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Monitoring Granular Terbufos Breakthrough: Comparison of Cotton Gauze and Alpha-Cellulose

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Several research studies have reported permeation testing of chemical-resistant glove materials performed by the standard test procedures and with different collecting media. Fricker and Hardy (1992) investigated the permeation characteristics of glove materials by organic solids such as quinone, camphor, phenol, naphthalene, and p-nitro-toluene. In this study, helium was used as a collecting medium. Gaseous helium flowed through a stainless steel cell and contacted with the back of specimens of glove materials; then the collecting medium exited from the cell and was injected into a gas chromatograph (GC) column for quantitative analyses. Inert gas, such as nitrogen or helium, is considered a good collection medium because of its high solubility properties. However, it may not simulate accurately the permeation characteristics of glove use.

To simulate practical use of gloves, aqueous liquid media have been used as collection media. Fricker and Hardy (1994) used a saline solution as a collection medium to investigate the permeation characteristics of organic solids through protective glove materials. The result showed that the saline-based collection method usually generated longer breakthrough time and lower steady state permeation rate than the method using helium collection media. The authors concluded that the polarity of the glove materials might be a reason that causes the decrease of measured permeation rate. In a study about relative rates of solvent and solute penetration through protective glove materials (Watkinson et al. 1993) distilled water was used as the collection medium for measuring the permeation of cyclohexanone; a mixture of ethanol and water (50/50 by volume) was used for evaluation involving p-xylene as permeant because of the low-water solubility of p-xylene.

Although water or a gas can be used as the effective collection medium in experiments involving volatile or water-soluble permeants, they may be inappropriate as collection media for many pesticide formulations in which the active ingredients are neither water soluble nor volatile (Ehntholt et al. 1990). Thus, it is important to select a collection medium that will efficiently absorb or solubilize a low-volatility, low-water solubility active ingredient permeant. Some organic solvents or mixtures of solvent and water have been used as the

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collection medium for the evaluation of glove permeation properties. However, these methods have limitations because some solvents have interaction with glove materials that can alter permeation characteristics of the glove materials themselves.

As an alternative, a solid collection medium was used to test the permeation through glove materials of active ingredients with low-water solubility and low-volatility. Ehntholt et al. (1990) used a thin (0.02 in. thick) sheet of silicone rubber as solid collection medium to test permeation of six concentrated pesticides through 10 commercially available glove materials. They found that silicone rubber was a satisfactory collection material for the low-water and low-volatility active ingredients, but was less useful for active ingredients with high water solubility. For the latter, water is usually considered as the best collection medium. An appropriate collection medium must be selected for the specific pesticide formulation of interest.

In field exposure studies of pesticide deposition on clothing, both cotton gauze and alpha-cellulose sheets have been used as collection media to monitor pesticide exposure (Bhat & Perenich, 1990; Cloud, 1988). However, studies of the effectiveness of these materials as collection media to absorb residues of granular pesticides have not been reported. In fact, no standard test methods exist for determination of residues of granular pesticides in fabrics.

Previous studies of granular contamination of chemical-resistant glove materials reported the contamination levels found within glove materials, but did not measure contamination passing through glove materials (Stone et al. 1995, Stone et al. 1997). A collection medium is required to judge whether a chemical has crossed a chemical-resistant barrier material. In anticipation of further study of granular contamination of chemical-resistant glove materials, a suitable collection medium was needed. The purpose of this study was to compare the effectiveness of cotton gauze with alpha-cellulose pads as the collection media to absorb residues of granular terbufos.

MATERIALS AND METHODS

A simple contamination and extraction experiment was conducted to determine whether cotton gauze or alpha-cellulose was the most reliable collection medium for measuring permeation and penetration of granular terbufos through glove materials.

Sterilized 12-ply cotton gauze from Abco, Inc., Milwaukee, WI, and alpha-cellulose pads donated by Rayonier Corporation, Jacksonville, FL, were used as collection media. A thin piece of paper, Kimwipes® from Kimberly-Clark Corporation, Roswell, GA, was used to substitute for glove materials as a penetration barrier because Kimwipes® are penetrated more easily than glove materials by granular pesticides.

The 6 x 6 cm^2 paper specimens were backed together with the same size alpha-cellulose pads or cotton gauze by tapes at the edges. A contamination area of 4 x 4 cm^2 in the center of the paper specimen face was marked. Terbufos granules (0.05 g of Counter® 15G) were put evenly on the contamination area of the paper specimens. After 1-hour exposure in the covered petri dishes, the granular terbufos was rolled off the specimens into waste containers. The 6 x 6cm^2 specimens were held with tweezers and trimmed to 4 x 4 cm^2 by a scissors. Paper specimens were separated from alpha-cellulose pads and discarded to a waste container while alpha-cellulose pads and gauze were individually put into 25 ml of ethyl acetate in separate test tubes for the 18-hour extraction.

All analytical procedures were consistent with those outlined by Stahr (1992). A Varian 3400 GC with a thermionic N.P. selective detector was used to determine the level of residue in each material after contamination. The GC column was 3% OV-17, 2 m x 1/4" x 2 mm i.d. Initial column temperature was 160°C; injector and final temperature were 240°C. Detector temperature was 300°C. The carrier gas was nitrogen with a flow rate of 35 ml/min. Each specimen, alpha-cellulose pad or cotton gauze, had three replications. Two GC injections were run per replication. The value of terbufos residue absorbed by the 4 x 4 cm^2 collection media was divided by 16 and reported as the amount of terbufos residue per cm^2.

RESULTS AND DISCUSSION

Table 1 presents the amount of terbufos found in alpha-cellulose pads and cotton gauze. A Student's t test (Myers & Well, 1991) was used to determine statistical difference in the mean amount of terbufos absorbed by alpha-cellulose pads and cotton gauze. Statistical significance was set at the 0.05 level of probability.

Table 1. The amount of terbufos in alpha-cellulose pads and cotton gauze.

	Terbufos residue ($\mu g/cm^2$)	
Materials (n = 6)	Mean	Standard deviation
Alpha-cellulose	1.06	0.09
Cotton gauze	0.50	0.1

($p < 0.0001$)

The t-test showed that the amount of terbufos found in alpha-cellulose pads was significantly more than that found in cotton gauze ($p < 0.0001$). This is consistent with earlier Bhat and Perenich (1990) findings reporting that 8-ply gauze as backing material showed a lower level of penetration of pesticides (8.8%) than did alpha-cellulose (12.0%). This difference in the amount of pesticide absorbed by alpha-cellulose and cotton gauze is likely due to the different surface characteristics and structure of the two materials. The surface of alpha-cellulose is smoother and its structure is more compact than that of cotton gauze. Thus, as an absorptive backing material, the smoother alpha-cellulose pads may have more

complete contact with the back of the barrier material so that the transfer of pesticide is more efficient.

To maximize possible pesticide transfer and residue collection, alpha-cellulose should be selected as a collection medium to monitor permeation and penetration of granular terbufos through glove materials.

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