

PRESERVATION OF WOOLLENS AGAINST CLOTHES MOTHS & CARPET BEETLES

OM PRAKASH, J. BANERJEE & L. M. PARTHASARATHY

Defence Materials and Stores Research & Development Establishment, Kanpur-208013

(Received 6 January 1979)

Physico-chemical protective measures employed in various countries all over the World for the preservation of woollens against clothes moths & carpet beetles are reviewed.

Since times immemorial clothes moths and carpet beetles have been causing serious economic losses to carpets, feathers, hair, silk, leather, fur and fur lined aviator's garments, helmets,¹ boots, blankets and other products of animal origin.

The most important species of insects destroying wool are woolly bears (*Anthrenus flavipes*), buffalo carpet beetle (*Anthrenus scrophulariae*), black carpet beetle (*Attagenus piceus*), webbing clothes moth (*Tineola bisselliella*), carpet moth (*Trichophaga tapetzella*) and case-bearing clothesmoth (*Tinea pellionella*). The losses due to these insects have been estimated by U.S.A. entomologists to be from 200 million to 500 million dollars annually¹. Total estimate of losses during storage in India are not available so far. However, in the Defence Services², a loss of Rs. 1.23 lakhs was reported in the year 1952.

Since 1920 much has been learnt about the bionomics of clothes moth and carpet beetles. Moth-proofing solutions were studied for several years, and it was observed that a thorough treatment of fabrics with silicofluoride solution gave a worthwhile degree of protection¹. Hartley³ *et. al.* also reported that fluorine at the rate of 0.2-0.3% gave adequate protection to woollen clothes. Some of the fungicides i.e. sodium fluoride, salicylanilide, sodium fluosilicate, and β -naphthol were recommended for the preservation of woollens against these pests⁴.

Systematic work on devising control measures against these insects appear to have been initiated between 1920 and 1940, and great emphasis was placed on the development of more effective space sprays and contact sprays¹. During World War II, very large quantities of felt were treated with sodium salt of dinitro- α -naphthol (Martius Yellow) and dinitro-*o*-cresol at the rate of 0.03%, and it was observed by Hartley³ *et. al.* that dinitro-*o*-cresol was more effective against these insects.

A new era in the preservation of woollens began only after 1947 with the introduction of chlorinated organic insecticides. Prior to this, use of thick cedar chests and usual mechanical methods such as brushing, shaking, heating, airing and sunning of susceptible fabrics, etc. for controlling the insects were recommended^{5, 6}. Similar observations were recorded by Fernald & Shepard⁷.

Arsenical compounds are very effective in killing larvae. Their use is, however, objectionable because of their toxicity to humans, and American medical authorities have advised abandonment of these compounds¹. A number of chemicals/insecticides that have been recommended for preservation of woollens are given in Table 1.

Application of paradichlorobenzene crystals or naphthalene flakes at the rate of 453 gram/2.83 cu m of space is being used for the preservation of woollens with encouraging results^{1, 6, 7, 8}. Pradhan⁹ *et. al.* have reported that neem seed kernel possess extraordinary gustatory repellent properties, much higher than neem leaves, against the desert and migratory locusts. It is an age old practice still prevalent in some parts of rural India, to mix dry leaves of neem (*Azadirachta indica*) along with woollen articles for protection, against clothes moths and carpet beetles, but as no systematic studies have been done in India, therefore the effect of neem has not been fully established as yet.

According to Parker¹⁰ *et. al.*, when woollen cloth treated with 0.8 or 1.2% of their weight of toxaphene was exposed to larvae of *Attagenus piceus* and *Anthrenus vorax* for two weeks at 26.7°C and 50.60% relative humidity, no loss in efficiency was observed. Weinman¹¹ *et. al.* reported that mixtures of pentachlorophenol and benzene, pentachlorophenol and acetone or other soluble solvents at the rate of 0.5-5% gave a very effective control (for 9-15 months) against carpet beetle and killed the larvae more quickly than similar dosages of DDT. It was also observed that propyl, *n*-butyl and primary amyl ethers of pentachlorophenol or allyl ether or butyl ether were highly toxic and repellent to cloth moths larvae. Lesser¹² tried to kill the clothes moths and carpet beetles by fumigation with naphthalene, cedar products, camphor or paradichlorobenzene and obtained effective control. He had also suggested that inorganic fluosilicates, cinchona alkaloids and aluminium fluoformate can be used as stomach poisons to kill the clothes moths.

Application of DDT, rotenone, pyrethrum, benzene-hexachloride, chlordane, toxaphene and boconize had been reported to protect wool against moth damage¹⁰⁻¹⁷. Spraying with lindane at the rate of 1.3 gm in 566.32 cu m per 24 hr gave almost complete control against *Tineola bisselliella* and *Anthrenus scrofulariae*¹⁸.

Insecticidal dusts are most commonly used for controlling woollen pests, throughout the world. An application of 5% DDT dust by weight of the material has been recommended for satisfactory control¹⁴. Ferguson¹⁵ *et. al.* found that Mitin at the rate of 1-2% by weight of wool gave complete kill of clothes moth larvae. When camel hair were treated with Mitin (0.025%—2.5%), it gave complete kill of month old larvae and protected camel hair satisfactorily for 5 to 6 years.

Higgins¹⁶ *et. al.* recommended 0.5% of pentachlorophenol hydrogen-phosphate to protect woollen textiles against *Attagenus piceus*. Laudani¹⁷ *et. al.* also suggested the use of naphthalene, paradichlorobenzene crystals, DDT (0.19-0.61% by weight); EQ 53 (10.1-20.2 ml per 453 gm. of feathers) against carpet beetles.

Dieldrin at low concentration (0.05% by weight of the wool) in petroleum ether gave a moth-proof effect on woollen fabrics¹⁸. Mixture of diphenyl urea and dialkyl ketones or chlorobenzene or pyridine at the rate of 0.1%-1% gave permanent protection to the woollens against clothes moths and carpet beetles¹⁹. An application of 25% pyrethrins (0.8%), piperonyl butoxide (2%) α BHC (0.5-5%), chlordane (2%), gave complete control and killed larvae within two weeks²⁰. Imidazole (1%) gave satisfactory protection to woollen fabrics²¹. Pence and Viray²² recommended the use of chlordecone (0.06-0.5%) and mirex (0.06—0.5%) for killing these insects. They further observed that spraying with mirex gave 100% mortality to *Anthrenus flavipes* and *Attagenus megatoma*. The use of hyamine-3500 at the rate of 0.2-3% gave satisfactory protection to wool from damage by *Tineola bisselliella*²³.

Bry²⁴, as a result of his studies reported that barthrin (0.5-1% by weight of the wool) and dimethrin (0.5-1% by weight of wool) gave 2.5-5% and 7.5-17.5% mortality to cloth moths respectively. Application of 0.5% allethrin²⁵ and 0.5%-0.03% iodofenphos²⁶ have been recommended to check insect intensity and protect the fabric from feeding damage by larvae of *Attagenus megatoma* and *Tineola bisselliella*. Suggestions have also been made for use of aldrin, toxaphene, chlordane, endosulfan, endrin, DDD and heptachlor for protecting wool against clothes moths and carpet beetles. In this connection it is also recorded that DDT and α BHC should not be used for moth-proofing woollen materials in commercial dry cleaning²⁷. DDT, naphthalene, camphor, carbon disulphide, paradichlorobenzene, triphenyl methane²⁸, *N*-phenyl-*N*(2-benzo-thiazolyl) thiourea, *N*-phenyl-*N*-acryloyl thiourea and phenyl thiourea²⁹ have been used successfully for the control of clothes moths and carpet beetles. The use of triphenyltin chloride at the rate of 0.25% effectively protects woollen fabrics from moths and carpet beetles³⁰.

Recently Bry³¹ *et. al.* has claimed a satisfactory protection of woollens with the application of acetone solutions of pyrethrins (0.05% by weight of woollens cloth) or a mixture of pyrethrins (0.005% pyrethrins by weight) and piperonyl butoxide 1 : 10. Hoskinson and Russell³² reported that chlopyrifos at the rate of 0.005-0.5% was very effective moth-proofing agent on woollen fabrics.

Butler³³ carried out laboratory experiments to determine the effect of malathion alone (0.1%), and a mixture of malathion and regulaid, malathion and tween 80, malathion and multifilm X-77 on the mortality of black carpet beetle and found that a mixture of malathion and regulaid gave 93% mortality to black carpet beetles. Dobrivojevic³⁴ *et. al.* had reported that application of Dipel TM/Bactospein PM 600 at the rate of 11-28 ppm gave very effective control against woolly moth. Verme's^{35,36} *et. al.* in his recent publication recorded that raw skin's woollen materials can be preserved against these insects by treating the surface with a mixture of naphthalene (70-95%) and insecticidal organophosphate (1-10%).

Insecticides like phosvel or ethyl phosvel or mixture of R 15396 and imidan or trithion or B 11163 have been recommended for *Anthrenus* control³⁷. Moreover, United States Department of Agriculture¹ reported that application with 5% DDT once or twice a year or 5% methoxychlor or paradichlorobenzene or naphthalene flakes (453 grams of crystals per 2.83 cu m of space) or 2% chlordane or 0.5% lindane or 5% silicofluoride solution i.e. berlone, guardex, larvex, per-ma-moth etc. gave adequate protection to woollen materials and killed the carpet beetles and clothes moths larvae. Fernald and Shepard⁷ mentioned that pyrethrum carbon tetrachloride or ethylene dibromide (1 : 3) may be used as fumigant to control the clothes moths and carpet beetles. They also emphasized that naphthalene flakes or paradichlorobenzene or cedar chest or cedar oil should be used as repellent. But Billings³⁸ and Bottimer³⁹ reported that the repellent effect of naphthalene or paradichlorobenzene on moth or grub was negligible. At low temperatures the vapour pressure of naphthalene or paradichlorobenzene falls appreciably⁴⁰ and; therefore, temperature above 23°C have been recommended for both naphthalene and paradichlorobenzene treatments. Recently Mayfield⁴¹ recommended that the use of dieldrin for moth-proofing be discontinued and it should be replaced with other common moth-proofing agents. Use of synthetic pyrethroids, especially cypermethrin [cyano(3-phenoxyphenyl) methyl 3-2 (2,2-dichloro-ethyl)-2, 2-dimethyl cyclopropane carboxylate] and permethrin gave good protection to woollen fabrics against these pests⁴².

CONCLUSION

From the above literature it is apparent that vast amount of research work has been carried out during the past decade. Laboratory and field trials have been made by many workers throughout the world, many of which are highly valuable. Treatment with martius yellow (sodium salt of α -dinitro naphthol), 2% solution of sodium or chromium fluoride, synthetic pyrethroids, especially cypermethrin, permethrin, moth-proofing materials e.g. Eulan CN (penta chloro-di-hydroxy triphenyl methane), Mitin FF (halogen-substituted acylamino sulfonic acid, Amuno (organic fluoride), DDT (2 : 2 *bis-p*-chlorophenyl, 1 : 1 : 1 trichloroethane), packing with paradichlorobenzene, naphthalene, camphor, etc, would help in protecting these stores. If, however, they are already infested with woolly bears and clothes moths they should be disinfested by exposure to hot air or steam or fumigation with carbon tetrachloride.

FUTURE COURSE OF ACTION

It may be observed that a number of synthetic insecticides have been used to control the pests of woollen materials. In view of the hazards associated with synthetic insecticides, use of plant products merit consideration. Systematic work on the use of Aluminium phosphide tablets for fumigation of infested materials and the minimal dosage of naphthalene required for different periods of storage would be necessary. In view of the ban imposed on the use of dieldrin for moth-proofing of woollens, other moth-proofing agents need also to be studied for finding out a suitable substitute.

TABLE I
CHEMICALS/INSECTICIDES FOR PRESERVATION OF WOOLLEN

- (a) *Inorganic Insecticides*
Aluminium fluoformate¹², chromium fluoride⁴³, sodium flouride^{4, 42, 48}, sodium silico-fluoride⁴³ sodium fluosilicate^{4, 48}, silico fluoride solution¹.
- (b) *Chlorinated Hydrocarbon Compounds*
Aldrin²⁷, α BHC (benzene hexachloride)^{12, 20, 27}, chlordecone (kepone)²², chlordane^{1, 12, 20, 27}, DDT (dichlorodiphenyl trichloroethane)^{1, 12, 14, 17, 27, 28}, DDD (dichloro diphenyl dichloroethane)²⁷, endrin²⁷, endosulfan⁷, heptachlor²⁷, lindane (gammexane)^{1, 13}, mirex (dodecachloro octa hydro-^{1, 3}, 4-metheno 2H cyclobuta (cd) pentalane)²², methoxychlor¹, naphthalene flakes^{1, 5, 6, 28}, paradichlorobenzene crystals^{1, 5, 6, 28}, toxaphene (octachloro-camphane)^{10, 12, 27}.
- (c) *Organophosphorus Insecticides*
Chlorpyrifos³², iodofenphos²⁶, malathion³³.
- (d) *Phenol & Nitro Compounds*
 β -naphthol⁴, D.A.N. (martiu's yellow)³, D.N.O.C. (dinitro-ortho-cresol)³, pentachlorophenol⁴³ salicylanilide⁴.
- (e) *Microbial Insecticides*
Bactospein—PM 600³⁴, dipel TM³⁴.
- (f) *Organometallic Compound*
Triphenyltin chloride³⁰.
- (g) *Organic Thiocynate*
Lethane (*n*-butyl carbinol thiocyanate)⁴⁸.
- (h) *Amide Compounds*
Phenyl thiourea²⁹, triphenyl methane²⁸.
- (j) *Quaternary Ammonium Compound*
Hyamine-3500²³.
- (k) *Botanical Insecticides*
Allethrin^{25, 48}, barthrin²⁴, camphor²⁸, cinchona alkaloids¹², cedar oil⁷, cypermethrin⁴², dime-thrin²⁴, permethrin⁴³, piperonyl butoxide²⁰, pyrethrum^{5, 12}, pyrethrin^{20, 48}, pyrethrin & piperonyl butoxide³¹, pyrethroid^{45, 46}, NRDC 143 (new synthetic pyrethroid)^{49, 50}, rotenone^{12, 45}.
- (l) *Fumigants*
Carbon disulphide⁶, carbon tetrachloride^{7, 48}, ethylene dibromide & carbon tetrachloride⁷, hydro cyanic acid gas^{5, 48}.

(m) *Moth-Proofing Insecticides*

Amuno (organic fluoride)⁴³, EQ 53 (25% DDT, 1% non ionic emulsifier and 65% aromatic hydrocarbon solvent)⁴⁷, eulan—CN (penta chloro-dihydroxy triphenyl methane sulfonic acid)⁴³, imidazole²¹, mitin FF (sodium salt of N-3-4-dichlorophenyl)-N-2-(2-Sulpho-4-chlorophenoxy)-5-chlorophenyl-urea^{15, 43} penta-chloro-phenol hydrogen-phosphate¹⁶.

(n) *Miscellaneous*

Dieldrin & petroleum ether¹⁸, diphenyl urea & pyridane bases¹⁹, diphenyl urea & chloro benzenes¹⁹ DDT & lindane⁴⁷, malathion & regulaid³³, malathion & tween 80³³, malathion & multifilm³³, naphthalene & insecticidal organo phosphate³⁵, naphthalene & phosphoric acid ester derivatives insecticides³⁵, pentachloro-phenol & benzene or acetone or other soluble solvent¹¹, propyl, n-butyl & primary amyl ethers, of pentachloro-phenol¹¹, pyrethrin & acetone solution^{31, 47}, pyrethrin & odourless kerosene & lindane⁴⁷, R 15396/phosvel/ethyl-phosvel/ekalux & imidan/trithion/B 11163³⁷.

ACKNOWLEDGEMENTS

The authors are thankful to Dr. H. B. Mathur, Director, Defence Materials and Stores Research & Development Establishment, Kanpur for giving permission to publish this review and to Shri R. N. Tandan, Assistant Director for help rendered during the preparation of this review.

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