The Use of Recovery as a Criterion for Toxicity

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Recovery, in varying degrees, has been shown to occur in aquatic organisms after exposure to oil dispersants (WILSON, 1968) and surfactants (SWEDMARK *et al.*, 1971). Almost all of the information available in the literature on the toxicity of surfactants to aquatic organisms is based on simple "knock-down" concentrations or times, with virtually no attention being paid to the ability of the animals to recover when removed to clean surroundings. PERKINS *et al.* (1973) however incorporated a recovery period into their method of assessing the toxicity of oil dispersants to marine invertebrates.

A simple experiment was set up to illustrate that toxicity, as determined on the basis of simple "knock-down" concentrations, does not fully describe the biological impact of a chemical on an organism. The stage II nauplius of the barnacle *Elminius modestus* (Darwin) was used as the test organism. Nauplii were hatched from adults (CRISP *et al.*, 1967) and kept overnight at 15 C to allow for the complete metamorphosis of the stage I to the stage II form. The 30 min. EC50's producing immobility were determined for various nonionic, anionic and cationic surfactants using the method outlined by CRISP *et al.* (1967). The surfactants used and the results are listed in TABLE 1.

TABLE 1

Surfactant	Type	30 min. EC50
Decanol ethoxylate (20 EO units)	nonionic	5.6×10^{-4}M
Decyltrimethylammonium bromide	cationic	4.1×10^{-3}M
Nonyltrimethylammonium bromide	cationic	1.5×10^{-2}M
Decyl sodium sulphate	anionic	1.8×10^{-3}M
Octyl sodium sulphate	anionic	1.7×10^{-2}M

From TABLE 1 it is clear that for an exposure period of 30 minutes, the nonionic surfactant possesses a toxicity at least one order of magnitude greater than the corresponding anionic and cationic homologues. On this basis the relative toxicities of the different decyl surfactants would be in descending order, nonionic > anionic > cationic.

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The nauplii were then exposed to the equitoxic concentrations of the decyl surfactants, shown in TABLE 1, for thirty minutes after which time they were removed from the test solutions, washed and placed in a recovery dish containing aerated sterile sea water. Observations of the condition of the nauplii were made at intervals up to 48 hours. Recovery was assessed on the ability of the nauplii to fully regain their swimming ability. This condition corresponds to the score of 1.0 as used by CRISP *et al.* (1967).

The following recovery pattern was found. With nauplii exposed to the nonionic surfactant, 50% had fully recovered after 20 minutes whereas those exposed to the ionic surfactants had failed to recover any swimming activity by the end of the 48 hour recovery period. The experiment was repeated using lower homologues of the ionic surfactants, the results of which are shown in FIG. 1. No recovery of the animals exposed to the cationic surfactant at the 30 min. EC50 or even half this concentration was observed. At a concentration equivalent to ¼ of the 30 min. EC50, 50% of the animals recovered after 30 minutes but all died during the subsequent 24 hour recovery period. Recovery of animals exposed to the anionic octyl sodium sulphate was slow, with only 40% fully recovering by the end of the experiment.

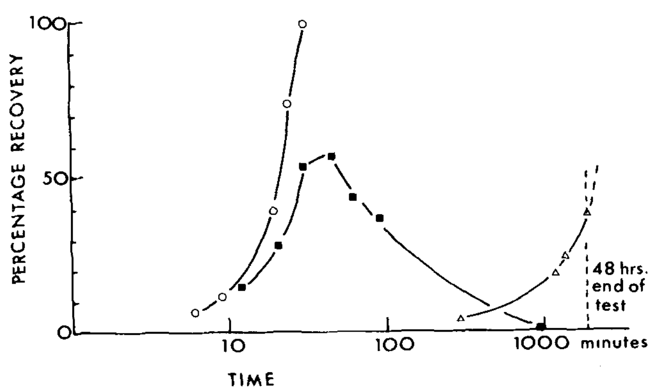

Figure 1. Effect of a nonionic (○), anionic (△) and cationic (■) surfactant on the ability of *Elminius* nauplii to recover swimming activity. Points are means of triplicate determinations.

By using recovery as an index of toxicity, the cationic surfactant is by far the most toxic, followed, in decreasing order, by the anionic and nonionic. This sequence is the complete reverse of that determined on the basis of the 30 min. EC50's.

Most toxicity tests are based on the continuous exposure of the bioassay organisms to a series of fixed concentrations of toxin. Such a method does not allow for the fluctuations in the concentrations of toxins which occur in the environment. These fluctuations could permit periods to occur in which the toxin may be absent or greatly reduced in concentration, so that affected or partially affected animals could be able to recover. Predictions of the biological effect of a toxin based only on EC50 estimates therefore could be considered to be insufficient, and should be supplemented with recovery data. From the results in TABLE 1 it can be seen that the nonionic surfactant is one to two orders of magnitude more toxic than the anionic and cationic types. However even though the nonionic surfactant may act initially at a much lower concentration, once it is reduced, the animals quickly recover. This is in contrast to the ionic surfactants. On the basis of recovery, it could be considered that the nonionic surfactant is the least toxic whereas the cationics are the most so.

If recovery experiments are included as an integral part of aquatic bioassay techniques then the mode of action of toxins may be more fully understood. This in turn could lead to a better assessment of their impact in the environment.

References

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