LETHAL TOXICITY OF EXPERIMENTAL AQUEOUS FORMULATIONS OF AMINOCARB AND FENITROTHION CONTAINING TRITON® X-100 AND TRITON® X-114 TO RAINBOW TROUT.

File Report No. 49. March 1983.

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INTRODUCTION

Fenitrothion (0,0-dimethyl 0-(3-methyl-4-nitrophenyl) phosphorothioate) and aminocarb (4-dimethylamino-m-tolyl N-methylcarbamate) are 2 insecticides which have been used extensively to control spruce budworm infestations in eastern Canada. Both insecticides are currently available in formulations which can be applied by aircraft either as solutions in oil or as water-based emulsions. Until recently ATLOX 3409F was the emulsifier used in spruce budworm spray formulations in New Brunswick. On 28 April 1982, however, the New Brunswick Task Force on the Environment and Reye's Syndrome released a report to the New Brunswick government which recommended that the use of ATLOX 3409F in forest spraying be discontinued. The major objection to the use of ATLOX 3409F was that it has shown viral enhancing properties in the laboratory and is currently being investigated as a possible cofactor in the pathogenesis of Reye's Syndrome in children. ATLOX 3409F was subsequently dropped from the 1982 New Brunswick spray program and a search was initiated to find a replacement for the 1983 field season. TRITON® X-100 and TRITON® X-114 were identified as potentially suitable candidates and testing was begun by the Forest Pest Management Institute to investigate the efficacy and environmental impact of formulations containing these emulsifiers. As part of this testing program, laboratory toxicity studies were conducted to determine the relative toxicities of aminocarb and fenitrothion formulations containing ATLOX 3409F, TRITON® X-100 and TRITON® X-114 to rainbow trout, the results of which are presented here.

MATERIALS AND METHODS

MATACIL® 180F[1] (19.6% active ingredient) and Sumithion® Technical[2] (99.8% AI) were supplied by Chemagro Ltd., Mississauga, Ont., and Sumitomo Canada Ltd., Toronto, Ont., respectively. TRITON® X-100 and TRITON® X-114 were obtained from Rohm and Haas Canada Inc., Westhill, Ont., ATLOX 3409F from Atlas Chemical Industries, Brantford, Ont., Cyclo-Sol 63 from Shell Canada Chemical Co., Toronto, Ont., and Dowanol TPM from Dow Chemical of Canada Ltd., Sarnia, Ont. Stock solutions of the test materials were prepared as follows:

Solution I - by weight 24.9% MATACIL® 180F + 3.1% TRITON® X-100 + 72.0% water

Solution II - by weight 24.9% MATACIL® 180F + 3.1% TRITON® X-114 + 72.0% water

Solution III - by weight 13.9% Sumithion® Technical + 13.9% TRITON® X-100 + 72.2% water

Solution IV - by weight 13.9% Sumithion® Technical + 13.9% TRITON® X-114 + 72.2% water

Solution V - by weight 14.3% Sumithion® Technical + 23.7% Cyclo-Sol 63 + 3.0% TRITON® X-100 + 59.0% water

Solution VI - by weight 14.3% Sumithion® Technical + 23.7% Cyclo-Sol 63 + 3.0% TRITON® X-114 + 59.0% water

Solution VII - by weight 14.5% Sumithion® Technical + 2.0% Dowanol TPM + 2.0% ATLOX 3409F + 81.5% water

Solutions I, III and V were similar to the tank mixes used in the 1982 New Brunswick Action Plan field applications (Holmes, 1982; McLeod, 1982).

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[1] MATACIL® 180F = aminocarb flowable formulation containing 180 g AI/L
[2] Sumithion® Technical = 99.8% pure technical fenitrothion.

Table 1. Rainbow trout used in toxicity tests of aminocarb and fenitrothion field formulations containing TRITON® X-100, TRITON® X-114 and ATLOX 3409F.

Testing Date	Solution Tested	Size of Fish ($\bar{x}$ ± S.D.)	
		Fork Length (cm)	Weight (gm)
September 21-25, 1982	I	5.8 ± 0.5	2.2 ± 0.5
October 12-16, 1982	III	5.9 ± 0.5	1.9 ± 0.6
October 18-22, 1982	V	5.9 ± 0.8	2.1 ± 0.5
December 15-19, 1982	VI	6.7 ± 0.5	3.0 ± 0.8
December 20-24, 1982	IV	6.8 ± 0.6	2.9 ± 0.8
January 24-28, 1982	II	7.0 ± 0.8	3.1 ± 1.2
January 31-February 4, 1982	VII	6.6 ± 0.6	2.8 ± 0.8

Table 2. LC_{50} values and lethal thresholds of aminocarb and fenitrothion field formulations containing TRITON® X-100, TRITON® X-114 and ATLOX 3409F to rainbow trout.

	24-h LC_{50} (mg/L) and 95% Confidence Limits		96-h LC_{50} (mg/L) and 95% Confidence Limits		Lethal Threshold (mg/L)	
	nominal concentration*	active ingredient**	nominal concentration	active ingredient	nominal concentration	active ingredient
MATACIL® 180F + TRITON® X-100 + Water	353.4 (282.7-455.2)	17.2 (13.8-22.2)	296.2 (238.0-368.3)	14.5 (11.6-18.0)	193.6	9.4
MATACIL® 180F + TRITON® X-114 + Water	238.3 (199.6-282.4)	11.6 (9.7-13.8)	224.4 (184.6-268.0)	11.0 (9.0-13.1)	172.0	8.4
Sumithion® Technical + TRITON® X-100 + Water	26.0 (22.5-30.1)	3.6 (3.1-4.2)	17.6 (15.5-19.9)	2.4 (2.1-2.8)	16.8	2.3
Sumithion® Technical + TRITON® X-114 + Water	22.4	3.1	19.9 (19.0-20.9)+	2.8 (2.6-2.9)+	18.8	2.6
Sumithion® Technical + Cyclo-Sol® 63 + TRITON® X-100 + Water	26.1 (21.5-32.0)	3.7 (3.1-4.6)	17.4 (14.9-20.2)	2.5 (2.1-2.9)	15.8	2.3
Sumithion® Technical + Cyclo-Sol® 63 + TRITON® X-114 + Water	24.1 (21.0-27.9)	3.4 (3.0-4.0)	19.9 (18.8-21.1)+	2.8 (2.7-3.0)+	20.3	2.9
Sumithion® Technical + Dowanol TPM + ATLOX 3409F + Water	22.3 (18.7-26.3)+	3.2 (2.7-3.8)	17.9 (14.9-22.4)	2.6 (2.2-3.2)	10.1	1.5

* nominal concentration = mg of field formulation (tank mix)/L of test water.

** active ingredient = mg of aminocarb or fenitrothion active ingredient/L of test water.

+ computed by the method of Litchfield and Wilcoxon (1949).

Solutions II, IV and VI were identical to I, III and V except that TRITON® X-100 was replaced by TRITON® X-114. Solution VII was similar to the tank mix used operationally prior to 1982 to control spruce budworm in New Brunswick.

Rainbow trout fingerlings were obtained from Piscine Developments Inc., Sault Ste. Marie, Ont. and held in the laboratory in dechlorinated tap water at 15 ± 2°C until needed. Toxicity tests were conducted over a period of approximately 4 months during which time the fish grew appreciably (Table 1) on a diet of Purina Trout Chow.

Tests were static and of 96 hours duration. Fish were exposed in 20 L aliquots of dechlorinated tap water fortified with the stock solutions to give a range of not less than 7 concentrations for each formulation plus an untreated control. Nine rainbow trout were tested at each concentration. The test solutions were aerated gently to prevent oxygen depletion and temperature was maintained at 15 ± 0.5°C.

LC_{50}'s and LT_{50}'s were estimated by probit analysis. Lethal thresholds were calculated from lethality lines by the method of Żitko (1979). Toxicity curves were compared by multiple linear regression and an F test for equality of lines across treatments.

RESULTS AND DISCUSSION

The results of the lethality tests are summarized in Table 2. LC_{50}'s and lethal thresholds are presented both as nominal concentrations (mg formulation/L) and in terms of active ingredient (mg active ingredient/L) to facilitate comparisons with other published data.

LC_{50} values for the 5 fenitrothion formulations tested (24-h LC_{50}'s, 3.1-3.7 mg (AI)/L; 96-h LC_{50}'s, 2.4-2.8 mg (AI)/L) are similar to those reported by Klaverkamp et al. (1977) for technical fenitrothion to rainbow trout (24-h LC_{50}, 3.4 mg (AI)/L; 96-h LC_{50}, 2.0 mg (AI)/L). Ernst et al. (1981) reported a higher 96-h LC_{50} for technical fenitrothion to rainbow trout (3.3 mg (AI)/L), but a slightly lower 96-h LC_{50} for an operational fenitrothion spray mixture formulated in fuel oil (11 mg (form.)/L as compared to 17.4-19.9 mg (form.)/L in our study). Statistical analysis of the toxicity curves presented in Figure 1 revealed that there was no significant difference in the toxicities of the 5 fenitrothion formulations tested ($P < 0.05$). For all formulations the intensity of response was greatest in the first 24-hours of exposure, but by 96-hours LC_{50} values for the TRITON® X-100 and TRITON® X-114 formulations had reached, or were approaching, the lethal threshold levels. The lethal threshold level for the operational fenitrothion formulation containing ATLOX 3409F (1.5 mg AI/L) was lower than for the other fenitrothion formulations (2.3-2.9 mg (AI)/L)) however, and also lower than its own 96-h LC_{50} (2.6 mg AI/L), indicating that this formulation, unlike the others, might have continued to exert its toxic effect beyond the standard 96-hour exposure period.

Many of the fish exposed at concentrations of fenitrothion between 2.2-3.9 mg (AI)/L developed a pronounced distension of the abdomen (Figure 2). When these fish were dissected it was discovered that their stomachs had become bloated with a clear fluid. Fish whose stomachs were only slightly swollen usually recovered when transferred to clean water, but those with greatly swollen stomachs invariably died. This 'sublethal'

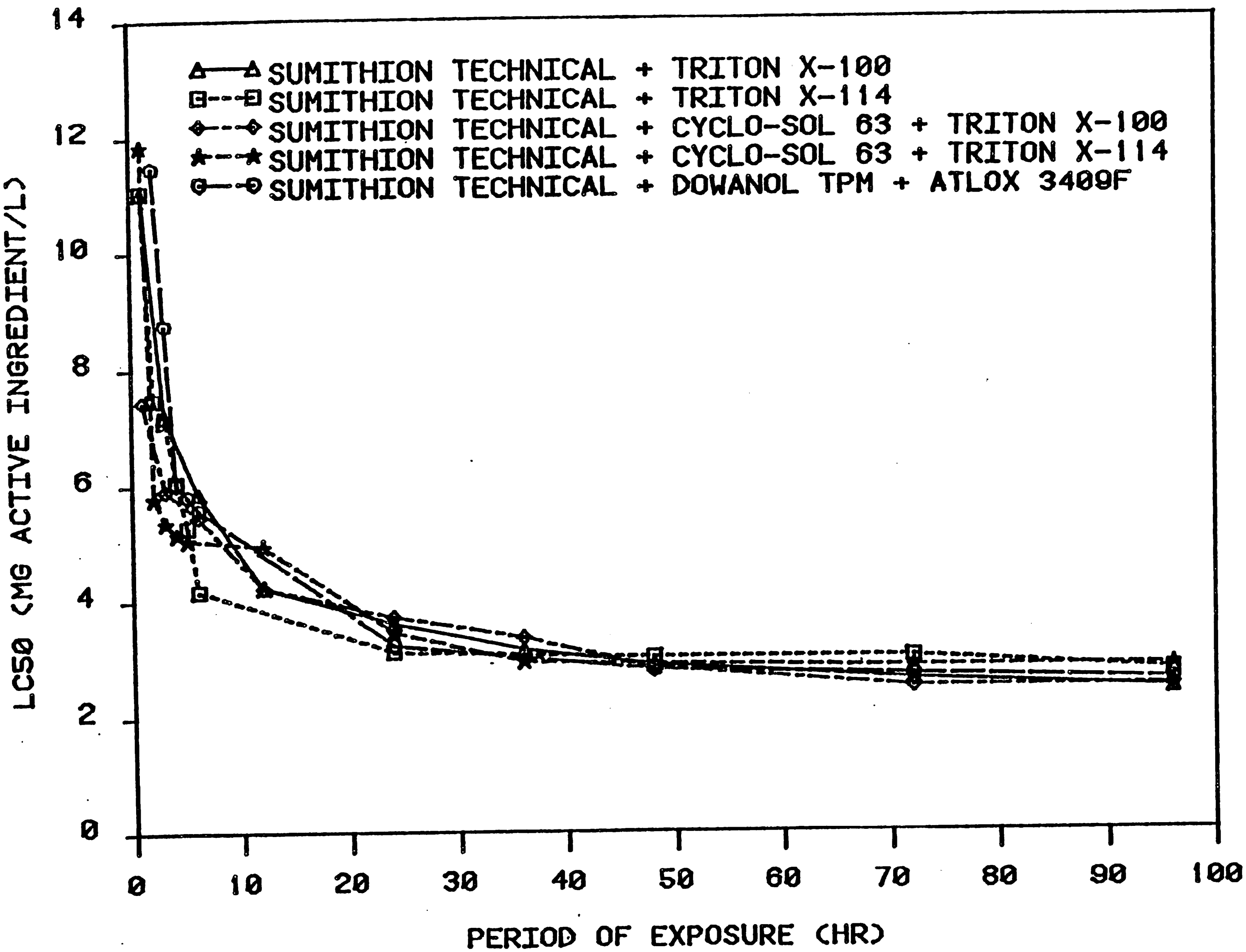

Figure 1. Toxicity curves of fenitrothion formulations containing ATLOX 3409F, TRITON® X-100 and TRITON® X-114 to rainbow trout.

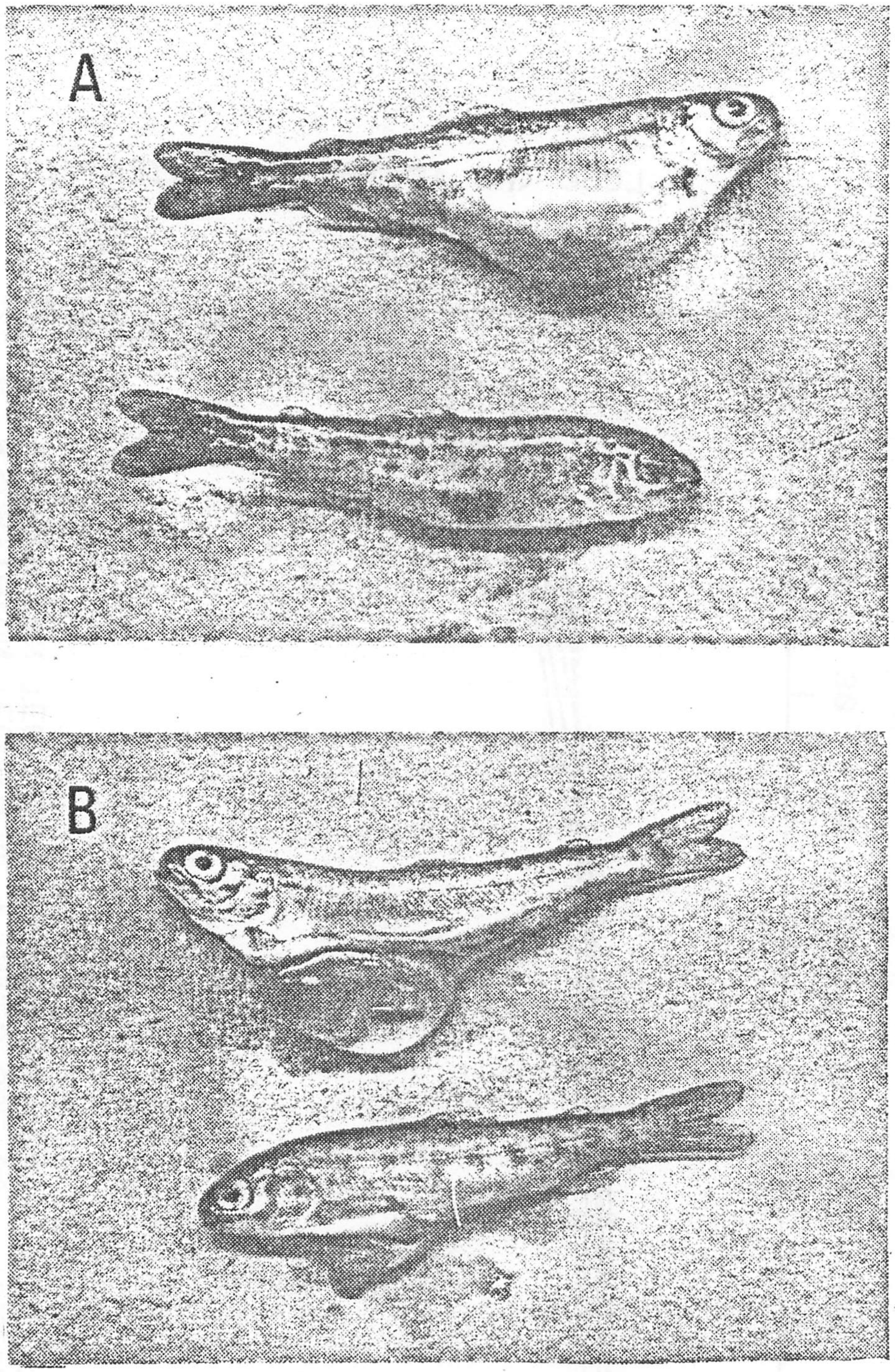

Figure 2. Photographs showing a sublethal effect of fenitrothion poisoning on rainbow trout fingerlings (fish at the top of each photograph have been exposed to fenitrothion; fish on the bottom are from a check group) A/ distension of abdomen B/ stomach swollen with fluid.

effect of fenitrothion poisoning has been previously reported by Klaverkamp et al. (1977) and Bull and McInerney (1974) working with rainbow trout fingerlings and underyearling coho salmon respectively. Klaverkamp et al. (1977) mistakenly attributed the swelling to accumulation of fluid in the peritoneal cavity however, probably because the stomachs were ruptured during dissection.

The 96-h LC_{50}'s for the MATACIL® 180F + TRITON® X-100 and MATACIL® 180F + TRITON® X-114 formulations (14.5 and 11.0 mg (AI)/L respectively) in our study (Table 2) were significantly lower than the 96-h LC_{50} for the MATACIL® 180F + ATLOX 3409F formulation (23.1 mg (AI)/L) reported by Szeto and Holmes (1982). Although this would seem to suggest a slightly higher toxicity for the TRITON® X-100 and TRITON® X-114 formulations, this difference might also be due to differences in the size and source of the test organisms used (rainbow trout fingerlings in our study were obtained from a private hatchery and averaged 2.2- 3.1 g in weight; fish in the other study were from an Ontario Ministry of Natural Resources hatchery and averaged 5.4 g in weight), the test temperature (15°C as compared to 9°C), or the loading density (1.0-1.4 g of fish/L of test water as compared to 1.6 g/L). Szeto and Holmes (1982) also tested an aminocarb oil formulation containing nonyl phenol (MATACIL® 1.8D + Insecticide Diluent 585) which was 30-40 times more toxic (96-h LC_{50}, 0.36 mg AI/L) than the TRITON® X-100 and X-114 water formulations. The lethal thresholds of the MATACIL® 180F + TRITON® X-100 and MATACIL® 180F + TRITON® X-114 formulations to rainbow trout (9.4 and 8.4 mg (AI)/L respectively) were similar to that of pure aminocarb to Atlantic salmon *(Salmo salar)* (8.7 mg (AI)/L) as reported by

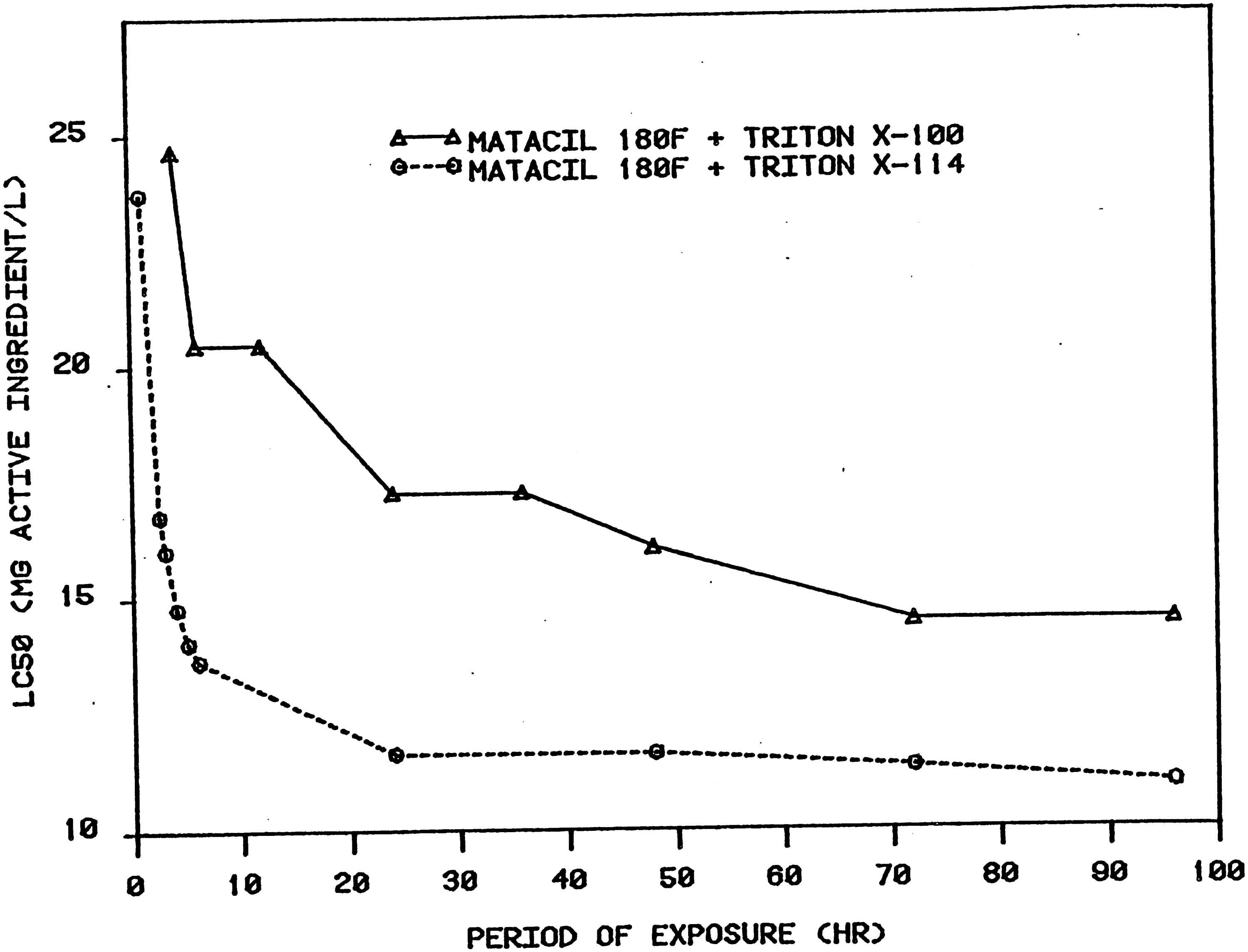

Figure 3. Toxicity curves of aminocarb formulations containing TRITON® X-100 and TRITON® X-114 to rainbow trout.

McLeese et al. (1980). The toxicity curves for the MATACIL® 180F + TRITON® X-100 and the MATACIL® 180F + TRITON® X-114 formulations (Figure 3) were compared and found to be significantly different ($P < 0.05$). The MATACIL® 180F + TRITON® X-114 formulation was, however, tested approximately 4 mo. later than the MATACIL® 180F + TRITON® X-100 formulation and by this time mortality in the holding tank was becoming a problem. It is possible that the test fish were in a weakened condition near the end of the study due to the long holding period and therefore more susceptible to insecticide poisoning.

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