TECHNICAL PAPERS

Toxicity of γ-Benzene Hexachloride in Clothing[1]

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The marked effectiveness of the γ isomer of hexachlorocyclohexane (GBH) as an insecticide and miticide has stimulated the manufacture and experimental field use of this compound, popularized under a trade name, Gammexane. Several months ago it was shown in tests conducted by the U. S. Department of Agriculture at Orlando, Florida, that herringbone twill impregnated with the standard test concentration of 2.0 gm of GBH/square foot of cloth is highly effective against mites and withstands repeated launderings better than other proposed miticide impregnates (*1*).

TABLE 1

LETHALITY OF ACETONE SOLUTIONS OF HEXACHLOROCYCLOHEXANE APPLIED TO CLIPPED OR DEPILATED SKIN*

Species	Mortality fraction at dose					Time of death	No. of survivors showing toxic symptoms
	200	250	400	500	1,000		
	GBH (mg/kg)					(hrs)	
Rabbit	0/1	..	2/2	..	2/2	16–48	None
Guinea pig	..	0/4	..	0/4	1/4	72	None
Rat	..	0/4	..	0/4	1/4	24	1 at 500 mg/kg & 1 at 1,000
Goat	..	..	..	0/1	0/2	..	None

* Within this small series of animals, GBH, either pure or in the 83% mixture, appeared to be equally toxic on both depilated and clipped skin.

However, the appearance of unusual symptoms in two workers engaged in preparing batches of the compound for field tests (*4*) suggested that these symptoms might be manifestations of GBH absorbed through the skin. Since the wearing of impregnated clothing would subject large and varied areas of the body to contact with the impregnate, since during bodily motion the impregnate would be rubbed against the skin, and since, furthermore, impregnated clothing might be worn frequently within a short period of time or continuously for several days (as by troops in the field), it was felt that an investigation of the toxicity of GBH-impregnated cloth was urgent. A small series of observations was, therefore, made on clipped laboratory animals wearing simulated garments impregnated with the agent.

Acetone solutions applied directly to the skin. The toxicity of 40% acetone solutions (a) of the pure γ isomer or (b) of a mixture of hexachlorocyclohexanes containing 83% γ isomer was determined by direct application to the backs and sides of animals clipped or depilated 24 hrs previously. To eliminate ingestion or inhalation of the compound during the initial 72-hr period of observation, the animals were restrained in a ventilated hood or, in the case of goats, placed in stocks outdoors. Results are shown in Table 1.

Impregnated clothing worn as a suit. Bleached herringbone twill cloths were impregnated by spraying with, or by machine-dipping in, an acetone solution of hexachlorocyclohexanes (83% γ isomer) of such strength (approximately 10%) as to yield a concentration of 2 gm of γ isomer/square foot of cloth. After the twill had been air-dried for 24 hrs or longer, suitable holes were cut for the fore and hind legs of the species to be used. The cloths were retained as snugly fitting coats about the trunks of the animals by stapling or taping the overlapping edges of the cloth over the back. The animals had been clipped by electric clippers approximately 24 hrs previously. The covered area per unit body weight

TABLE 2

LETHALITY OF CLOTHING IMPREGNATED WITH GBH (Fresh impregnation = 2.4 gm of 83% GBH mixture/square foot)

Species	Impregnation	Mortality fraction			
		24 hrs	48 hrs	72 hrs	1 wk
Rabbit	None	0/6	0/6	0/6	0/6
	Fresh	8/10	8/10	9/10	10/10
	Fresh	4/4	4/4	4/4	4/4
	Fresh*	1/4	1/4	3/4	3/4†
	Worn‡	1/6	3/6	4/6	6/6
	3 Launderings*	0/4	2/4	4/4	4/4
	Fresh§	0/3	0/3	0/3	3/3
Guinea pig	None	0/5	0/5	0/5	0/5
	Fresh	0/5	0/5	0/5	0/5
Rat	None	0/3	0/3	0/3	0/3
	Fresh	0/4	1/4	1/4	1/4

* Impregnated by machine dipping.

† The rabbit surviving at one week died at 10 days.

‡ Worn previously approximately 24 hrs by rabbits which died in above groups.

§ These rabbits were restricted for the first 4 days to very small cages so that a minimum amount of movement was possible.

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corresponded approximately to that for a man in a suit (0.28 square foot/kg) so that about 560 mg of γ isomer were in the cloth/kg of body weight. Table 2 indicates the results.

The symptoms of animals affected, whether by direct skin application or by wearing of impregnated suits, were those typical after parenterally administered GBH: weakness, sometimes flaccid paralysis, and finally periodic convulsions, generally leading to eventual death. The observation period was one week or longer.

In both types of experiments it was evident that, of the species tested, rabbits are most sensitive and guinea pigs least sensitive to cutaneously applied GBH.

Chemical determinations (*3*) of the total loss of hexachlorocyclohexanes from the impregnated suits of rabbits showed the following averages: 17% after one wearing, 23% after two wearings, and 36% after three launderings and no wearings.

While it seemed unlikely that any of the affected animals could have absorbed GBH from a route other than the percutaneous, particularly since at no time was it observed that the clothed animals or the unclothed restrained animals were able to ingest the substance by licking, it was, nevertheless, desirable to rule out inhalation as a possible route of intoxication. Therefore, two rabbits were left for a week in cages with minimal openings and with walls covered by GBH-treated cloth behind a screen, the surface area of the cloth being large enough to produce at room temperature as much vapor as would be given off by an impregnated rabbit suit at body temperature. During an observation period of 10 days, no ill effects were noted. A third rabbit, clothed in a GBH-treated suit, confined in a rabbit box permitting body movement, and placed in a ventilated hood so that vapor could not be inhaled, died within 24 hrs.

Further evidence for the unimportance, in these studies, of inhalation as a toxic route is given by the following experiment: Inasmuch as it was suspected that movement might be significant in bringing about greater absorption through the skin, three rabbits in GBH-treated suits (see Table 2) were confined, in a ventilated hood, in small wire cages permitting the minimal amount of movement consistent with normal respiratory function. After confinement for 96 hrs, only one rabbit had exhibited typical symptoms followed by death, which occurred shortly before it was removed from the cage. The other two, however, began to develop symptoms soon after removal from their cages and eventually died. Since bodily motion seemed to contribute to an increased rate of absorption of GBH in the clothed animals, it is presumed that movement brings about flaking of the small crystals from the fibers and, through chafing by the clothing, causes them to be worked into the skin.

The work of others on the toxicity of GBH to rabbits shows that only small amounts would have to be absorbed to produce symptoms: the acute i.v. LD_{50} is about 4 mg/kg (*5*), while during a 3-week period of daily inunction of the γ isomer in dimethyl phthalate, symptoms occurred with daily doses of 20 mg/kg (*2*). In wearing tests on rabbits with cloth freshly impregnated with acetone at 2.0, 4.0, and 8.0 gm of GBH/square foot, typical symptoms, including convulsions, occurred (*2*).

In conclusion, it may be stated that the effective insecticidal component of hexachlorocyclohexane, the γ isomer, appears to be sufficiently hazardous to some mammals to warrant the utmost caution in its use as a miticidal impregnate at 2 gm/square foot in human clothing. Even at 64% of this concentration, suits were lethal to 4/4 rabbits in 72 hrs. Unless it can be shown that man is markedly more resistant than the rabbit, it is probable that γ-benzene hexachloride can be used safely as an impregnate only at concentrations so low as to eliminate any advantages it might otherwise offer in insecticidal effectiveness and durability over other compounds currently under test.

References

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Inactivation of 2,4-D on Sweet-Potato Slips With Activated Carbon[1]

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A recent article by Lucas and Hamner (*1*) on the inactivation of 2,4-D in cleaning knapsack sprayers with activated carbon suggested the possible use of this material to protect sensitive field crops from 2,4-D injury.

In order to test the above use, two field experiments were conducted with Unit 1 Porto Rico sweet-potato slips, one on Leeper clay at State College, Mississippi, and one on Sarpy sandy loam at Stoneville, Mississippi.

The soil, which received normal seedbed preparation, was treated with the sodium salt of 2,4-D immediately before planting. The concentrations used were 1,000 and 4,000 ppm (free acid equivalent) at State College, and 1,000, 2,000, 3,000, and 4,000 ppm at Stoneville. The solutions were applied with 3-gal compressed air sprayers at the rate of 155 gal/acre.

One-half of each plot was planted with untreated sweet-potato sprouts and the other half with sprouts, the roots of which were first moistened and then dusted with activated carbon (Norit A, about 1 lb/1,000 sprouts). The treatments were replicated four times at State College and three times at Stoneville.

The results of these tests are shown in Tables 1 and 2. The data show that activated carbon used in this manner minimized the injury to the sprouts from 2,4-D. The treated sweet-potato plants growing in soil previously

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