# The BugBeater - A New Approach to the Control of Microorganisms in Photoprocessing Applications

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## Abstract

BugBeater is a more effective and environmentally acceptable approach for the control of microorganisms. The system uses a flow-through device in recirculation mode; it contains a novel formulation of biocide immobilised on an inert support. Control of microbiological growth is provided by selective release of the biocide direct to the microorganisms. In this way the biocide is used on-demand and is therefore used more efficiently. It is not released to the effluent and so provides a more environmentally attractive strategy to control microbiological contamination, resulting in reduced processor maintenance. The BugBeater 300 device has been developed primarily for minilabs, but this proprietary technology is applicable to other aqueous environments.

## Introduction

Microorganisms will proliferate in any aqueous environment which has suitable conditions for growth; certain photoprocessing solutions are particularly attractive environments (30-40°C, moderate pH and a supply of nutrients). Bacteria and other microorganisms readily form biofilms which can cause damage to processing machine components (eg racks and rollers) and more significantly detach from surfaces and transfer to film or paper passing through the processor. Traditionally, solution biocides have been used to address the problem but these do have limitations of use and necessitate the handling of relatively undesirable solutions. Furthermore careful dosing is required and ultimately the biocide goes down the drain leading to potential environmental problems. Any approach which minimises operator contact with solution biocides must be seen as desirable. Alternative approaches have included UV treatment, but this is only really effective at point of water entry, and does not provide a sustained means of controlling microbiological growth in photoprocessing environments. It has also been reported that certain microorganisms can develop resistance to UV[1].

## Immobilised Biocide

In seeking a more effective and environmentally acceptable way of delivering biocidal activity to a photoprocessing solution, a number of slow or controlled release systems were considered[2-6]. The most attractive approach involved the immobilisation of a conventional biocide on an inert support, by hydrophobic exclusion (adsorption). The selection of biocide was based on its broad spectrum activity and its hydrophobicity (as determined by log P, n-octanol/water partition coefficient). The selection of support was based on particle size, surface area and relative hydrophobicity; material robustness and ability to pack into a column bed were also significant factors. After screening a number of candidates a hydrophobic isothiazolinone (1) adsorbed on a polyacrylate polymer bead was chosen.

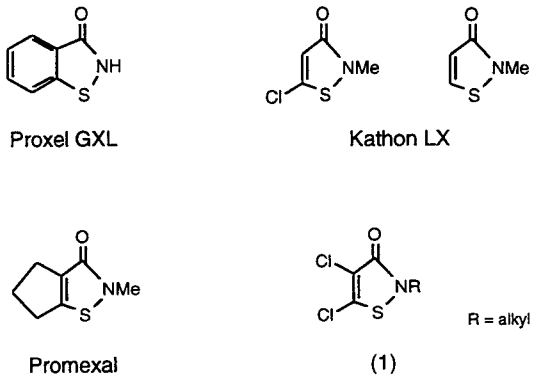


*Figure 1: Isothiazolinone biocides*

Isothiazolinone biocides such as Proxel GXL™, Kathon LX™ and Promexal™ are well known industrial biocides, some of which have been used in photoprocessing applications (Figure 1). These biocides exhibit good biocidal activity against Gram negative bacteria (eg *Pseudomonads*) and fungi (eg *Fusarium*) which are often found in photoprocessing solutions.

## Laboratory Evaluation of Immobilised Biocide

Biocidal activity of the immobilised biocide was determined in the Laboratory using a small scale recirculation system, inoculated with $10^5$ colony forming units (cfu)/ml of a representative Gram negative bacterium, *Pseudomonas aeruginosa*, (NCIMB 10421)[7]. Immobilised biocide was placed in a glass column (10ml), and a nutrient solution containing the bacteria was circulated at a moderate flow rate (5-50ml/min) for 24 hours. It was found that the level of bacteria was reduced to less than 16 cfu/ml (which was the detection limit for this experiment), compared to the control (which contained untreated polymer beads) which rose to $10^9$ cfu/ml, (Figure 2).

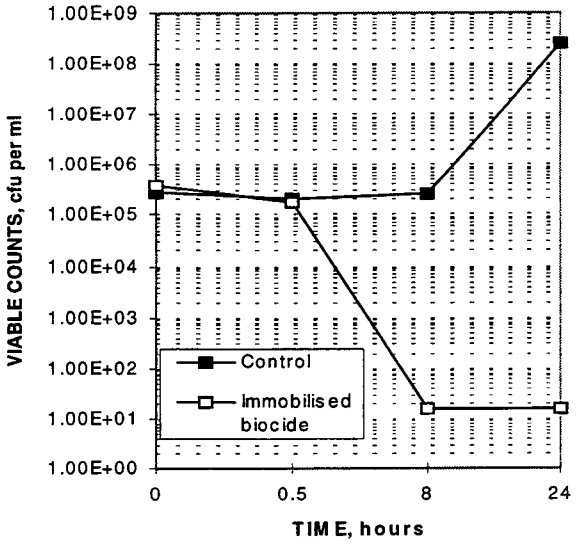


*Figure 2: Laboratory evaluation of immobilised biocide*

Longer term rechallenge experiments were also carried out, whereby fresh bacteria were added to the system every 2-3 days, simulating a photoprocessing environment more accurately. In this case similar results were obtained, leading to very low levels of bacteria after two weeks. In a further study using representative fungal spores, *Fusarium solani*, rechallenge experiments showed biocidal control over a four week period, (Figure 3).

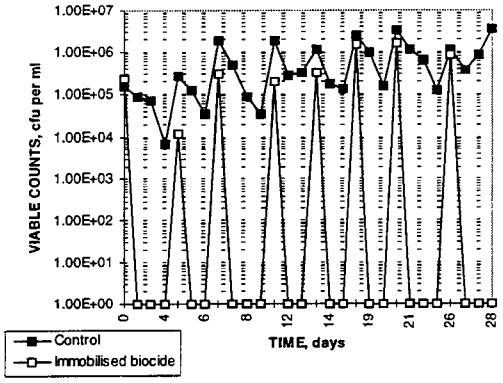


*Figure 3: Fungal spores rechallenge test*

## BugBeater 300 Cartridge

Further evaluation in a processing environment was carried out using the BugBeater 300 cartridge. The device itself fits into a head that resides on the processor; replacement of a cartridge takes a few seconds. The device is connected to the recirculation line of a stabiliser tank (usually the one containing the highest level of microbiological contamination); installation of the whole assembly is relatively quick and straightforward. BugBeater 300 contains immobilised biocide, and a system of protective filters to prevent escape of material from the cartridge.

It has been shown that use of a BugBeater 300 cartridge on a paper minilab photoprocessor led to significant control of the microbiological population found in stabiliser tank 1, (which contained the highest microbiological challenge). The device was left to run at a recirculation rate of 1-2L/min during the normal operation period of the machine, typically 6-8 hr/day). Data relating to a representative trial is shown in Figure 4.

## Mode of Action

Since the biocide is hydrophobic it remains adsorbed on the polymeric support in an aqueous environment unless the system is perturbed. Passage of microorganisms over the surface of the polymer beads perturbs the system and allows biocide molecules to transfer from the surface of the bead to the surface of the microorganism. In this way the biocide passes directly to the target, and is thus used on-demand (Figure 5).

Having reached the microorganism's outer membrane, the biocide, being hydrophobic in nature, is able to pass rapidly through the membrane towards its site of action. In the case of bacteria, it is not restricted to transportation through ionic channels (porins), unlike hydrophilic biocides, so uptake may well be more efficient.

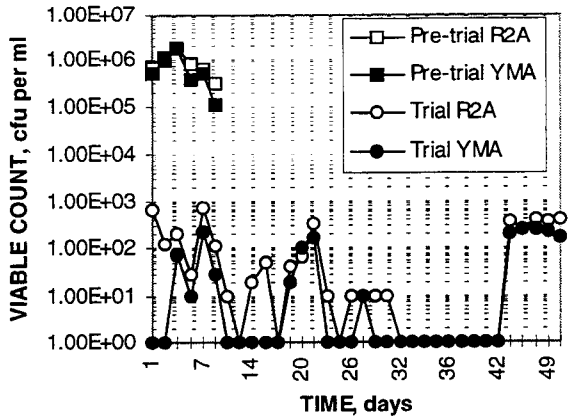


*Figure 4: Evaluation of BugBeater 300 on paper minilab*

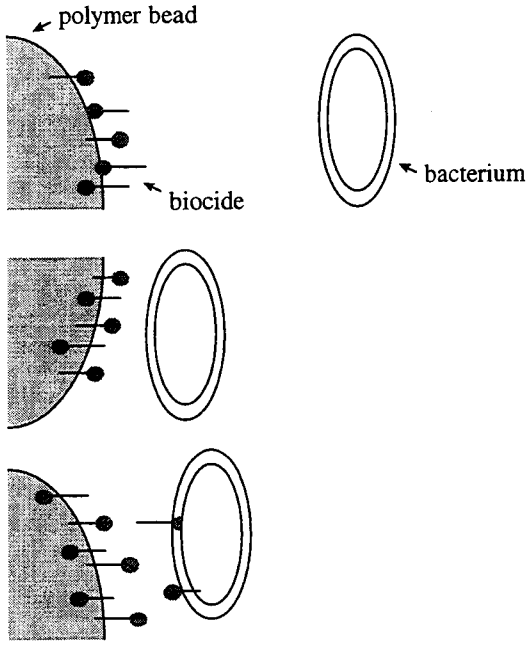


*Figure 5: Suggested mechanism of immobilised biocide transfer to microorganisms*

Isothiazolinones are known to interact with the thiol containing enzymes found within microorganisms; it is believed that the chemical mechanism is as described in Figure 6, where the biocide reacts with the enzyme irreversibly by a number of related pathways.

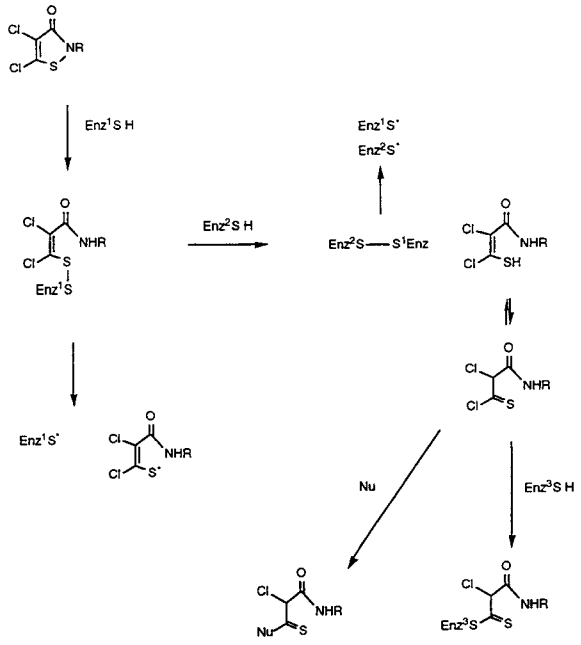


*Figure 6: Suggested mechanism of isothiazolinone action*

## Advantages

Control of microbiological growth in a photoprocessing solution using an immobilised biocide system offers a number of benefits compared to conventional approaches. A cleaner running process will require less maintenance and will improve overall operational performance. The device is simple to install and use and does not require special precautions. The processor operator is no longer in contact with biocide, which provides a number of health safety and environment advantages including non-hazardous labelling and no risk of spills. The biocide is supplied direct to the microorganisms, and is thus used "on-demand", and therefore more efficiently. Since the biocide is largely insoluble in water and it is consumed by the microorganisms directly, this technology does not add biocide to the effluent. It is believed that this approach can provide a drop-in replacement for other microbiological growth control technologies.

## Conclusions

The efficacy of an immobilised biocide system to control the growth of microorganisms in both laboratory and processing environments has been demonstrated. Mechanisms have been postulated to explain the mode of action; these are under study and will be reported elsewhere. It is likely that this technology will find application in other photoprocessing environments in due course. Furthermore it is of potential use to a number of other industries where

conventional biocides have been used traditionally, since immobilised biocides offer health, safety, environmental and economic advantages over other approaches to microbiological growth control.

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