

Encapsulation of Solid Particles

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“ESP” to Control Problems of Taste and Waste

Some individuals may be upset at the suggestion that controlled release of a pesticide can be achieved by “ESP”. Frankly, I don’t know why. Everything else has been tried with varying degrees of success, so why not ESP? The letters of ESP refer, of course, to Encapsulation of Solid Particles. I’m sure that no one thought for a moment that the letters “ESP” could be referring to something else.

I propose and hope to demonstrate the “ESP”, as we know it in the encapsulation field, can be an alternative to less reliable procedures, some of which may be as far-removed as extrasensory perception.

I should like to tell you what we, at the Wisconsin Alumni Research Foundation, have done with the encapsulation of solid particles to control the taste of the anticoagulant rodenticide warfarin to make it more acceptable to rats and mice, and how this technology has been applied to cotton seed to control the release of a systemic pesticide conforming to the growth rate of the plants, thereby eliminating wasteful application. Finally, a brief description of this “ESP” process, which is known as the Wurster air suspension process.

Those who are even moderately familiar with the rodenticide industry are aware of the role the Environmental Protection Agency (EPA) has in regulating rodenticide compounds, formulations, quality and labeling. They are also aware of the consternation that griped many rodenticide formulators when the EPA’s test protocol for acceptability and mortality of commercial rodenticides was announced.

Very briefly, the protocol states: The test rodenticide is to be fed to 20 individually caged adult rats, 10 males and 10 females. Each rat is to have water ad lib and a free choice between the toxic commercial test bait and a control bait which consists of 65% cornmeal, 25% rolled oats, 5% corn oil and 5% confectioner’s sugar, and no toxicant. In order to meet the EPA acceptability requirements, the test bait is to be consumed at a level consisting of at least 33% of all the food eaten during the test period. 90% mortality must be obtained within 15 days.

While some rodenticide formulators found that their baits could somehow be made to meet these performance levels, the great majority of commercial rodenticide baits failed miserably, with acceptability levels often below 10%. I might add that we are referring here mainly to anticoagulant rodenticide baits inasmuch as the anticoagulants constitute by far the major part of the commercial product sold.

Somewhere along the line it became evident that bait rejection by rats was not necessarily the sole fault of the formulator or a result of poor quality bait ingredients. Although anticoagulant baits almost invariably met the mortality requirements of the EPA, the relatively small amount of test bait consumed in many of these tests indicated that something in the test bait was displeasing to the target rats. The displeasing substance turned out upon investigation to be the technical anticoagulant itself.

Because the Wisconsin Alumni Research Foundation has a background on anticoagulant rodenticides and a process that encapsulates solid particles, we hypothesized that the problems of the formulator might well be attacked by encapsulating technical warfarin so that any objectionable taste was masked and the compound itself was not released until it reached the digestive system of the animal. The project was not a simple challenge. It was a series of challenges relating to:

- a) Encapsulating a needle-like crystalline structure
- b) Maintaining small particle size distribution of the encapsulated product
- c) Selecting a formulation and coating level that would keep the active ingredient biologically available to rats and mice

In other words, the encapsulated product would have to be equally as toxic as the unencapsulated compound. This was accomplished. The May 1974 issue of PEST CONTROL MAGAZINE presents test results summarizing the data in an article entitled “Acceptability and Performance of Encapsulated Warfarin”.

These tests showed that while baits containing uncoated warfarin were accepted by laboratory rats at levels of 3% and 9% when warfarin from the same lot was encapsulated and incorporated into an identical bait, acceptability levels rose dramatically to about 30% to 80%. Mortality among the rats given encapsulated warfarin baits was, if anything, better than for those given unencapsulated warfarin baits. It was certainly no worse. The encapsulated warfarin is available commercially under the registered trademark TOX-HID.

Encapsulation of solid particles by the Wurster process comes under two headings – microencapsulation, represented by the encapsulation of warfarin, and macroencapsulation, represented by the encapsulation of cottonseed.

The young cotton plant is a prime target for the cotton aphid, which damages the plant during emergence and the early weeks of growth. If not controlled, the cotton aphid causes severe economic loss for the growers. Effective control agents have been systemic insecticides, particularly of the organophosphate type, such as Di-Syston, manufactured by Chemagro Corporation.

The Bolivar Delinting Company of Clarksdale¹, Mississippi suggested to the WARF Coating Laboratory that the cotton seed might be coated with a material containing the pesticide that would eventually release the pesticide without adversely affecting the storage life of the seed, its inherent germination characteristics, or the growth pattern of the plant. As an added marketing inducement, they also suggested that the system might just as well be designed to release the insecticide at a uniform rate conforming to the growth rate of the plant to assure its availability through these early weeks when the plant is most vulnerable to the aphid. A formidable goal. The idea was of sufficient importance to warrant a feasibility program to study the problems associated with incorporating the insecticide into a compatible and suitable resin, coating the resin mixture onto the cottonseed and determining the release rate of the insecticide from the resin.

Working out the technical details to meet these objectives did not come easily and without a great deal of effort and testing on the part of all parties¹ in addition to WARF and its client. The results showed that several coating formulations were developed and processing conditions were established that enabled the cottonseed to be macroencapsulated. The encapsulated seed met the germination and growth pattern of the unencapsulated seeds and the release rate of the insecticide gave maximum protection during the early growth period of the cotton plant when the insecticide is most needed.

In greenhouse tests the Wurster coated cottonseeds were tested for insecticidal performance as compared with controls having fresh treatment of insecticide. Cotton plants grown from encapsulated seeds showed 77% greater insecticidal effectiveness 5 weeks and 3 days after the cotyledon stage than the unencapsulated seeds. In connection with this product, fungicides may also

¹ U.S. Patent issued- #3,911,183

be added to the resin, either with the insecticide or without. The following table shows the pesticide performance.

Pesticide Performance from Cotton Seeds Encapsulated
In Polymeric Resin Films¹ Containing Di-Syston

Treatment	<u>Age of Plants²</u>				
	2 Weeks	3 Weeks	4 Weeks	5 Weeks	5 Weeks, 3 days
Resin A	100%	100%	100%	87%	77%
Resin B	100%	100%	100%	95%	77%
Resin C	100%	100%	100%	100%	77%
Control Uncoated ³	100%	100%	100%	3%	0%

¹Rating: 0% is no kill (or loss) of live cotton aphids; 100% is complete kill (or loss) of aphids.

²Indicates age of plant after emerged and at full, open, cotyledon stage (1 week after planting).

³Contains no resin but treated with Di-Syston

The advantages of an encapsulated insecticide on seeds are:

1. It reduces the total amount of insecticide applied per acre by eliminating repeat applications.
2. It extends the availability of the insecticide without increasing the levels permitted by USDA regulations.
3. It reduces labor required to apply the insecticides.
4. It is safer to handle.
5. It is not readily washed away.

Based upon our experience and the present state of the art of micro and macroencapsulation of solid particles, it is obvious that the potentials offered by encapsulation, especially in the general area of controlled release pesticides, are not being exploited. Perhaps one reason for not having more encapsulated products is that the various processes available for encapsulation have not been adequately publicized. Therefore, I would like to make a few comments about the process itself.

The Wisconsin Alumni Research Foundation owns and licenses patents covering the Wurster air suspension coating process in which the particles to be coated are circulated in a fluidized bed in a controlled pattern so that statistically each particle is exposed to the coating spray no more nor no less than any other particle in the system. The temperature of the air in the coating chamber is also closely controlled. The coating spray is applied continuously to the particles in the course of their repeated cycling pattern so that in each cycle the particles not only receive an additional coating increment, but they are also dried in the warm circulating air. Thus, no post-treatment drying is necessary. A diagram of the Wurster coating chamber is shown on the following page.

The foundation operates a prelicensing coating laboratory, to work with clients on a fee basis. Feasibility studies are conducted to determine if various products can be encapsulated and if they perform according to the clients' specifications. If these studies are successful, licensing agreements are thereupon negotiated for use of the Wurster process by the client. It was in the prelicensing laboratory that studies on encapsulated warfarin (TOX-HID) and the controlled release pesticide were conducted.

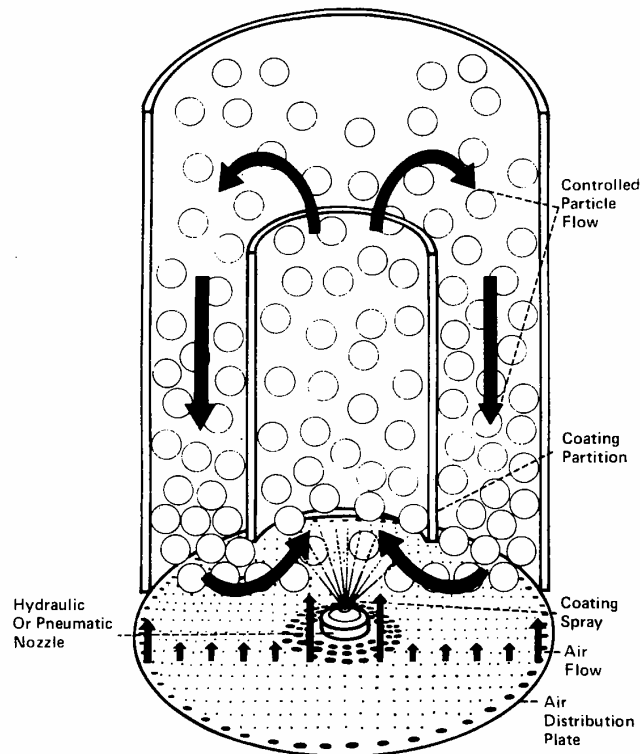


DIAGRAM OF
WURSTER COATING CHAMBER

The applications that “ESP” offers can be greatly expanded to develop and almost limit less variety of pesticide products. For example, there are also controlled release piscicides, fish toxicants having EPA registration that are on the market under the Tradename “Fintrol”, Ayerst Laboratories. The active ingredient is coating onto sand particles with a chemical compound that dissolves upon immersion in water. While the coated sand is sinking to the bottom in lakes and ponds, the chemical coating is released and distributed uniformly in regions where it is needed. Formulations are designed to distribute the chemical evenly in five, fifteen and thirty feet of water.

What is required at this point is for the pesticide industry to recognize the possibilities encapsulation offers, to explore their practicability, and to proceed from that point as the data and the markets dictate.

I wish to acknowledge the assistance of my colleague and co-author Joe Abrams and Mr. Bob Jones of the Bolivar Delinting Company for permission to present the data on the encapsulation of controlled release insecticides on cotton seeds.

¹ Chemagro Corporation. Mississippi State University, Department of Agronomy. USDA Agricultural Research Service, Stoneville, Mississippi.