

Effects of Exposure Time, Material Type, and Granular Pesticide on Glove Contamination

C. Guo,¹ J. Stone,² H. M. Stahr,³ M. Shelley⁴

¹ Ansell Healthcare Incorporated, 1000 Spring St., Wilkesboro, North Carolina 28697, USA

² Textiles and Clothing Extension, Iowa State University, 1055 LeBaron Hall, Ames, Iowa 50011-1120, USA

³ College of Veterinary Medicine, Diagnostic Laboratory, 2630 Veterinary Medicine, Iowa State University, Ames, Iowa 50011, USA

⁴ Department of Statistics, 210 Snedecor, Iowa State University, Ames, Iowa 50011, USA

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Abstract. Chemical-resistant gloves are recommended for pesticide applicators to reduce their exposure to agricultural chemicals. In this research, three chemical-resistant glove materials—nitrile, neoprene, and barrier laminate—were studied in relation to contamination with granular terbufos and tefluthrin. Surfaces of specimens backed with alpha cellulose were contaminated with 300 mg of either granular terbufos or tefluthrin for 1-, 2-, 4-, 8-, 16-, and 24-h time periods in petri dishes in the laboratory. Residues were extracted using ethyl acetate for terbufos and iso-octane for tefluthrin in test tubes for 24 h. Analysis of extracts by gas chromatograph and statistical analysis of the data showed that contamination levels varied with the time of exposure, material type, and pesticide used. Pesticide was not detected in the alpha cellulose even after 24 h contamination time. A linear relationship was found between contamination level and exposure time for terbufos in the three materials, with longer exposure times causing higher contamination levels. Contamination of nitrile was significantly less than neoprene or barrier laminate. Exposed glove materials contained higher levels of contamination of terbufos than tefluthrin.

Several studies of pesticide exposure in agriculture have reported that hands receive the largest dermal exposure, therefore gloves are important for farm safety and worker protection during pesticide handling or application (Abbott 1984; Zweig *et al.* 1985; Keeble *et al.* 1993; Scanderson *et al.* 1995).

Pesticide labels and the Worker Protection Standard for Agriculture require the use of unlined waterproof or chemical resistant gloves for pesticide handling and application to prevent hand exposure (U.S. EPA 1993). Surveys show that farmers often say they don't know about different glove materials that they could choose or where to get gloves (Stone *et al.*

1994), but wearing gloves for pesticide work is strongly advocated (Stone 1999).

Pesticide labels may show the type of glove material recommended with a letter that corresponds to the Environmental Protection Agency's Chemical Resistance Category Chart (U.S. EPA 1999). Nitrile, neoprene, and barrier laminate gloves are shown in the chart for various categories of pesticides. The resistance of these and other materials to permeation by pesticides has been evaluated by using standard ASTM test procedures that were developed for measuring liquid permeation (Jencen and Hardy 1988, 1989; Ehntholt *et al.* 1990; Moody and Ritter 1990).

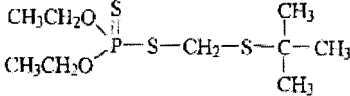
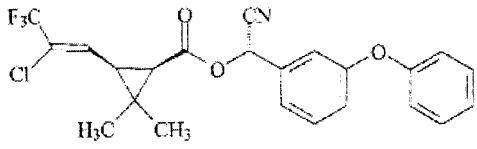
Granular forms of pesticides have been considered safer to use than liquids, but few studies of chemical contamination by granular products have been made. No standard test methods to determine chemical contamination of clothing and personal protective equipment (PPE) by granular products have been developed.

Terbufos (Counter[®]), S-[[1.1-dimethylethyl]thio]methyl]O,O-di-ethyl phosphorodithioate, and tefluthrin (Force[®]), α -cyano-3-phenoxybenzyl 3-(2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropanecarboxylate, a 1:1 mixture of the (Z)-(1R,3R), S-ester and (Z), (1S,3S), R-ester, are widely used insecticides (see Table 1) to control soil pests in corn agriculture and were applied to 71.2 million acres of corn in the United States in 1995 (Sands and Holden 1996). In Iowa at that time, Counter[®] ranked second and Force[®] fourth in the total quantity of insecticide used for corn with about 1 million pounds of Counter[®] and 46,000 pounds of Force[®] being applied to 11.7 million acres.

Terbufos is highly toxic and has a "Danger" label. It can be absorbed rapidly through skin. Repeated and prolonged skin contact may result in progressively increased susceptibility to poisoning. If swallowed, inhaled, or absorbed through the skin, terbufos may be fatal. Compared with terbufos, tefluthrin is less toxic. It has a "Caution" label and is classified as slightly toxic. However, farmers have reported skin irritation and sensitization after handling granular tefluthrin.

The objectives of this project were to determine: (1) the effect of exposure time on permeation and contamination levels in three glove materials (nitrile, neoprene, and barrier laminate)

Table 1. Material characteristics

Terbufos (American Cyanamid Co., Wayne, NJ) Organophosphate systemic insecticide Oral LD ₅₀ in male rats Tech 4.5 mg/kg Melting point 29.2°C a. Water solubility 15 ppm Molecular weight 288.43 Molecular formula C ₉ H ₂₁ O ₂ PS ₃		Tefluthrin (Zeneca Inc., Wilmington, DE) Synthetic pyrethroid insecticide, acaricide Oral LD ₅₀ in male rats Tech 79 mg/kg Melting point 49.2°C Water solubility 4 ppm. Molecular weight 449.86 Molecular formula C ₂₃ H ₁₉ ClF ₃ NO ₃
		
Nitrile gloves, Solvex®	Gauge: 0.381 mm Unlined and unsupported	Material weight: 441.51 g/m ²
Molecular formula	[CH ₂ -CH=CH-CH ₂ -CH ₂ -CH-CH ₂ -CH=CH-CH ₂] _n CN	
Neoprene gloves	Gauge: 0.432 mm Unlined and unsupported	Material weight: 912.88 g/m ²
Molecular formula	[CH ₂ -CH=C-CH ₂] _n Cl	
Barrier laminate* gloves	Gauge: 0.076 mm	Material weight: 56.67 g/m ²
Molecular formula	[CH ₂ -CH ₂ -CH ₂ -CH] _n OH	

* SilverShield®

using two granular pesticides with differing chemical composition (terbufos and tefluthrin), (2) the effect of glove material type on contamination amounts, and (3) the effect of pesticide chemical composition on contamination amounts.

The ASTM F 903-96 (ASTM 1997a) standard test method is widely accepted to test gloves for liquid penetration. This method relies on visual detection of penetration. The ASTM F 739-96 (ASTM 1997b) method is used to test glove resistance to permeation. This method determines both breakthrough time and the steady state permeation rate. The permeation rate is affected by temperature, the chemical composition and thickness of glove materials, as well as the chemical composition and the formulation of pesticides (Raheel 1994). In general, as temperature rises, permeation rates increase, while breakthrough times decrease.

The thickness of glove materials is a critical factor affecting permeation (Schlatter and Miller 1986; Jencen and Hardy 1989). The permeation of a solvent and/or active ingredient through glove materials is related to the diffusion of that solvent and/or active ingredient in glove materials. Jencen and Hardy (1989) examined the effect of glove material thickness on permeation of neoprene and natural rubber materials with various solvents. They found a linear relationship between the square root of the breakthrough time and thickness. In addition, they reported that the steady state permeation rate was related inverse-linearly to thickness.

Ehnholt *et al.* (1990) reported the permeation resistance of 10 glove materials to ethyl parathion and meta-xylene using a

modified standard cell. Their results indicated that nitrile rubber, butyl rubber, and Silver Shield® glove materials exhibited good permeation resistance, while natural rubber and polyethylene glove materials exhibited very poor permeation resistance.

Schwöpe *et al.* (1992) reported the permeation resistance of 13 glove materials to several pesticide formulations, which included 10 active ingredients and 10 carrier solvents. They simultaneously monitored the permeation of the carrier solvents and active ingredients and found that the carrier solvent usually permeates earlier and at a higher rate than the active ingredient. Their results showed that nitrile rubber, butyl rubber, and plastic film laminate materials were most resistant to permeation, and that natural rubber and polyvinyl chloride (PVC) materials were least resistant.

Fricker and Hardy (1992) investigated glove material permeation resistance to organic solids. In their study, natural rubber, PVC, polyurethane, nitrile, and neoprene were evaluated against p-dichlorobenzene, 4,6-dinitro-o-cresol, 2,4-dinitrotoluene, quinone, camphor, naphthalene, hydroquinone, phenol, and p-nitrotoluene. They found that nitrile and neoprene exhibited the best permeation resistance.

Mickelsen and Hall (1987) investigated the differences in breakthrough time of nitrile and neoprene glove materials having the same generic name and nominal thickness but produced by different manufacturers against n-butyl acetate, p-xylene, perchloroethylene, ethanol, and n-hexane. They found a significant difference in breakthrough times among the

same glove materials produced by different manufacturers. They attributed their findings to differences in glove chemical composition or in the fabrication process.

Raheel and Dai (1997) studied seven glove materials (PVC, latex, rubber, neoprene, nitrile, butyl, and Viton) to determine how exposure to 5% solutions of carbaryl and atrazine affected the physical properties (weight and thickness, flexural rigidity, puncture resistance, breaking load and elongation) of the materials. They found that liquid penetration testing (ASTM F903) does not adequately take into account the degradation of materials. For example, changes in stiffness affect strength and puncture resistance of materials as well as fit and dexterity. They concluded that nitrile, butyl, and Viton gloves provided "higher levels of chemical and penetration resistance" than other materials tested (Raheel and Dai, 1997, 578).

The pesticide formulation, whether liquid, dry, or granular, is a critical factor influencing permeation through chemical protective materials. The granular formulation, one of the most widely used in agriculture, is dry and ready to use. Granules are usually made by applying the active ingredient as aqueous solutions to various inert materials, such as clay, corn cobs, or walnut shells (Sawyer 1983). Most granules contain relatively low amounts of active ingredients, usually ranging from 1% to 20%. Manufacturers make many of the most toxic pesticides in granular form to reduce the potential risk of worker exposure. Granular products are considered to be relatively safe compared with liquid pesticide formulations.

The standard ASTM methods of studying liquid penetration and permeation cannot assess the levels of contamination when the pesticide is retained in the granular form used in agricultural production. Few studies have examined the effect of granular pesticides on textile or chemical-resistant fabrics, perhaps because no standard tests exist for measuring contamination by granules.

Braaten (1988) studied the contamination of cotton fabrics by granular aldicarb (Temik® 15G) when the fabrics were soiled with synthetic perspiration and synthetic sebum. Granular aldicarb (0.42 g) was placed on 5×5 cm² specimens. As the contact time increased, contamination increased.

Stone *et al.* (1992) contaminated starched and unstarved cotton 8×8 cm² fabric specimens with 0.1–0.5 g granular terbufos. The contamination level related to the exposure time, contamination amount, time delay before extraction, and moisture content of the specimen.

Stone *et al.* (1997) compared two methods for laboratory contamination of nitrile, neoprene, and barrier laminate glove materials by terbufos (Counter® 15G). In the first method, glove fingers were placed over test tubes and forced into beakers of granules. In the second, glove specimens were cut, placed flat in petri dishes, and 0.05 g of granules were spread on top for 30-min exposure. No contamination was found under the glove materials with either method; neoprene had the highest contamination levels.

Guo *et al.* (1998) compared contamination levels in nitrile, neoprene, and barrier laminate glove materials after 1- or 2 h exposure to granular terbufos (Counter® 15G). A significant difference in contamination level was found related to both exposure time and glove materials. Neoprene had the highest contamination, followed by barrier laminate and nitrile.

Our research was initiated to further examine the relationship

between glove contamination by granular formulations and exposure time, glove material type, and pesticide composition.

Materials and Methods

A $2 \times 3 \times 6$ factorial design was used. The two pesticides were terbufos and tefluthrin. The three gloves were barrier laminate, neoprene, and nitrile. The six exposure times used were 1, 2, 4, 8, 16, and 24 h.

The characteristics of the two granular pesticides—terbufos (Counter® 20CR) and tefluthrin (Force® 3G)—and three glove materials—nitrile, neoprene, and barrier laminate—used in this study are shown in Table 1. The pesticides were obtained from an Iowa State University research farm. The pure analytical reagent standards of terbufos and tefluthrin, respectively, were obtained from the manufacturers for the primary standards analysis.

The nitrile gloves (Sol-Vex®) were donated by Ansell Edmont Industrial Inc. (Coshocton, OH). The Neoprene™ gloves were made by Ansell Edmont and purchased from Lab Safety Supply Inc. (Janesville, WI). The barrier laminate (Silver Shield®) gloves were obtained from North Safety Products (Charleston, SC). Three replicate 6×6 cm² specimens were cut from the back of the hand or cuff of the three glove materials, and a 4×4 cm² zone for contamination was marked in the center. Alpha cellulose donated by Rayonier Corporation (Jacksonville, FL) was used as the collection medium to monitor permeation based on a preliminary study showing that terbufos residue was more completely extracted from it than from cotton gauze (Guo 1998).

Each 6×6 cm² glove material specimen was placed on top of a 6×6 cm² alpha-cellulose "pad." Aluminum foil was cut into 7×7 cm² pieces, placed under the alpha-cellulose and folded in 0.5 cm to cover the edges. The three layers were taped together with Scotch™ tape at the edges to prevent air flow around the sides so that the collection medium was less likely to be reached by volatile fumes. Specimens were maintained 24 h at standard conditions of $21 \pm 1^\circ\text{C}$ and $65 \pm 2\%$ relative humidity before contamination.

The alpha-cellulose and foil-backed glove specimens were placed in clean petri dishes under a hood. For each specimen 300 mg of terbufos or tefluthrin granules was weighed into a fresh aluminum foil dish on an electronic balance. The granular pesticide was sprinkled onto the 4×4 cm² contamination zone of the specimen as evenly as possible, and the petri dish was covered. The specimens were exposed for the time period specified by the experimental design. After exposure, specimens were tipped to let granules roll into a waste container, and all remaining visible granules were removed using a spatula. Specimens were held with tweezers and trimmed with scissors to 4×4 cm² to cut off the tape and separate the layers. The glove specimens and alpha-cellulose pads were placed in separate labeled test tubes with 25 ml of the extraction solvent. Test tubes were sealed with a screw cap for a 24-h extraction time. Ethyl acetate was used as extraction solvent for terbufos. The recovery rate for terbufos was 77.2%. Iso-octane was used as extraction solvent for tefluthrin. The recovery rate for tefluthrin was 89.4%.

A Varian 3400 gas chromatograph (GC) with a thermionic N.P. selective detector was used for the terbufos analysis. A Packard 427 GC with an electron capture detector was used for the tefluthrin analysis. The parameters of gas chromatography are shown in Table 2.

In the residue analysis of terbufos by Varian 3400 GC, the ng level of analytical standards of terbufos was used as the basis for calculating pesticide amount in the extraction solvent samples. Peak areas were used to measure the amount of terbufos in samples. In the residue analysis of tefluthrin by a Packard 427 GC, the 10^{-2} ng level of analytical standards of tefluthrin was used because the electron capture detector of that GC was highly sensitive to tefluthrin.

Three different volumes of pesticide standards were injected into the GC and run. Thus, three corresponding peak areas or peak heights

Table 2. Gas chromatograph parameters

	Varian 3400	Packard 427
Detector	TSD—thermionic nitrogen/phosphorus selective	ECD—electron capture
Column	3% OV-17, 2 m × 1/4" × 2 mm i.d.	1.5% OV-17, 1.95% OV-210, 4% SE 30, 6% QF1, 6 ft. × 3 mm i.d.
Temperature		
Column	initial: 160°C final: 240°C	205°C
Injector	240°C	225°C
Detector	300°C	275°C
Carrier gas	N ₂	N ₂
Flow rate	35 ml/min	35 ml/min

Peak height was used to measure the amount of tefluthrin in samples.

were obtained from the output of integrator of the GC. A linear curve of terbufos or tefluthrin was plotted using corresponding peak area or peak height as y-axis values and corresponding injected volumes as x-axis values using least squares regression methods. The amount of pesticides in each specimen was calculated from the recorded peak heights or peak areas per injection through the standard curve. Pesticide standards were run after every five sample injections.

Two GC injections were run per replication. They agreed within 3%, or an additional injection was made. In the analysis of terbufos, an aliquot of the extracts obtained from neoprene and barrier laminate glove specimens was injected directly into the GC. The extracts obtained from nitrile glove specimens and the alpha-cellulose pads needed to be concentrated to stand within the concentration range of the analytical standards. An aliquot of these concentrated solutions then was injected into the GC. In the analysis of tefluthrin, most of the extracts obtained from glove specimens and alpha-cellulose pads required dilution. However, some extracts of these required concentration or were injected directly into the GC.

The peak area or peak height values per GC injection were used to calculate the values of pesticide residue in a 16-cm square specimen. The computation was based on standard curves and conversion formulas (Stahr 1992). Finally, that value was divided by 16 and converted into the amount of pesticide residues per cm square specimen. Six values in each treatment cell were reported and their mean was used as the pesticide residue amount (ng/cm²) in a specimen.

Factorial analysis of variance was used to test for statistical differences in pesticide contamination levels among different exposure times, glove materials, and pesticides. *Post hoc* multiple comparisons also were used to identify further differences among the different levels of the factors. Linear regression was used to identify whether there was a linear relationship between pesticide contamination levels in three glove material specimens and exposure time (Myers and Well 1991). Statistical analyses were conducted by SAS programs (SAS Institute 1991). Significance levels were set at 0.05.

Results

No detectable pesticide contamination was found in any alpha-cellulose specimen held under three different glove materials with exposure to granular terbufos or tefluthrin for the six different time periods. Terbufos or tefluthrin did not penetrate glove materials into alpha-cellulose pads within 24 h of exposure time.

Terbufos

The amounts of terbufos residues in the three different glove materials varied with exposure time and glove material as

shown in Figure 1. The largest mean terbufos contamination of three types of glove materials was in glove specimens with 24 h exposure (67,404 ng/cm²) while the smallest one was in specimens with 1 h exposure (3,079 ng/cm²). With a longer exposure time, more terbufos residue was found in the specimens for all glove materials. Contamination amounts were heaviest in neoprene, followed by barrier laminate and nitrile.

Factorial analysis of variance indicated that the terbufos contamination amount was related significantly to the exposure time, the glove material type, and the interaction between these factors ($p < 0.01$) but was not related significantly to the two different observations (Measure), as shown in Table 3. Scheffé multiple comparisons further confirmed the difference in contamination levels among glove materials. Based on calculations of means using data from all exposure times summed together, the terbufos in neoprene was greatest (55,745 ng/cm²), followed by barrier laminate (14,336 ng/cm²) and nitrile (9,832 ng/cm²).

Figure 1 shows the interaction effects of exposure time and material type on terbufos residues in glove materials. The terbufos amounts in nitrile specimens gradually increased with exposure time; after 16 h, terbufos contamination increased more per hour than before that time. The barrier laminate exhibited slightly higher contamination than the nitrile and increased more sharply before 4 h exposure. The terbufos residue in neoprene was about three times greater than that in nitrile or barrier laminate.

Linear regression was used to identify whether there was a linear relationship between terbufos contamination and exposure time in three glove materials. The neoprene material had the strongest relationship (R^2 0.98), followed by barrier laminate (R^2 0.95) and nitrile (R^2 0.87) as shown in Figure 1. The results indicated that there were linear relationships between terbufos residue and exposure time in each type of glove material ($p < 0.01$). Total contamination at the end of the exposure time was much higher for the neoprene than for the barrier laminate and nitrile, which were nearly parallel and very similar in amount. The total contamination for the neoprene at the end of 24 h was three times greater than that of nitrile.

Tefluthrin

Factorial analysis of variance showed a statistically significant difference in the amount of tefluthrin in three different glove

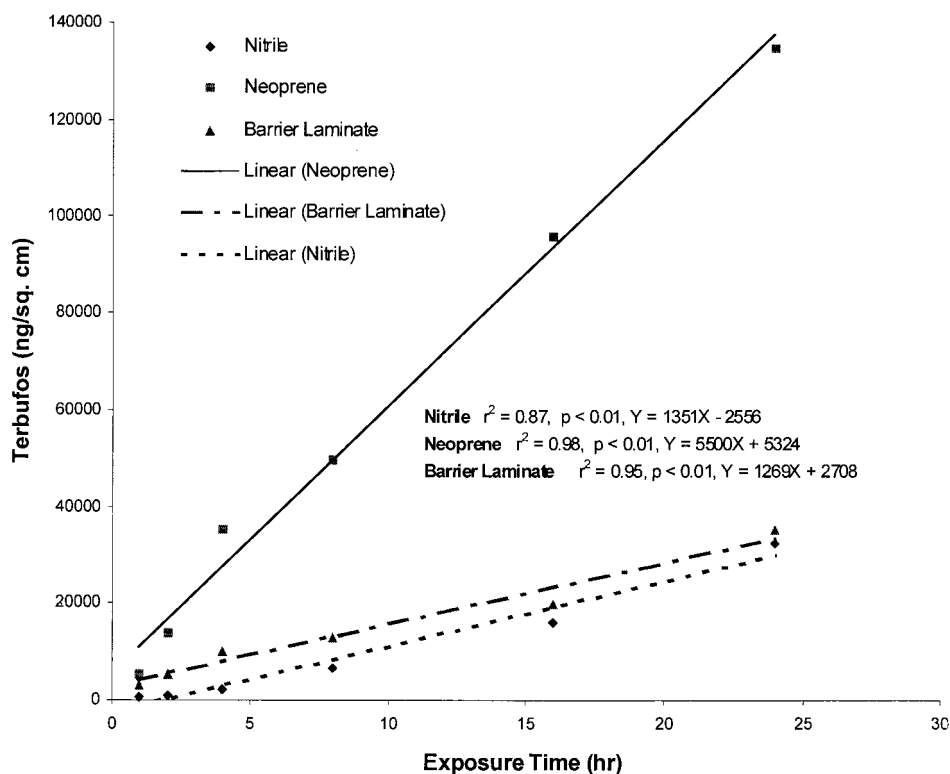


Fig. 1. Relationship between terbufos contamination and exposure time with different glove materials

Table 3. ANOVA for pesticide residue in glove materials with different exposure times

Source	Degrees of Freedom	Sum of Squares (10 ⁶)	Mean Square (10 ⁶)	F value	Pr > F
Terbufos					
Time	5	54,710	10,942	658.34	0.0001
Glove	2	46,116	23,058	1,387.32	0.0001
Measure	1	20	20	1.23	0.2699
Time * glove	10	29,662	2,966	178.46	0.0001
Tefluthrin					
Time	5	40,423,905	8,084,781	457.87	0.0001
Glove	2	182,617,785	91,308,893	5,171.17	0.0001
Measure	1	51,791	51,791	2.93	0.0905
Glove * time	10	67,956,669	6,795,667	384.86	0.0001

Measure = Two separate observations compared to verify results.

material specimens that varied with exposure time. As shown in Figure 2, the largest mean tefluthrin contamination of the three types of glove material was in glove specimens with 24 h exposure (1,960 ng/cm²) and the smallest was in specimens with 1 h exposure (233 ng/cm²). The rank order of tefluthrin residues in the three glove material specimens differed from that of terbufos. Tefluthrin contamination amounts were largest in barrier laminate, followed by neoprene and nitrile. As exposure time increased, tefluthrin contamination increased for barrier laminate and neoprene but not for nitrile.

Table 3 shows that exposure time, material type, and their interaction had significant effects ($p < 0.01$) on tefluthrin contamination amount in glove materials but the different

observations (Measure) did not. Scheffé multiple comparisons further confirmed the difference in tefluthrin contamination levels among three glove materials. Based on calculations of means using data from all exposure times summed together, the largest mean tefluthrin contamination was in barrier laminate glove specimens (3,033 ng/cm²), the second-largest in neoprene specimens (327 ng/cm²), and the smallest in nitrile specimens (51 ng/cm²).

The interaction of exposure time and material type is graphed in Figure 2. The tefluthrin residues in nitrile specimens were almost constant as exposure time increased from 1 h to 24 h. The contamination in neoprene slowly increased until 16 h and then basically remained constant. Compared with the other two types of glove materials, tefluthrin residues in barrier

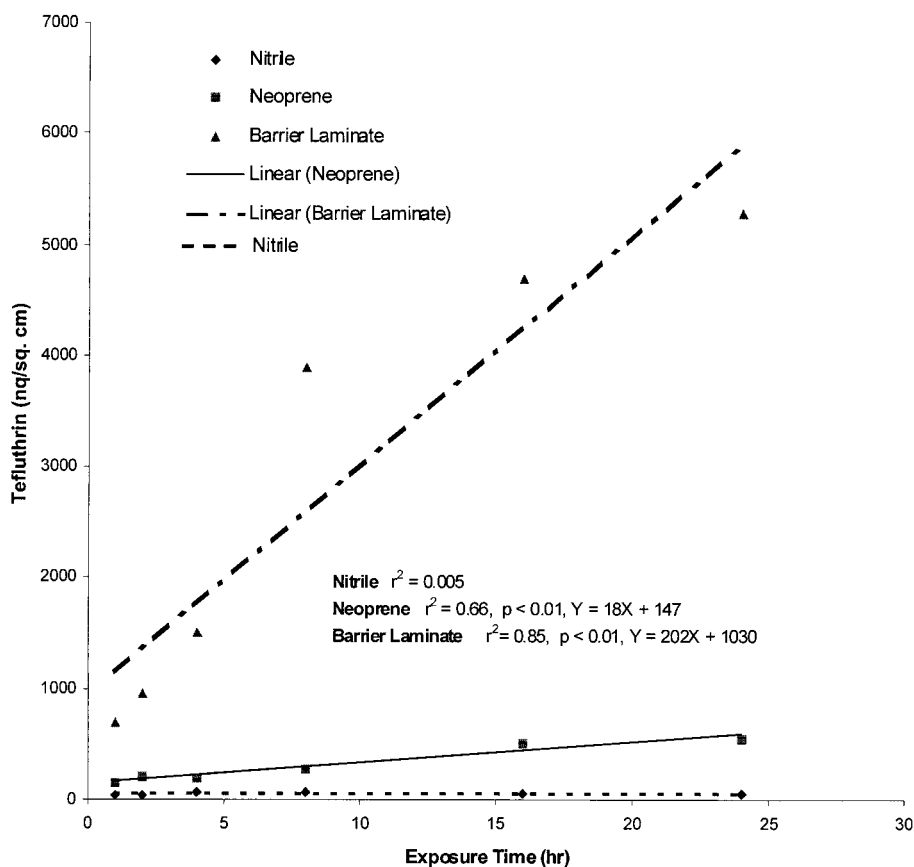


Fig. 2. Relationship between tefluthrin contamination and exposure time with different glove materials

laminate specimens increased sharply as exposure time increased.

Linear regression was used to identify whether there was a linear relationship between tefluthrin contamination and exposure time in three glove materials. The results (Figure 2) indicated that the barrier material had the highest relationship (R^2 0.85), followed by neoprene (R^2 0.66), and nitrile material (R^2 0.0052). The results indicated that there was a linear relationship between tefluthrin residue and exposure in barrier laminate ($p < 0.01$), and there was a relatively weak linear relationship between tefluthrin residue and exposure in neoprene ($p < 0.01$). There was no linear relationship between tefluthrin residue and exposure in nitrile material. The tefluthrin contamination in nitrile hardly varied with increased exposure time.

A factorial analysis of variance model was estimated with pesticide included as a variable in addition to exposure time and glove material type. The results indicated contamination in glove materials differed significantly by pesticide ($p < 0.01$). The terbufos residue in a glove specimen under a certain experimental treatment was much higher than the tefluthrin residue in the same experimental treatment.

Discussion

The active ingredients in granular terbufos or tefluthrin were not found on alpha-cellulose pads beneath three glove materials after 24 h exposure. This breakthrough time is far longer than

one found by researchers studying liquid permeation of pesticides through glove materials (Ehnholt *et al.* 1990; Forsberg and Keith 1995; Moody and Ritter 1990; Schwoppe *et al.* 1992).

The difference in breakthrough time may be attributed to the difference in formulation of the pesticides. With granular products, (1) the active ingredient concentration is low, (2) the contact is less because the product does not flow to cover a larger area, and (3) the granules do not contain solvents. Solvents have been shown to permeate glove materials at higher rates than the active ingredient (Schwoppe *et al.* 1992).

Differences in contamination levels among glove materials also may be attributed to the chemical composition of the substrate glove material in relation to the chemical composition of the pesticide and to the difference in the surface character of the glove materials. The nitrile and barrier laminate seem smoother than neoprene.

Statistical analysis confirmed contamination levels of terbufos and tefluthrin were significantly related to time of exposure and glove material type, as shown in Table 3. Both terbufos and tefluthrin contamination increased linearly with exposure time as shown in Figures 1 and 2. This is consistent with earlier findings regarding granular contamination with Counter® 15G (Guo 1998).

Analysis of the data also revealed that contamination levels in glove materials differed by pesticide for a given exposure time, with tefluthrin contamination being significantly lower than that of terbufos. This must be attributed to the differences in chemical composition of the pesticides.

In practical terms, the findings of this study indicate that

farm workers can be protected from hand exposure to terbufos or tefluthrin for at least 24 h by wearing gloves of any of these materials as long as the gloves are not punctured, torn, or otherwise damaged. However, the effect of longer exposure times remains to be determined. If gloves are used for more than one 8-h day, they probably will be contaminated (at least on the outside) after the first 8 h. The comparative safety of the granular products still varies with the pesticide, so label precautions regarding use cannot be ignored. Careful management from donning and doffing to storage separately from uncontaminated PPE between wearing is important to minimize transfer of contamination. More work is required to determine if contamination levels in gloves can be successfully reduced by common cleanup processes.

Conclusions

Residues of granular terbufos (Counter® 20CR) and tefluthrin (Force®) were not identified in alpha-cellulose pads beneath nitrile, neoprene, or barrier laminate gloves after 24 h exposure. Statistical analysis confirmed that the differences in contamination levels found in laboratory experiments were related significantly to exposure time, glove material type, and pesticide type. The longer the exposure time, the higher the contamination levels. Nitrile contamination was significantly less than neoprene or barrier laminate. Glove materials showed significantly more terbufos than tefluthrin residue. The interaction of pesticide and glove material type shows that glove materials are not equally protective for both pesticides. However, farm workers using the granular chemicals tested can have confidence that chemical resistant gloves provide protection for their hands. The management of used gloves between wearing to prevent contamination of other surfaces is an important consideration if gloves are to be reused safely.

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