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Dispersion of lambda-cyhalothrin in micro-emulsion of polystyrene

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Abstract: Attempts to obtain a micro-dispersion-based formulation insecticide were made. An aqueous micro-suspension of polystyrene had been used to trap pyrethroid lambda-cyhalothrin. A method of introducing the active substance into the polymer was developed. The biological efficiency of micro-emulsion of lambda-cyhalothrin with polystyrene was investigated.

Keywords: micro-emulsion, lambda-cyhalothrin, *Blatella germanica*, *Musca domestica*

INTRODUCTION

Controlled-release technology of an active substance has become popular as a mean of delivering drugs, agrochemicals and other biologically active agents [1-7]. Delivery of pesticides through controlled release systems has gained increased interest, since these can reduce their environmental impact [8]. This technology can solve a variety of problems concerning the application of an active compound. Conventional treatment with such agents cause severe damage to the environment [9], since they migrate readily to water and air. The type of formulation with a low content of active substance offers advantages for health, nutrition, environmental pollution control and economic development [10-12].

Authors of [13] remind that insecticides are applied in general to porous surfaces, which can have a negative effect on the biological availability of insecticides. In their opinion, a strong and persistent insecticidal effect on different substrates can be obtained by "protecting the active ingredient from the

substrate and environmental conditions, and controlling its rate of release". The authors conclude that the process of microencapsulation offers this opportunity. The product which they obtained was based on microencapsulation technology which consists on enclosing the liquid active ingredient in a polymer shell to provide protection against hostile environmental conditions.

The idea of our research was to introduce the active substance directly to the polymer mass to obtain slow release rate. We assumed also that the very small size of particles in micro-dispersion (0,1 μm) would result in high efficiency of the new pesticide. We used polystyrene to trap the active substance, lambda-cyhalothrin. A method of production of aqueous micro-dispersion of polymer with the active substance has been developed. Two types of micro-dispersive formulations with 8% lambda-cyhalothrin were prepared and the biological activity of the emulsions was investigated.

MATERIALS AND METHODS

Formulation of micro-suspension of lambda-cyhalothrin

A qualitative comparison of the biological activity of two micro-dispersive formulations of lambda-cyhalothrin – the first one in which lambda-cyhalothrin (about 10%) was introduced into the structure of chemically pure polystyrene (**emulsion 1**) and the second one (**emulsion 2**) based on polystyrene with auxiliary plasticizer added (paraffin oil) – was carried out. The micro-suspension formulation was obtained according to the following procedure.

The micro-suspension of lambda-cyhalothrin incorporated into the structure of micro-beads of plasticized polystyrene was obtained by dissolving a tenth of the mass of insecticide in styrene containing an addition of pharmaceutical paraffin oil (proportion 10:1). The next stage consisted on obtaining in aqueous medium a stable micro-emulsion of monomer in the presence of a surface-active agent, using an ultrasonic homogenizer (U400S – Hielscher GmbH) equipped with a titan sonotrode H22 at the 24 kHz frequency in an opened cooled stainless steel mixer. In the last phase, the polymerization process was carried out with a peroxide activator under a reflux condenser in a standard glass reactor equipped with propeller stirrer at 70-75 °C. The obtained micro-suspension was stable during storage and was composed of particles of 0,1 μm diameter, measured with laser ray diffraction in an Coulter® LS.

Determination of lambda-cyhalothrin in the forms

The water from the emulsion was evaporated and the sample was dried for 2 h

at 40 °C. The powder (approximately 30 mg) was added to 25 ml of acetone and dispersed for 10 min in an ultrasonic bath. The suspension was filtered and the filtrate analyzed by RP-HPLC using a 1.8 mm × 150 mm Hypersil 120-5 ODS column (Macherey-Nagel). The lambda-cyhalothrin was eluted with acetonitrile/water (80:20 v/v) and detected at 270 nm.

Biological activity

The test was performed on 25 females of *Musca domestica* (4-8 days) and *Blatella germanica* (5 males and 5 females) The test material was applied on surfaces: smooth (ceramic plate) and porous (plywood plate) structure. After 24 h test insects were placed on the applied surfaces and observed. The results were presented in Tables 1 and 2.

RESULTS AND DISCUSSION

Table 1 shows the insecticidal activity of emulsion 1 (without plasticizer) measured at several time intervals after application on two type surfaces: smooth (ceramic plate) and porous (plywood plate). Analogical results for the emulsion 2 are presented in Table 2. These data can be compared with the results obtained for the control group (Table 3) which did not have contact with lambda-cyhalothrin.

Table 1. Insecticidal activity of emulsion 1

Bioindicator		**Number of dead insects on surface**	**Time**							
			20 min	40 min	1 h	2 h	3 h	4 h	24 h	48 h
Musca domestica		Smooth surface	20	25	25	25	25	25	25	
		% Mortality	**80**	**100**	**100**	**100**	**100**	**100**	**100**	
		Porous surface	19	25	25	25	25	25	25	
		% Mortality	**76**	**100**	**100**	**100**	**100**	**100**	**100**	
Blatella germanica	♀	Smooth surface	0	2	4	5	5	5	5	5
		% Mortality	**0**	**40**	**80**	**100**	**100**	**100**	**100**	**100**
		Porous surface	0	0	0	4	4	4	5	5
		% Mortality	**0**	**0**	**0**	**80**	**80**	**80**	**100**	**100**
	♂	Smooth surface	0	1	1	5	5	5	5	5
		% Mortality	**0**	**20**	**20**	**100**	**100**	**100**	**100**	**100**
		Porous surface	0	0	2	3	5	5	5	5
		% Mortality	**0**	**0**	**40**	**60**	**100**	**100**	**100**	**100**

Table 2. Insecticidal activity of emulsion 2

Bioindicator		Number of dead insects on surface	Time							
			20 min	40 min	1 h	2 h	3 h	4 h	24 h	48 h
Musca domestica		Smooth surface	22	25	25	25	25	25	25	
		% Mortality	**88**	**100**	**100**	**100**	**100**	**100**	**100**	
		Porous surface	25	25	25	25	25	25	25	
		% Mortality	**100**	**100**	**100**	**100**	**100**	**100**	**100**	
Blatella germanica	♀	Smooth surface	0	3	5	5	5	5	5	5
		% Mortality	**0**	**60**	**100**	**100**	**100**	**100**	**100**	**100**
		Porous surface	0	4	5	5	5	5	5	5
		% Mortality	**0**	**80**	**100**	**100**	**100**	**100**	**100**	**100**
	♂	Smooth surface	0	2	4	5	5	5	5	5
		% Mortality	**0**	**40**	**80**	**100**	**100**	**100**	**100**	**100**
		Porous surface	0	3	4	5	5	5	5	5
		% Mortality	**0**	**60**	**80**	**100**	**100**	**100**	**100**	100

Table 3. Results of the control group

Bioindicator		Number of dead insects on surface	Time			
			20 min	40 min	24 h	48 h
Musca domestica		Smooth surface	0	0	3	
		% Mortality	**0**	**0**	**12**	
		Porous surface	0	0	6	
		% Mortality	**0**	**0**	**24**	
Blatella germanica	♀	Smooth surface	0	0	0	0
		% Mortality	**0**	**0**	**0**	**0**
		Porous surface	0	0	0	0
		% Mortality	**0**	**0**	**0**	**0**
	♂	Smooth surface	0	0	0	0
		% Mortality	**0**	**0**	**0**	**0**
		Porous surface	0	0	0	0
		% Mortality	**0**	**0**	0	0

The two obtained preparations were characterized by high mortality of bioindicators. An important acceleration of the insecticidal activity of the product with added plasticizer was observed, which is due probably to the fact that the migration of the active agent to the surface of polymer beads (micro-particles) occurred more easily. This relation can be established for a short-time exposure of insects to the product. The differences in biological activity of the two formulations were noticed in the case of exposure time between 20 min and 2 h.

However, we observed white sediment covering the bodies of the insects. This can be explained by the affinity of the waxy layer covering insects cuticle for the walls of polymer beads [13]. This effect is not positive, because insects may permanently stain the surface. We continue our attempts to improve the formulation and determine the maximum operating time.

CONCLUSIONS

More and more attention is paid to develop environmentally friendly and safe pesticides. Reduction in the dose of an active substance and a convenient packaging – are the main tasks of technology of commercial form.

The subject of our investigation was to a obtain product with the following profile: highly potent active ingredient, a low content of active substance and controlled-release system. We developed a method for obtaining two types of the aqueous micro-dispersion of polystyrene with the active substance with high biological activity. This strong insecticide effect can be associated with the very small size of the micro-suspension particles. However, we could not prove achieving slow release rate because this aspect needs a further investigation. In view of the very high mortality of insects caused by the two emulsions further reduction of lamba-cyhalothrin dose would be worth investigating.

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