PESTICIDE FORMULATIONS AND APPLICATION SYSTEMS

THIRD SYMPOSIUM

Kaneko/Akesson, editors

ASTM STP 828

PESTICIDE FORMULATIONS AND APPLICATION SYSTEMS: THIRD SYMPOSIUM

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Foreword

The papers in this publication, *Pesticide Formulations and Application Systems: Third Symposium*, were presented at a symposium titled Third Annual Symposium on Pesticide Applications and Formulation Systems, which was the third in a series of ASTM-sponsored symposia on this subject. This third symposium was held on 12 Oct. 1982 in Fort Mitchell, Ky., and was sponsored by ASTM Committee E-35 on Pesticides and its Subcommittee E35.22 on Pesticide Formulations and Application Systems. Thomas M. Kaneko of the BASF Wyandotte Corp. presided as chairman of the symposium, and Norman B. Akesson of the University of California at Davis was chairman of Subcommittee E35.22. Both men also served as editors of this publication.

Related ASTM Publications

Pesticide Formulations and Application Systems: Second Conference, STP 795 (1983), 04-795000-48

Pesticide Tank Mix Applications: First Conference, STP 764 (1982), 04-764000-48

Vertebrate Pest Control and Management Materials: Fourth Symposium, STP 817 (1983), 04-817000-48

Vertebrate Pest Control and Management Materials (Third Symposium), STP 752 (1981), 04-752000-48

Vertebrate Pest Control and Management Materials (Second Symposium), STP 680 (1979), 04-680000-48

Test Methods for Vertebrate Pest Control and Management Materials (First Symposium), STP 625 (1977), 04-625000-48

Avian and Mammalian Wildlife Toxicology: Second Conference, STP 757 (1981), 04-757000-48

Avian and Mammalian Wildlife Toxicology (First Symposium), STP 693 (1979), 04-693000-48

A Note of Appreciation to Reviewers

The quality of the papers that appear in this publication reflects not only the obvious efforts of the authors but also the unheralded, though essential, work of the reviewers. On behalf of ASTM we acknowledge with appreciation their dedication to high professional standards and their sacrifice of time and effort.

ASTM Committee on Publications

ASTM Editorial Staff

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Introduction

Since 1980, when the first of this series of symposia was held under the sponsorship of ASTM Committee E-35 on Pesticides and conducted by its Subcommittee E35.22 on Pesticide Formulations and Application Systems, the annual symposium on Pesticide Formulations and Application Systems has maintained its goal of providing an open forum in which industry, academia, and government all participate voluntarily. Each year, the program has covered a wide variety of topics: to name just a few, these have included toxicants, surfactants, dispersants, and other such raw materials required in formulating pesticides; their delivery equipment and application systems, efficacy in controlling pests, and safety in handling and use; and governmental regulations regarding pesticide testing, marketing, and uses.

The third ASTM-sponsored symposium was held on 12 Oct. 1982. The topics presented and reported in this volume fall into three main categories: formulations, applications, and water-dispersible granules. Under the subject area of formulations are included papers on entomopathogens, laboratory measurements and evaluations, quality control, and specific formulations. The section on applications includes papers on atomization and physical properties of fluids, spray drift assessment, flow rates, electrostatic atomization, helicopter application, and delivery to aquatic pests. The section on water-dispersible granules contains several papers that concentrate on this particular type of formulation.

At the presentation of the papers during the symposium, keen interest was expressed by the audience during the brief question and answer period that followed each presentation. All members of the symposium committee reported receiving favorable comments regarding the varied but interrelated topics. Sufficient interest was generated to justify expanding the program at the next symposium, the fourth in the series. Hence, the editors feel that the goal and scope of the annual series were achieved in this third symposium.

It has also become apparent that the need for such an interdisciplinary forum was accurately perceived by the original organizers, as this series continues to expand in scope and subject matter and as participation in it continues to grow.

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Formulations

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Formulations of Entomopathogens

REFERENCE: Sawicka, E. M. and Couch, T. L., "**Formulations of Entomopathogens,**" *Pesticide Formulations and Application Systems: Third Symposium, ASTM STP 828*, T. M. Kaneko and N. B. Akesson, Eds., American Society for Testing and Materials, Philadelphia, 1983, pp. 5–11.

ABSTRACT: A brief history of the development of entomopathogens will be presented. Descriptions of unusual problems faced by researchers when formulating, stabilizing, and testing biological materials, specifically *Bacillus thuringiensis* formulations, will be presented. The importance of adjusting the physical and biological properties of a formulation for delivery to the target species will be discussed. Environmental aspects of the use of biological pesticides will be presented.

KEY WORDS: pesticides, formulations, entomopathogens, *Bacillus thuringiensis*

Agricultural pesticide formulations are defined as mixtures of active ingredients with other materials to form stable, effective, safe, easily applied, and acceptable-to-the-user products. In this short paper, the authors will review pertinent information on formulations of the economically important entomopathogens.

Entomopathogens

Entomopathogens are bacteria, viruses, or fungi that infect insects and mites. Knowledge of bacteria-caused diseases in insects began in the late nineteenth century with Pasteur's study in 1870 of flacherie of the silkworm and with descriptions by Cheshire and Cheyne (1885) of *Bacillus alvei* and its role in diseases of honey bees. Since then, over 90 species and varieties of pathogenic bacteria have been described [*1*].[3] As information about ento-

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[3]The italic numbers in brackets refer to the list of references appended to this paper.

mopathogens developed, discoveries of fungus- and virus-caused diseases followed. The following list includes some of the more commonly used entomopathogens:

Bacteria:
- *Bacillus popilliae*
- *Bacillus thuringiensis*
- *Bacillus sphaericus*

Fungi:
- *Beauveria bassiana*
- *Beauveria brongniartii*
- *Hirsutella thompsonii*
- *Nomuraea rileyi*

Viruses:
- nucleopolyhedrosis viruses (NPV) of *heliothis* species
- cytoplasmic polyhydrosis viruses
- bacilloviruses
- nonoccluded viruses

Formulations of Entomopathogens

Several entomopathogens are being tested for field application, but the most economically important are formulations of *Bacillus thuringiensis*, subspecies *kurstaki* and *israeliensis* (Dipel and Vectobac from Abbott Laboratories, Thuricide and Teknar from Sandoz Inc., and Bactimos from Biochem Products).

The microbial insecticides have to be formulated into products acceptable to agricultural markets, which means the development of entomopathogens must closely parallel the forms of chemical insecticides. The chemical insecticides are formulated into the following products: emulsifiable concentrates, emulsifiable suspensions, aqueous suspensions; soluble powders, dusts, wettable powders, granules, baits, and microencapsulated formulations. Quite often an insecticide is introduced into the market in several forms, depending on the environment of the insect species to be controlled and the preferred method of application. Since insect pathogens are insoluble living entities, they cannot be formulated as emulsifiable concentrates or soluble powders. There are attempts being made to microencapsulate some of the entomopathogens, but there are difficulties in attaining proper release mechanisms.

A large number of insect pathogens discovered and tested in laboratories and greenhouses have no hope of entering the market because of the extreme difficulty of producing them and stabilizing them outside the host organism. Research for commercial development of an entomopathogen focuses on preserving the pathogen's viability and virulence during the production process and preparing a product form that will preserve or enhance these properties or do both.

Knowledge of the biology of the pathogen and target insect is essential in the development of entomopathogens. Biological pest control agents presently on the market are produced through the fermentation processes. The fermentation product, containing a small percentage of the insect pathogen, has to be treated as a preformulated material and carefully tested for its chemical, physical, and biological properties before preparation of the commercial formulation can be attempted. For the formulation of entomopathogens, the industry considers the biological, chemical, and physical effects of the inert carrier, surfactant, adjuvant, temperature, and moisture on the entomopathogen to be very important. Failure to manipulate all these factors to the advantage of the insect pathogen can impair its viability and virulence. To be commercially acceptable, the formulated insect pathogen, besides being viable and virulent, should remain so for a prolonged period of time (maintain biological stability).

Since the commercialization in 1950 of formulations of *Bacillus thuringiensis*, the bacterial strain, formulation yield, product form, and stability have constantly improved, making this entomopathogen an effective and economical alternative to chemical insecticides.

Formulations of *B. thuringiensis* (*Bt*) are constantly improving from the earlier wettable powder, which was almost impossible to wet, to a product that wets and disperses in seconds.

The development of aqueous and emulsifiable oil suspensions solved many problems connected with the acceptability of powder formulations but also created new ones, especially with the water carriers. Aqueous flowables contain *Bt* spores and crystals stabilized with fungistatic and bacteriostatic ingredients, which often fail to prevent vegetative growth.

Vegetative processes and autolysis cause the formation of gas, which then causes leakage out of or a rupturing of the container. The physical properties of formulations are very important for the applicator. For example, a powder should have a narrow distribution of particle size, no dust, and no large particles to plug the screen; it should wet, disperse, and become suspended with very little foam. The viscosity of a flowable should be low enough to allow it to be easily poured out of the container; it should easily disperse and become suspended; and it should not cake during storage.

All in all, it's much more difficult to achieve these properties with *Bt* formulations than with other agricultural chemical pesticides.

The formulation requirements vary among the different entomopathogens. While the formulations of *Bt* are quite stable in the dry form, research on *Hirsutella thompsonii* revealed that the moisture content required was much higher [*2*]. Furthermore, the commercial formulations of the nucleopolyhedrosis virus (NPV) and granulosis virus (a highly infectious, encapsulated virus) are spray dried, air dried or freeze dried. Liquid suspensions of insect viruses have been kept cold or frozen [*3*]. Some ways of sustaining the proper shelf life of the formulations of insect pathogens, which includes controlling the temperature and humidity, are quite costly and not easily achievable in commercial warehouses.

Entomopathogens are formulated into commercial products with carrier/diluent, wetting, and dispersing agents. This research requires time-consuming experiments with large numbers of ingredients and extensive pathogen/carrier compatibility and stability studies. Entomopathogens are extremely sensitive to surface-active agents and some can be formulated only with diluent/carrier agents.

Surface-Active Agents

The following list [*4,5,6*] includes some of the types of surface-active agents that can be used in entomopathogen formulations research:

Nonionic agents:
- polyoxyethylene alkylphenols
- polyoxyethylene alcohols
- polyoxyethylene esters of fatty acids
- polyoxyethylene aklylamides

Anionic agents:
- sodium salts of alkylnaphthalene sulfonates
- sodium salts of lignosulfonates
- sulfonated aliphatic polyesters
- sulfonated fatty acids

Cationic agents:
- quarternary ammonium derivatives of olefins
- quarternary ammonium derivatives of paraffins
- quarternary ammonium derivatives of alkyl aromatic hydrocarbons
- cationic polymers

Carriers and Extenders

Among the types of carriers and extenders that can be used in entomopathogen formulations research are the following:

Mineral carriers:
- attapulgite clays
- kaolinite clays
- montmorillonite clays
- synthetic silicates
- diatomaceous earths
- vermiculites