Comparison of the Efficacy of Two Biocides: Glutaraldehyde and Carbamate

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Biofouling in industrial water systems is commonly controlled by the use of biocides, which are, generally, chemical substances that kill the microorganisms responsible for biofilm growth or at least reduce their activity[1]. The use of biocides demands the previous knowledge of the factors that could affect its efficiency such as: the optimal values of pH and temperature of the system, the suitable biocide dosing programme and its application frequency, the environmental risks that the residual biocide can give rise to when the waste water is discharged. Because legislation is becoming ever more restrictive, this last factor has acquired such importance that it became a decisive factor in the choice of a certain biocide or combination of biocides. There are essentially two ways of minimising the environmental impact of biocides: i) the use of the so called "environmental friendly" biocides, that easily break down to harmless products after its application and ii) the implementation of a treatment scheme in a way to reduce the amount of biocide necessary to control the biological activity.

Two biocides (gluataraldehyde and carbamate) were tested with *P. fluorescens* suspended cultures in order to know the mechanism of each biocide action and to compare both performances. Hence, in order to determine the optimum conditions to properly apply these two chemicals, assays were carried out at several pH, applying different concentrations of each biocide, respectively 100, 200 and 300 g/L of carbamate and 50 and 100 g/L of glutaraldehyde and exposing the bacterial cultures to the biocides at different contact times. The effect of each biocide on the bacterial surface charge was determined by zeta potential measurements. The effect on the bacterial suspension was evaluated in terms of oxygen uptake rates, as a measure of bacterial activity. These respirometric assays were fulfilled in a biological oxygen monitor (BOM) and the procedure used was described elsewhere[2].

The results clearly indicate that, contrary to the glutaraldehyde, the carbamate shifts the surface electrical charge of the *P. fluorescens* from negative to neutral or positive values, depending on the pH value and the biocide concentration. Thus, this biocide may promote cell aggregation when electrostatic repulsion between cells becomes low or non-existent. The changes in the surface properties and in the composition of the medium, caused by the carbamate, may lead to a reduction in a production of extra-cellular polymers, thereby reducing biofilm formation.

The results also show that carbamate causes a small decrease on the *P. fluorescens* activity, its action being more significant for higher concentrations and longer contact times. Oppositely, gluataraldehyde has a faster and stronger killing effect, because the bacterial activity decreases down to value close to zero, independently of the pH and the biocide concentration applied. The results stress that gluataraldehyde is more effective as a biocide than carbamate. However, it can also have a negative effect on the operation of the treatment systems when wastewater is discharged, enhancing the environmental risks. On the contrary, carbamate is considered almost an "environmental friendly" biocide, since its decomposition occurs rather quickly and does not affect the biological processes in treatment systems.

[1] Bott, T. R., *Fouling of Heat Exchangers*, 287-356, 1995.

[2] Nogueira, R., Lazarova, V., Melo, L. F., *Microbial Ecology of Biofilms: Concepts, Tools, and Applications*, Illinois, 8-10 October, 1998.