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Performance of Microencapsulated Fungicide in Exterior Latex Paint on Wood Substrate

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ABSTRAK

Fungasid 3-iodo-2-propanil butil karbamid (IPBC) diselaputi melalui kaedah pempolimeran in situ resin urea fomaldehid di dalam nisbah rangkai silang 1 dan 2. Kadar melarut resapan mikrokapsul didapati lebih rendah berbanding dengan fungasid bebas. Mikrokapsul yang disediakan dengan nisbah rangkai silang yang lebih tinggi memberikan kadar melarutresapan yang lebih rendah. Dua kepekatan berasaskan berat bahan aktif kepada isipadu cat untuk 0.3 % dan 1 % mikrokapsul dan fungasid bebas dicampurkan ke dalam cat lateks luaran dan disapu pada panel kayu getah. Panel-panel tersebut didedahkan kepada persekitaran. Perlindungan daripada penyahwarnaan yang lebih lama diperolehi melalui penyelaputan IPBC di dalam kepekatan 1%.

ABSTRACT

3-iodo-2-propynyl butyl carbamate (IPBC) was encapsulated by in situ polymerization of urea formaldehyde resin of crosslink (formaldehyde : urea) ratios 1 and 2. The leaching rate of the microcapsules was reduced compared to the free fungicide. Microcapsules prepared at the higher urea formaldehyde crosslink ratio gave a lower leaching rate. Two concentrations based on the weight of the active ingredient per volume of paint (a.i./v) of 0.3 % and 1 % of microcapsules or free IPBC were incorporated into exterior latex paint and applied onto rubberwood panels. The panels were then exposed to the environment. A longer protection from discoloration was provided by the encapsulated IPBC of 1% concentration.

INTRODUCTION

Wood coatings are not only for decorative purposes but also provide protection from deterioration and discoloration by environment factors. The primary problem experienced on coated surfaces is discoloration by fungal growth. Addition of fungicides into coating formulations can control this problem but rapid leaching of the fungicide can necessitate repeated applications. Leaching rate from the coating matrix can be controlled by placing the fungicide in a polymeric matrix which limits the release to the level required to prevent discoloration. This method also reduces fungicide releases into the environment, hence minimizing pollution.

Microencapsulation is one of the methods for containing pesticidal agents using a polymeric matrix. Microencapsulation is based on the principles of coacervation in which a polymeric film envelopes a core material, which can be a pest control agent. Chemical release occurs by permeation or rupture of the membrane wall. Theoretically, two different structures can be formed, each with its own characteristic release kinetics. The first has a solid core of the material to be released centred in a spherical shell and is known as depot device.

The second type has the material to be released dispersed in a polymeric matrix and is known as a monolithic device (Noren *et al.* 1979).

Two fungicides, 2,3,5,6,-tetrachloro-4-methyl sulfonyl pyridine and tetrachloroisophthalonitrile have been successfully encapsulated by in situ polymerization of urea formaldehyde resin. Both formulations exhibited release rates indicative of porous-monolithic systems (Noren *et al.* 1986).

This paper investigates the leaching rate and exterior performance of urea formaldehyde encapsulated 3-iodo-2-propynyl butyl carbamate (IPBC) fungicide incorporated in latex paint applied on wood substrate against surface discoloration.

MATERIALS AND METHODS

Chemicals were obtained from a local supplier and used without further purification. Chemicals used were technical grade IPBC of 97% purity (Troysan Polyphase P-100), urea of 99 % purity (Riedel-deHaen) and 37 % aqueous formaldehyde solution. Urea formaldehyde precondensate of crosslink ratios 2 and 1 and IPBC microcapsules were prepared following the method as described by Noren *et al.* (1986).

Rate of Release Measurements

Active ingredient determinations were carried out by refluxing the microcapsules for 10 hours in 100 % methanol. Two g of microcapsules and an equivalent amount of IPBC based on the active ingredient were placed in an extraction thimble separately and extracted with 250 ml of 100% methanol. Ten ml samples were removed every five minutes, filtered with a 0.45 micron PTFE membrane filter and injected on a Shimadzu High Performance Liquid Chromatgraph (HPLC) with Reversed Phase C–18 column (Shim-pack, Japan), a mobile phase of methanol and water (60 : 40) and a U.V. detector. The IPBC was analysed by U.V. absorption spectroscopy at a wavelength of 254 nm. A 10 ml portion of fresh methanol was replenished before the next sampling was carried out.

Exposure Test

Two concentrations of microcapsules containing 0.3 % and 1 % IPBC per unit volume of paint (a.i./v) were incorporated into latex paint. The same concentrations of non-encapsulated fungicide were incorporated into another portion of the latex paint. The test paints were applied on rubberwood panels which were then placed at 45° angle facing south on an exposure rack located at the Forest Research Institute Malaysia (FRIM). Inspections were carried out after 4 and 10 months exposure. The panels were visually assessed on a scale of 1 to 10 with 10 indicating no discoloration (Anonymous, 1977).

RESULTS AND DISCUSSION

Rate of Release

Methanol was chosen for measuring the amount of IPBC released from the microcapsules because it solubilizes IPBC readily and does not solubilize the urea-formaldehyde matrix. The average IPBC concentration in the microcapsules was 35.30 %. The average values of IPBC release per minute for the first four hours were 0.42 %, 0.27 % and 0.18 % for free IPBC and encapsulated IPBC of urea formaldehyde crosslink ratio values of 1 and 2 respectively (Table 1). Lower fungicide releases occurred per minute from the encapsulated IPBC than from non-encapsulated IPBC, confirming that the encapsulation process reduces the rate of release. Higher release rates were also noted with the lower urea formaldehyde crosslink ratio.

TABLE 1
Percentage of weight released from encapsulated and unencapsulated IPBC

	Amount released (% of original weight)		
Time (mins)	Free IPBC	Encapsulated IPBC *C.R.=1	C.R.=2
00	0.00	0.00	0.00
05	9.92	1.50	0.92
10	23.74	2.90	2.47
15	30.37	3.30	2.81
20	36.42	4.43	3.22
25	42.58	5.64	3.46
30	50.00	6.90	3.58
35	58.28	7.90	3.79
40	64.33	8.67	4.68
45	71.62	9.46	4.92
50	79.33	10.83	5.29
55	86.66	11.95	5.64
60	93.57	13.36	6.00
120	100.00	35.40	15.70
180	–	49.50	25.50
240	–	65.80	43.60
Average values per minute	0.42	0.27	0.18

*cross link ratio

The results also show that all 100% IPBC was released after two hours, while the release rates for IPBC of crosslink ratio of 1 and 2 were 35.4 % and 15.7% respectively.

Exposure Test Results
The observations after 4 and 10 months exposure indicated that the surfaces of all panels were discolored after 4 months exposure due to dirt collection and mould (Table 2). However, the degree of discoloration differed with the treatments and period of exposure.

For the 0.3% concentration of fungicide, the degree of discoloration was rated 6 for both encapsulated and free fungicide after 4 months exposure. This indicates that there was no difference in the effectiveness of these treatments. After 10 months exposure, the panels were rated 2 for both treatments. It can be concluded that 0.3% concentration of IPBC, in the free or encapsulated form was insufficient to protect the surface against discoloration.

For 1% concentration of IPBC, the rating after 4 months showed a slight difference in the effectiveness of the various treatments. The ratings were 8 and 4 for the encapsulated and free fungicide respectively indicating that the encapsulated fungicide improved protection against discoloration. However, after 10 months exposure, the ratings dropped to 4 for both treatments. Thus, IPBC fungicide in the encapsulated form imparted protection against discoloration up to a certain period between 4 to 10 months. After 10 months exposure, 1% encapsulated IPBC was able to provide a better protection compared to 0.3% of the same chemical.

IPBC has shown excellent resistance against UV-degradation, basidiomycetes (wood destroying fungi) and blue stain fungi (Bravery *et al.* 1984). However in this experiment, the test panels were exposed to an environment which may have contained a wider spectrum of organisms. That perhaps explains why the protection period against surface discoloration was short even for the free IPBC form incorporated into the paint system.

CONCLUSION

Leaching tests of IPBC microencapsulated in urea formaldehyde resins at two different crosslink ratios showed that the average amount of IPBC leached into solution per minute was higher for microcapsules prepared in urea formaldehyde resins at lower cross link ratios. Leaching rates were lower following encapsulation. Field tests of microencapsulated IPBC at various concentrations in latex paint showed that the microcapsules provided slightly better protection against discoloration compared to free IPBC, but this difference was negligible after 10 months of exposure.

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TABLE 2
Observations of painted panels after 4 and 10 months exposure

Observations	0.3%				1%				Control	
	4 mths		10 mths		4 mths		10 mths		4 mths	10 mths
	*EF	*FF	EF	FF	EF	FF	EF	FF	WITHOUT	FUNGICIDE
Coating Appearance	← Good but discolored →									
Degree of discoloration	6	6	2	2	8	6	4	4	4	2
Wood defects	← None →									

*EF : Encapsulated Fungicide
*EF : Free Fungicide

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