT
Ethyl acetate	69.6	56.9	48.9	44.95
Methylene chloride	94.5	86.3	76.6	NT

NT — Not tested on this day of the study

Results and Discussion

All bag results represent the average of at least 2 injections per bag. The results are reported in % Recovery for each day, relative to Day 0. Depending on when each study was started, all bags were not analyzed on the same days.

There are many publications demonstrating that Tedlar film has good stability for many compounds. All the test compounds showed a recovery of greater than 80% after 2 days of storage, with the exception of acrylonitrile.

Compounds tested in FluoroFilm bags did not show good stability for several compounds after 2 days. It is unclear whether the loss of compound was due to reactivity of the chemical with the FluoroFilm or to permeability of the VOC from the bag. This bag is used widely due to the low VOC background and the supposed lack of chemical reactivity with the film.

Kynar Flex, a newer film on the market, did not show good compound stability for any of the chemicals tested. This bag would not be recommended for sampling VOCs.

SamplePro FlexFilm, a new proprietary film, had similar stability properties to that of Tedlar. Several compounds were tested with this material as it was investigated as a possible replacement for Tedlar. With the exception of acrylonitrile and acetonitrile, 14 compounds showed recoveries of greater than 80% after 2 days of storage at ambient temperatures. Many of the chlorinated compounds, although stable for 2 days, showed losses at 3 to 4 days of storage. This was not observed with Tedlar. The data from the background study on the Tedlar and FlexFilm bags demonstrated that the FlexFilm had 3 times lower VOC background than Tedlar. However, the FlexFilm bag had higher levels of hydrogen sulfide and carbonyl sulfide when compared to the Tedlar bag.

Summary

Air sampling bags will continue to be used for collecting VOCs and for the calibration of direct-reading instrumentation. They represent an inexpensive and simple option when compared to canisters. One drawback to using bags for sample collection is that bag materials can outgas and confound analytical measurements of the bag contents. Other potential issues include bag and compound incompatibility and loss of sample integrity during extended storage.

The data from this study show that it is important to know the stability of the test compound in the bag that will be used for sample collection. Both Tedlar and FlexFilm demonstrated good sample stability for a wide variety of compounds.

The data from this study show that the total VOCs outgassed from FlexFilm was 3 times less than that for Tedlar. This new film provides a new option for sample collection using sample bags for both ambient air and industrial hygiene applications.

SKC

www.skcinc.com