SUMITOMO CHEMICAL

The Fastest Knockdown Against Cockroaches

Pralle®

— 50% Imiprothrin MUP —

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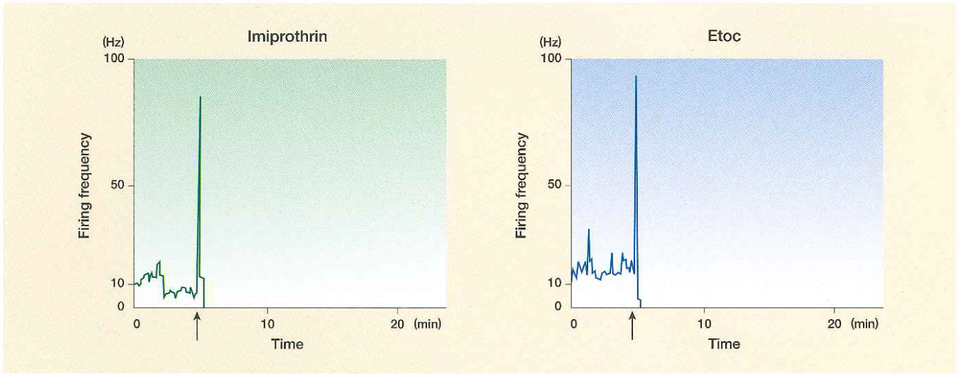

Fig. 6. Time course of the firing frequency of the central nervous system of German cockroach treated with 2.5×10^{-5} M pyrethroids. Arrow indicates the application of pyrethroid solution.

an appropriate concentration with physiological saline before use. Final concentration of DMSO in the solution never exceeded 0.5%, a concentration with no effect on the nerve preparation. The diluted solution was directly applied to the abdominal nerve cord. Figure 6 presents the time course of the firing frequency of the central nervous system in connection with the application of Imiprothrin and Etoc. When Imiprothrin was applied, there was a rapid decline in spontaneous firing following its application which was concluded by its disappearance altogether. The time taken for the disappearance of spontaneous discharge following application of Imiprothrin was shorter than that in the case of Etoc (Fig. 7). Therefore, we may be able to conclude that the high knockdown activity of Imiprothrin seems to be the result of its quick effect on the target site.

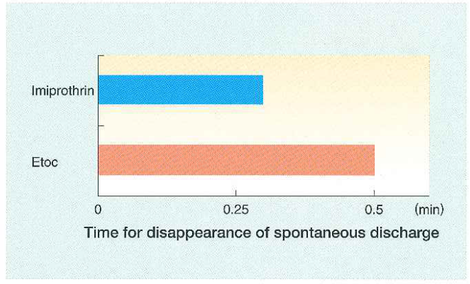

Fig. 7. Time for the disappearance of spontaneous discharge after applying 2.5×10^{-5} M Imiprothrin and Etoc

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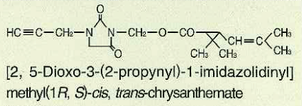
A New Synthetic Pyrethroid, Imiprothrin with Super Knockdown Activity

Introduction

Our market research proves that consumers insist upon more rapid knockdown efficacy concerning cockroach control delivered by aerosol. In cases where they were able to surprise a cockroach and spray aerosol directly onto it, the cockroach was not always subject to immediate and terminal knockdown. The cockroaches often had the ability to escape and seek refuge behind a cupboard or a refrigerator. Even if the cockroach died soon after its escape, the consumer, unable to visually confirm its demise, might not feel satisfied with the efficacy of the aerosol. In consideration of this situation, we designed and developed a new pyrethroid insecticide, Imiprothrin, which produces a very rapid knockdown capability against household insects, with cockroaches being affected most severely (Hirano *et al.*, 1979, Senbo *et al.*, 1995, Ishiwatari *et al.*, 1996, Hirano *et al.*, 1998). This effective compound has been registered in Japan (October, 1996) and USA (March, 1998).

Table 1. Physical and chemical properties of Imiprothrin

Item	Outline of properties
Chemical structure	
Chemical name	[2, 5-Dioxo-3-(2-propynyl)-1-imidazolidinyl] methyl(1*R*, *S*)-*cis*, *trans*-chrysanthemate
Formula	$C_{17}H_{22}N_2O_4$
Molecular weight	318.4
Appearance	Brownish viscous liquid
Specific gravity	d_{25}^{20}=1.122
Viscosity	52900 cP at 30˚C
Solubility	Miscible with most aromatic and aliphatic hydrocarbons, chlorinated hydrocarbons, and other organic solvents. Slightly soluble in water (85.8 ppm at 25˚C).
Stability	Stable under normal storage conditions for technical grade. Stable in most organic solvents. Unstable in methanol.
Vapor pressure	7.07×10^{-5} mmHg at 20˚C

Insecticidal activity of Imiprothrin

1. Physical and chemical properties

Physical and chemical properties appear in Table 1. Almost all physical and chemical properties of Imiprothrin were suitable for formulation of household insecticides with the exception of its high viscosity. In order to create ease in handling, Imiprothrin was dissolved in isopropyl myristate to create the manufacturing use product (MUP), designated as Pralle®.

2. Knockdown activity of Imiprothrin

Direct spray method using an oil-based aerosol against cockroaches

An oil-based aerosol formulation was prepared according to the recipe presented in Table 2. The container into which test cockroaches were released was placed at the bottom of a glass cylinder and the aerosol was sprayed directly against cockroaches from the top of the cylinder. Then the number of knocked-down insects was counted at designated intervals for 20 minutes. The insects were collected in a plastic cup with food and water, and kept to observe their mortality

Table 2. Recipe of oil-based aerosol

Pralle	0.15-1.0 (0.075-0.5 as Imiprothrin)
Deodorized kerosene	40.0
Solvent	balance
Propellant	40.0
Total	100.0%W/W

Tetramethrin or Bioallethrin	0.5-1.0
Deodorized kerosene	balance
Propellant	40.0
Total	100.0%W/W

Propoxur	1.0-2.0
Deodorized kerosene	30.0
Solvent	balance
Propellant	40.0
Total	100.0%W/W

Table 3. Efficacy of oil-based aerosol (Direct spray method)

Test aerosol	Conc. (%W/W)	German cockroach (spray amount: 0.4g)		American cockroach (spray amount: 1.0g)	
		KT_{50} (min.)	Mortality (%)	KT_{50} (min.)	Mortality (%)
Imiprothrin	0.075	0.9	34	2.5	33
	0.1	0.8	78	2.0	42
	0.2	<0.7	88	1.2	83
	0.5	<0.7	100	0.8	100
Tetramethrin	0.5	9.4	36	>20	3
	1.0	5.0	60	14	23
Bioallethrin	0.5	12	42	17	8
	1.0	7.9	74	10	25
Propoxur	1.0	4.5	100	–	–
	2.0	4.1	100	–	–

rates after 72 hours. The results are presented in Table 3. Imiprothrin aerosol demonstrated the highest knockdown activity against German cockroaches and American cockroaches among the aerosols tested.

Moving distance measurement method using water-based aerosol against cockroaches

A vinyl chloride sheet, upon which concentric circles with various radiuses (10-140 cm) were drawn, was laid on the floor of the chamber (Fig.1). A plastic ring was placed at the center of the concentric circles, and German cockroaches or American cockroaches were released into this ring. An appropriate amount of water-based aerosol (the recipe is presented in Table 4) was sprayed directly onto the cockroaches from 30 cm above the floor. Following this, the plastic ring was immediately removed and the cockroaches were allowed to flee as best they could. Distances between the center of the circle and the site where the cockroaches were eventually knocked down and stopped moving were measured. The MD_{50} (median moving distance of the test insects, which refers to the distance from the spray point which required that 50% of test insects were knocked down) was obtained by utilization of Finney's method. The results are presented in Table 5. The activity of aerosols containing Imiprothrin was much higher than that registered by reference commercial aerosols.

Table 4. Recipe of water-based aerosol

Pralle	0.2 (0.1 as Imiprothrin)
Gokilaht-S[1] or Sumi-alpha[2]	0.1
Emulsifier	0.5
Solvent	0.5
Deodorized kerosene	balance
Deionized water	60.0
Propellant	20.0
Total	100.0%W/W

1) Cyphenothrin-S 2) Esfenvalerate

Table 5. Efficacy of water-based aerosol (Moving distance measurement method)

Test aerosol	Conc. (%W/W)	German cockroach (spray amount: 0.4g)		American cockroach (spray amount: 1.0g)	
		MD_{50} (cm)	Mortality (%)	MD_{50} (cm)	Mortality (%)
Imiprothrin/Cyphenothrin-S	0.1/0.1	16.7	100	32.2	100
Imiprothrin/Esfenvalerate	0.1/0.1	15.8	100	25.5	100
Dichlorvos/Tetramethrin /Propoxur/Cyfluthrin (reference, oil-based aerosol)	0.5/0.3 /1.0/0.025	82.7	100	>140	100

Why does Imiprothrin demonstrate such high knockdown activity?

We present two hypotheses described below.

(1) Imiprothrin penetrates the cuticle of insects more rapidly than other pyrethroids.

(2) The action of Imiprothrin on a target site (which is considered to be the nervous system of the insects) is faster than those of other pyrethroids.

To examine these hypotheses, we conducted two experiments in comparison with Etoc® (Prallethrin), which is the strongest knockdown agent available among commercial insecticides.

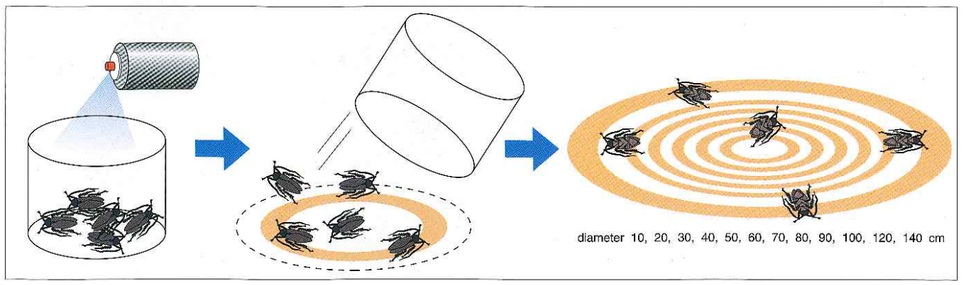


Fig. 1 Moving distance measurement method

1. Knockdown activity by topical application method and injection method

Zero point five micro liter of test solution (acetone solution and kerosene solution) was 1) applied on the thoracic sternum of a male adult German cockroach or 2) injected into a male adult German cockroach through the membrane between the coxa of the middle leg and the sternum without anesthesia and immediately the cockroach was released into a plastic cup. The time until the cockroach was knocked down after treatment was recorded (Fig.2). The relationship between KT_{50} value and treatment dosages delivered by topical application and injection method is presented in Figure 3 (Imiprothrin) and Figure 4 (Etoc). When an acetone solution of Imiprothrin was applied, KT_{50} value by topical application was much larger than that generated by the injection method. On the other hand, when a kerosene solution of Imiprothrin was applied, there was no significant difference between KT_{50} value by topical application and injection method. When an acetone solution of Etoc was applied, KT_{50} value by topical application was also much larger than that by injection method but the difference was smaller than that in the case of Imiprothrin. When a kerosene solution of Etoc was applied, there was no significant difference between KT_{50} value by topical application and injection method like Imiprothrin.

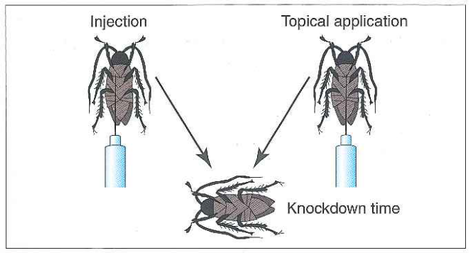


Fig. 2 Knockdown activity by topical application and injection method

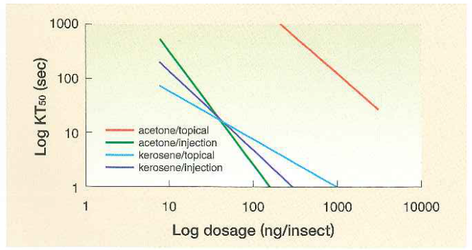


Fig. 3 Relationship between KT_{50} values and dosages of kerosene solution and acetone solution of Imiprothrin by topical application method and injection method

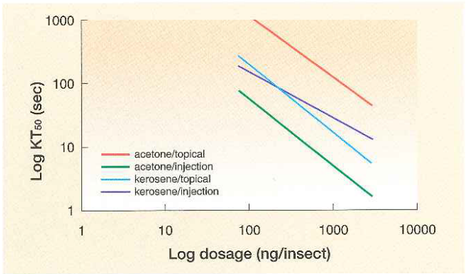


Fig. 4 Relationship between KT_{50} values and dosages of kerosene solution and acetone solution of Etoc by topical application method and injection method

From these results, both Imiprothrin and Etoc seemed to penetrate quickly through the cuticle of the cockroaches when kerosene solution was topically applied, but failed to do so in the case of acetone solution. In particular, Imiprothrin seemed to penetrate more slowly in comparison with Etoc in acetone solution because the difference between KT_{50} value by topical application and that by injection method was larger than that in the case of Etoc. In other words, Imiprothrin without kerosene or any other appropriate solvent was unable to penetrate the cuticle of insects rapidly in comparison with Etoc. Therefore, we can disprove hypothesis (1).

2. Electrophysiological activity on the central nervous system

A cockroach with wings, legs and head removed was fixed on a platform using bee's wax and dissected. The gut, fatbody and other tissues were removed from the connective between the third and forth ganglion of the abdominal nerve cord. Spontaneous discharge was recorded from the abdominal nerve cord using a suction electrode (Fig.5). The frequency of firing was observed for 1 hr. In the preparation of pyrethroid solution, dimethyl sulfoxide (DMSO) was used as a solvent of the stock solution. The stock solution (10^{-2}M) was diluted to

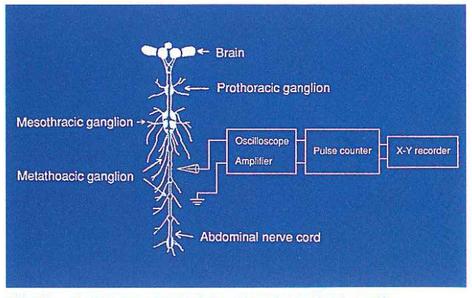


Fig. 5 Procedure of electrophysiological study