Spinosad – An Industry Perspective on Green Pesticides

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Background

Spinosad is a class of chemical insecticides developed by Dow Chemical Company. For farmers who need pest control, Spinosad is a chemical insecticide that can effectively kill a wide range of pests within 1 to 2 days of application. Unlike traditional halogenated pesticides, Spinosad degrades rapidly through photolysis and does not persist in the environment. Also, the production of Spinoseuid utilises fermentation of Saccharopolyspora spinosa, which has lower energy consumption and environmental impacts.

Our team proposed to study Spinoseuid's product development process. We identified a series of milestones during the history of Spinoseuid: the serendipitous isolation of S. spinosa during a scientist's vacation; the initial decision to develop Spinoseuid as a pesticide; the identification of organic farming as an emerging market for Spinoseuid; the bold act to embrace fermentation as part of Dow's manufacturing; the step by step scale up from academic discovery to commercialization; and the discovery of its potential as a DDT substitute to fight malaria.

Much to our surprise, although the underlying production technology of spinosad is drastically different from traditional chemical syntheses, the Spinoseuid product development is a natural extension of the chemical-based pesticides. It seems that the pesticide industry is directed by an invisible hand, guiding the sector towards greener and safer fermentation products.

Pest Control

Weather and pest control are the two biggest challenges farmers constantly face.

- The issues often overlap in that pests in wet years differ from pests in dry years
- Whereas weather is uncontrollable, pests can be managed
- The majority of farmers hire independent pest control advisors to manage pests via spraying
- Over time, spraying has evolved out of necessity, regulation, and the organic movement

Market Drivers

Necessity

- Over usage of pesticides leads to resistance, making old products ineffective
- Once resistance has developed, the pesticide chemistry must be updated or changed

Regulation

- Pesticides are regulated by the EPA
- The EPA’s “fast track” safe products to market with the Reduced Risk Pesticide Program
- Farmers are deterred from using pesticides with a danger rating (category) i since they require very stringent controls like blood testing before and after use

Organic Movement

- Only 2% of all crops in the United States are grown organically, half of which are grown in California
- Despite small industry adoption, organizations like the CCDH have brought organic farming to the consumers’ attention

Spinoseuid is unique in that address all three market drivers

- The pesticide is based on a new biochemistry that insects currently have no resistance to
- Due to its insect selectivity, Spinoseuid was approved for the EPA's Reduced Risk Pesticide Program
- Being a natural product, the chemical is allowed for use on organic crops

Trend toward Biodegradability and Selectivity in Insecticides Development

From Spinoseuid to Spinetoram (1982 - 2010)

In 1982, a vaccinating chemist collected a soil sample from an abandoned rum still in the Caribbean as part of a program to search for soil microorganisms with unique biological activity. From this soil sample, a new species of actinomycete (S. spinosa) was isolated. Extracts from the fermentation broth of S. spinosa showed both contact and ingestion activity against southern armyworm (Spodoptera eridania). Due to the rarity of natural products against Lepidoptera, this discovery spurred further studies leading to the identification of a series of new macrocyclic structures, later named “spinosyns,” Spinoseuid A and D. The highest level of insecticidal activity and are produced in the greatest quantity among the many spinosyns extracted from the fermentation broth. The common name Spinoseuid is assigned to the naturally occurring mixture of spinosyn A and D.

During a trip to the West Coast, a Dow AgroSciences scientist met with a friend who happened to be working on a robotic vacuum cleaner that used an artificial neural network (ANN) as a means to learn the layout of an owner’s house. The scientist recognized artificial neural networks as an alternative approach to classic QSAR analysis. Artificial neural networks are a form of software-based artificial intelligence, essentially a learning machine that mimics neural connections of the brain. Artificial neural networks are very good at pattern recognition and work well with incomplete data. Using ANN-based QSAR modeling to analyze the spinosyns, the 3′,3′,4′-tri-D-ethyl analog of spinosyn A was identified as having strong potential for improved biological activity. Further ANN analysis determined that the 3′-D-ethyl group was the most potent in altering nicotinic function in the insect nervous system.

Industry Motivation

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