Evaluation of the Permea-Tec Pads as New Technology for the Detection of Chemical Breakthrough in PPC

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BACKGROUND

Occupational skin exposure to chemicals and their mixtures is a major problem for workers involved in production, use, and handling of these chemicals. Regulatory standards require that workers use protective gloves and other protective equipment when they come in contact with chemicals. The degree of protection provided by the different types of protective equipment, especially gloves, depends on their ability to resist the permeation of these chemicals.

Permea-Tec Pads (PTP) are a breakthrough indicator that enhances the workers' ability to protect themselves from skin exposure to chemicals. The pads employ microencapsulated color indicators that respond to a wide range of chemical contaminants such as aromatic amines, aliphatic amines, and acids/bases. General solvent PTP combines a charcoal sorption pad with a colorimetric strip in the center. The pads are attached to the workers' hands before donning the gloves. The color indicator responds to the chemical, if contamination occurs. [Foelschow, 1992; Hirayma and Ikeda, 1997].

An evaluation of three types of PTP was performed using gloves that had a published breakthrough time of <1 h. The objective was to evaluate these products as a protective clothing end-of-service-life indicator.

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MATERIAL AND METHOD

PTP for solvents, aliphatic amines and aromatic amines were evaluated. The pads were purchased from Colormetric Laboratories, Inc. Three types of gloves were used in the evaluation, Edmont Nitrile (model 37-175) gloves and Edmont Polyvinyl chloride, PVC (model 34-100) gloves which were obtained from Ansell-Edmont and N-Dex nitrile obtained from Best Manufacturing. Methanol, triethylamine, and aniline were selected for testing based on their widespread industrial use. They were obtained from Sigma Chemical Company, Inc. and were 99+% purity.

The test setup consisted of a Miran 1-A infrared analyzer for early detection of breakthrough time [Berardinelli and Roder, 1983] a metal bellows pump for circulation, and a test cell with the specimen mounted in it. The components were connected in a closed loop vapor collection system. Two types of permeation test cells were used. One was the standard (2-in.)ASTM permeation cell and the other a smaller (1-in. AMK) permeation cell manufactured by the Pesce Company [Berardinelli and Moyer, 1988].

Specimens

The specimens were taken from the palm and the back of finished gloves of the same lot for each material. The average thickness for the nitrile (Edmont 37-175) gloves was 0.42 ± 0.2 mm, while the average thickness for the PVC (Edmont 34-100) was 0.16 ± 0.11 mm. Each specimen was inspected visually for irregularities. The thickness was measured with an AMES 214-10 micrometer with a pressure foot of 1 cm. All measurements were made to the nearest ± 0.01 mm. Glove specimens were assigned randomly to a treatment.

To determine breakthrough time, specimens were mounted in the cell with the outer surface toward the challenge side of the cell. A PTP was affixed to the back of the glove specimen with the micro encapsulated indicator facing the glove specimen. Testing was conducted at a room temperature of $24 \pm 4°C$. Pure dry air at a flow rate of 11.3 L/min was used as a collection medium. The neat chemical that was used was measured by volume and injected in the challenge side of the cell. At that moment, a timer was started. As soon as the analyzer detected a response of twice the signal divided by the noise, breakthrough was recorded. The cell was then disassembled and the microencapsulated indicator was checked for color change. When evaluating general solvent PTP which had both sorbent pad and indicator, charcoal pads were saved in glass vials for GC analysis. Methanol was desorbed from the charcoal pads to determine the concentration of the methanol at breakthrough time. A co-solvent mixture was used for the extraction.

RESULTS AND CONCLUSION

The breakthrough time for each chemical was determined first. Table I indicates the breakthrough time for methanol using nitrile gloves. General purpose solvent PTP did not change color during testing. Mean breakthrough time was calculated as 54 ± 5 minutes.

Methanol spiked charcoal pads were desorbed in co-solvent mixtures of 2% DMSO in CS_2, 1% 2-butanol in CS_2, and 1% 2-propanol in CS_2. The desorption efficiency of methanol from charcoal was <15%. Further experiments with 2-butanol yielded >90% efficiency and was used for desorption. GC analysis indicated that methanol was sorbed/desorbed from the test specimens, [Hirayama and Ikeda, 1979].

The aliphatic amine pads were much more sensitive to the treatment. The pad indicator changed color before IR breakthrough occurred which indicated that the concentration at breakthrough time was below the IR minimum detection limit of 0.3 ppm. The mean was 2.3 ± 0.7 minutes. Therefore, these pads do work according to their intended application (Table II). The aromatic amine pads were sensitive to treatment of neat aniline. The indicator pad changed color with IR breakthrough time which occurred at a concentration about 7 ppm. Calculated mean time with the Edmont 37-175 Nitrile gloves was 12.7 ± 1.5 minutes (Table III).

TABLE I. Nitrile (Edmont 37-175) Methanol Breakthrough Detected by IR-Miran 1A In a Closed Loop System 2 -in. ASTM

Breakthrough time (min)	Concentration at breakthrough (ppm)	Thickness (mm)
56	~15	0.45
48	~15	0.42
59	~15	0.43
52	~15	0.44

TABLE II. PVC (Edmont 34-100) Triethylamine Breakthrough Detected by IR-Miran 1A In a Closed Loop System 1 -in. AMK

Breakthrough time (min)	Concentration at breakthrough (ppm)	Thickness (mm)
1.8	<0.3	0.16
3.1	<0.3	0.24
1.6	<0.3	0.15
2.7	<0.3	0.27

TABLE III. Nitrile (Edmont 37-175) Aniline Breakthrough Detected by IR-Miran 1A In a Closed Loop System 2 -inch ASTM

Breakthrough time (min)	Concentration (ppm)	Thickness (mm)
10.5	~7	0.32
13.4	~7	0.33
13.2	~7	0.37
13.9	~7	0.36

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