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SHORT PAPER

An investigation of the efficacy of organotin compounds for the control of the cotton stainer, *Dysdercus cingulatus*, the mosquito, *Anophelese stephensi*, and the common house fly, *Musca domestica*

Prabhu N Saxena and Alan J Crowe*
Toxicology Section, Department of Zoology, Agra University, Agra 282004, India and *International Tin Research Institute, Kingston Lane, Uxbridge, Middlesex UB8 3PJ, UK

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A series of commercial organotin compounds was screened for efficacy against the three insect species *Dysdercus cingulatus* (cotton stainer), *Anophelese stephensi* (mosquito) and *Musca domestica* (house fly). Tributyltin species in the general order $Bu_3SnCl > (Bu_3Sn)_2O > Bu_3Sn$(linoleate) were more effective than two triphenyltin compounds. Tricyclohexyltin hydroxide, dimethyltin chloride, phenyltin trichloride and a diethyltin dichloride–phenanthroline adduct were less effective.

Key words: Organotins, tributyltin, insecticidal properties, *Dysdercus cingulatus*, *Anophelese stephensi*, *Musca domestica*

INTRODUCTION

Organotin compounds, which are currently consumed at a rate of some 50 000 tons per year, have a wide range of industrial applications.[1] The use of organotins in agriculture was pioneered in the 1950s and early 1960s by van der Kerk and co-workers.[2–6] Currently, there are five commercially available organotin agrochemicals: triphenyltin acetate (Brestan), triphenyltin hydroxide (Duter) and triphenyltin chloride (Brestanol) are used as fungicides and bactericides; bis(trineophyltin) oxide (Vendex or Torque) and tricyclohexyltin-1,2,4-triazole (Peropal) are used as acaricides for the control of phytophagous (plant-eating) mites.[7,8] A sixth compound, tricyclohexyltin hydroxide (Plictran), has until recently been used as an acaricide, but it has been withdrawn since it has been found to produce birth defects in rabbits. The three triphenyltin compounds have, in addition, shown antifeedant and chemosterilant properties.[7,8] Plictran also exhibits the former property.

The insecticidal properties of various triorganotin compounds have been known for many years and yet, to date, none of them has reached practical use.[9–11] One of the main reasons for this, which precludes their use, is that the most potent organotin insecticides tend to be the trimethyltins, which also possess high mammalian toxicity.[12] For this reason trimethyltin compounds were not included in these tests.

In this study we have examined the activity of ten compounds (Table 1) against three insect species; the common house fly (*Musca domestica*); the cotton stainer (*Dysdercus cingulatus*) and the mosquito (*Anopheles stephensi*). Nine of these compounds (**1–9**) have (or have had) commercial applications and three of them are used as agrochemicals; triphenyltin hydroxide (**5**), triphenyltin acetate (**6**) and tricyclohexyltin hydroxide (**7**). The 1:1 adduct (**10**) between diethyltin dichloride and 1,10-phenanthroline Et_2SnCl_2.phen, has been found to possess antitumour activity towards the P388 lymphocytic leukaemia in mice.[13]

MATERIALS AND METHODS

The organotin compounds (**1–9**) were obtained commercially, while Et_2SnCl_2.phen (**10**) was synthesized via the literature route.[14]

The compounds were serially diluted with acetone to bracket approximate LD_{50} doses. One hundred house flies were lightly anaesthetized with carbon dioxide. Groups of 25 flies were placed in 0.47-litre Fonda containers with screen tops for a 24-h acclimatization period at 24°C. These flies were fed on milk-soaked cotton pads placed on the screen tops. After the 24-h acclimatization, the flies were again lightly anaesthetized with carbon dioxide. Each fly was then carefully held with forceps and the thorax treated with 1 μl of a preassigned insecticide dilution. Control flies were treated with 1 μl of acetone. An automated microapplication was used for treatment. The treated flies were then returned to appropriately labelled containers, given access to milk-soaked cotton, and maintained at 25 ± 1°C for 24 h, when mortality counts were made. The criterion for mortality was lack of response to probing; any movement was construed as survival.

After the approximate LD_{50} range was bracketed, a new stock solution of each insecticide was serially diluted with acetone to obtain five concentrations. Four replications per concentration were then tested; 25 female flies were tested in each replication. Control flies were treated with 1 μl of acetone. Post-treatment handling conditions were the same as described above.

A statistical analysis system (SAS) software package[15] was used to estimate LD_{50} values, their fiducial limits, and slopes ($\pm$SE) for each regression. Slopes of the probit regressions obtained for populations were analysed by the method of Steele and Torrie.[16]

Present mortalities were corrected using Abbott's formula.[17] Similar treatments using groups of 25 newly emerged, adult females were performed on the other two insect species. Thus the cotton stainers (*D. cingulatus*) were treated on the thorax like the house flies and were provided with cotton seeds as food. While the mosquitoes (*A. stephensi*) were treated on the dorsal side of the thorax in between the two wings and were supplied with honey water as food.

RESULTS AND DISCUSSION

The results are presented in Table 1 with the compounds listed in descending order of activity. With the exception of the two triphenyltin derivatives (**5** and **6**), which had activity against *A. stephensi* similar to that of the tributyltins (**1**–**4**), the overall trend in response of the insects to the compounds was the same for each species. However, in some cases, response of individual species varied, i.e. differential resistance was observed.

The progressive introduction of organic groups at the tin atom in any R_nSnX_{4-n} series produces a maximum biological activity against all species when $n = 3$, i.e. for the triorganotin compounds,

Table 1 Response of *Musca domestica*, *Dysdercus cingulatus* and *Anophelese stephensi* to organotin compounds

Compound	No. of insects	*Musca* LD_{50} (%)	*Musca* Fiducial limit of LD_{50} (%)	*Anophelese* LD_{50} (%)	*Anophelese* Fiducial limit of LD_{50} (%)	*Dysdercus* LD_{50} (%)	*Dysdercus* Fiducial limit of LD_{50} (%)
1 Bu_3SnCl	100	0.48	0.44–0.51	0.29	0.23–0.34	0.52	0.48–0.57
2 $(Bu_3Sn)_2O$	100	0.70	0.57–0.84	0.31	0.25–0.38	0.87	0.78–1.12
3 Bu_3SnL[a]	100	0.68	0.64–0.78	0.62	0.58–0.74	0.70	0.68–0.78
4 Bu_3SnL^+Quat[a]	100	0.72	0.67–0.84	0.69	0.66–0.83	0.76	0.70–0.81
5 Ph_3SnOH	100	1.24	1.11–1.39	0.49	0.44–0.52	0.96	0.86–1.32
6 $Ph_3SnOCOCH_3$	100	2.00	1.76–2.23	0.52	0.46–0.55	0.98	0.78–1.31
7 Cy_3SnOH	100	2.12	1.32–2.92	0.85	0.75–0.98	1.09	0.99–1.32
8 Me_2SnCl_2	100	3.67	2.75–6.51	0.87	0.78–1.12	1.24	1.04–1.41
9 $PhSnCl_3$	100	6.00	3.92–7.74	1.12	0.91–1.52	1.49	1.31–1.75
10 Et_2SnCl_2.phen[b]	100	6.12	4.12–7.62	1.83	1.64–2.25	4.08	3.53–5.84

[a]L = linoleate ($C_{18}H_{31}O_2^-$); Quat = quaternary ammonium salt added to aid solubility. [b]phen = 1,10-phenanthroline.

R_3SnX.[1] The species towards which the R_3SnX compound is most active is primarily determined by the nature of the organic group, R, attached to the tin atom. As the number of carbon atoms in R increases, so the species toxicity rises to a maximum value, after which any further increase in the n-alkyl chain length usually produces a sharp drop in the biological activity. Aryl groups tend to be less toxic than the lower alkyls (i.e. C_1–C_4). Our results reflect this general toxicological trend.

The nature of the X group in an R_3SnX derivative generally has only a minor effect on the biological activity,[2,18] unless X itself is active, or X can intramolecularly coordinate to the tin atom to form a five-coordinate monomer. In the former case activity may be enhanced (synergism), whilst the latter often produces a significant reduction in activity.[1] However, in an earlier study,[19] one of us demonstrated that the presence of a halogen group was an important contributor to activity, and these results add further support to this theory, in that the most active compound is tributyltin chloride (Bu_3SnCl; **1**). Both this compound and bis(tributyltin) oxide ($(Bu_3Sn)_2O$; **2**) have relatively high mammalian toxicity, viz. LD_{50}(rat) *ca* 122 and 148 mg kg^{-1} respectively.[20] However, tributyltin linoleate (Bu_3SnL, L = lineolate; **3**) has a slightly lower mammalian toxicity, viz. LD_{50}(rat) 190 mg kg^{-1},[21] while retaining good insecticidal properties. It can be seen that the compounds tested here are considerably less active than corresponding ones bearing the trimethyltin moiety (cf. typical LD_{50} values for *Musca* in the range 0.0007%)*, but the latter would not be used commercially for reasons of mammalian toxicity.

In summary, we have demonstrated that tributyltin compounds show high activity against three common insect species. Unfortunately, current world-wide restrictions on the use of organotin biocides may preclude their practical application in this area.

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*Me_3SnBr LD_{50} 4.5×10^{-10} mole/fly (Ref. 22) $\equiv 1.1 \times 10^{-7}$ g/fly.

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