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Technical report: Controlled Release of the Insecticide Carbofuran

and

Controlled Release of the Mosquito-Control Agent Abate *

Prepared for the Government of the Republic of India
by the United Nations Industrial Development Organization,
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CONTROLLED RELEASE OF THE INSECTICIDE CARBOFURAN

Field applications of pure insecticides typically involve massive over doses of the material to kill all insects, followed by rebirth of the insect population as new eggs hatch after the insecticide dissipates into (and pollutes) the surrounding environment. Far superior results would be expected of the use of an encapsulated insecticide, with the capsule being designed to release its contents progressively at just the rate required for long-term control. This report on such a development is divided into four parts: a brief discussion of the encapsulation process, the subsequent evaluation of the product by field tests on crops of cotton, sorghum and rice, the correlation between the field test results and the laboratory mechanistic studies of insecticide release rate and, fourthly, the question of pollution abatement in any commercial process.

Logically, one may wish to study as variables in the encapsulation process the chemical variety of the polymeric encapsulant to be used, its degree of polymerization (and crosslinking), the filler concentration and variety and the particle size of the insecticide being coated. Substantially all of these variables have been explored in the work at NCL. Mechanistic as well as field evaluations of the coated particles have been conducted and the latter are impressive in both scope and depth.

Briefly, as a result of all the above, coating formulations of urea-formaldehyde and of urea-formaldehyde-starch polymers have been developed, which have shown excellent crop protection in the field tests on all these crops. Further, by varying the starch content of the urea-formaldehyde film, the biodegradability of the coat can be changed over a wide range, with the result that the release rate of the insecticide can be controlled (at least in principle) as either constant, decreasing or increasing with time. Thus, a working technology of the coating process has been developed which enables the tailoring of the coating formulation to suit a wide variety of end-uses of the product. This is an impressive technology which now appears to be ready for scale-up to commercial application.

The field evaluations of these coated carbofuran particles have not only yielded data under conditions of interest but also appear to provide a clear administrative pathway for any further testing which may be needed for certification of the products, for trouble-shooting as the need for this arises and for extension to new crops or to new insecticides.

The mechanistic studies of release-rate carried out to date appear to be definitive in themselves but their correlation with the field results is less clear. The Pune team is aware of this and expects to be able to determine whether particles with much slower release rates than those obtained to date would still be useful in actual practice, as the laboratory mechanistic work would seem to indicate. If this is so, it would open the door to adequate crop protection with a far lower consumption of insecticide than envisioned previously. It is important to emphasize, however, that even if these indications prove to be unattainable in practice, the present formulations are superior to what have been available heretofore. The mechanistic studies also suggest that a closer approach to the desired ideal of "zero-order solution kinetics" may be helpful.

Scale-up of the laboratory encapsulating process must be undertaken with considerable care. The product particles obtained from the laboratory appear to be many-bodied aggregates, whose size is presumably determined by the agitation conditions used. Since the release rate is sensitive to particle size distribution, the scale-up should seek to reproduce that obtained in the laboratory and this is a non-trivial requirement. NCL engineers are well-versed in agitation technology and it is timely that this expertise now be brought to bear on the project.

Finally, the process being used appear to produce fairly large quantities of waste water saturated with carbofuran. It is important to consider the pollution-abatement requirements of this by-product, by recycling or recovery of the carbofuran in the water, or by decomposing it.

In overall summary, the NCL work on carbofuran encapsulation appears to have resulted in development of a commercial product of proven superiority. A team of scientists and technologists has been established, who can not only complete the present project but who have the expertise to attack other problems in the general area of agrichemical controlled-release systems. The appropriate liaison with agricultural field research stations is in place. All of this is quite gratifying to this reviewer, as it must be to the NCL staff and to UNIDO. Attention must now be directed to scale-up of the process, to pollution control in any commercial venture and to a series of mechanistic studies discussed in some detail with the NCL team.

Arthur B. Metzner

CONTROLLED RELEASE OF THE MOSQUITO-CONTROL AGENT ABATE

Extensive studies have been carried out, in both the laboratory and in the field, to identify encapsulating systems of optimal performance: "optimal" implying a sufficiently rapid release to eradicate the pest and yet sufficiently slow to minimize the excessive pollution of the entire aquatic ecosystem by overdosing with a highly toxic chemical. The "window" within which one must operate was found to be a relatively broad one: between 0.02 ppm (the minimum necessary for mosquito control) and 1 ppm (the maximum concentration as limited by WHO standards).

This reviewer was generally impressed with the evolution of the controlled-release system at the National Chemical Laboratory. The number of "practical problems" which needed to be overcome was impressive: submergence of the larvicide dispenser was found to be necessary to avoid fouling the entire dispensing system with surface silt, microbial matter and debris the larvicide degrades photochemically unless shielded by an opaque barrier and the subsurface location is also needed to minimize pilferage of the dispensing system by the curious passer-by. Further, adsorption and/or absorption of the abate molecule on sundry debris and silt tends to remove the active ingredient from solution prematurely. Fungal and algael attack of the hydrogel also occurs and it may be attacked by microorganisms in the water. Consequently, the evaluation of dispensing devices necessarily must occur primarily through field trials. In these, release rates, into water, of 0.003 - 0.005 ppm per day were found to be necessary to maintain the desired concentration levels. The field data from which these conclusions were drawn, were derived from systems having working volumes ranging from 120 to 1,000 liters - providing a broad range of the data base from which to extrapolate, though the total number of field trials carried out todate is too small to be definitive.

In view of the disturbing array of practical problems, the NCL plans for further work are important. It would appear presumptuous to offer, at this time, any explicit statement concerning the eventual practical outcome of this work.

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