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Elimination of the formation of biofilm in industrial pipes using enzyme cleaning technique

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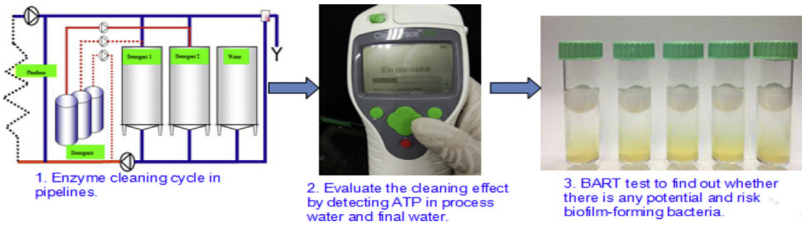
GRAPHICAL ABSTRACT



ABSTRACT

Currently, there is a growing demand in how to eliminate the biofilm formed in industrial pipelines, especially in food, fermentation, and water treatment industry. However, the traditional techniques for CIP (cleaning in place) are usually ineffective, superficial, halfway, and do not clean or sterilize microbes located in the inner layers of the biofilm. A recent strategy for removing the biofilm in pipes is employing enzymes to clean it in the circulating water system under an optimal condition. However, how to operate and control the whole cleaning process is difficult. Here, we will introduce the strategy of enzyme cleaning to make it more appropriated and effective.

- A modification of CIP method is proposed for higher efficiency by using N-acetylmuramide glycanohydrolase as catalysts whose optimal pH and temperature is 10 ± 1 and $45 \pm 2\,^{\circ}C$, respectively.
- The initial efficiency of enzyme cleaning was evaluated by testing the content of ATP in water sample using Clean-Trace™ (3M Corporation).
- Lastly, the terminal water was tested with SLYM-BART™ (HACH Corporation) to find out whether there were biofilm-forming bacteria, such as *Pseudomonas aeruginosa* (Lakretz et al. (2011) [1]), *Pseudomonas fluorescens* (O'Toole and Kolter (1998) [2]), iron bacterium, etc.

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Method details

In the water treatment process, traditional CIP techniques can usually remove or sterilize microbes on the surface of pipes. Taking the advantages of low cost and low energy consumption, these strategies were universally used in food, fermentation, and water treatment industry [1,3]. However, when the biofilm forms in pipelines, the traditional methods would not be available to eliminate it completely [2]. By contrast, the strategy of using muramidase to remove the biofilm in pipes is more effective and in-depth. The comparison of effectiveness between the traditional CIP and enzyme cleaning technique is shown in Fig. 1 and Table 1.

Preparation of material

In this new strategy, N-acetylmuramide glycanohydrolase is introduced as the critical enzyme which will react with the polymeric matrix of the biofilm, reduce its adherence and make the biofilm detach from the surface. In this study, the optimal pH and temperature for reaction is 10 ± 1 and $45 \pm 2\,^{\circ}C$, respectively. The temperature of $45 \pm 2\,^{\circ}C$ is used throughout the whole application procedure. The material was processed in the following manner.

Chemicals

- Pure soda (200 g/L solution)
- Pure acid (5 mol/L HNO_3/H_2SO_4/citric acid)
- 0.25% Enzyme (Biorem A1, Biorem 10)
- Aller test kit (MERCK Corporation)

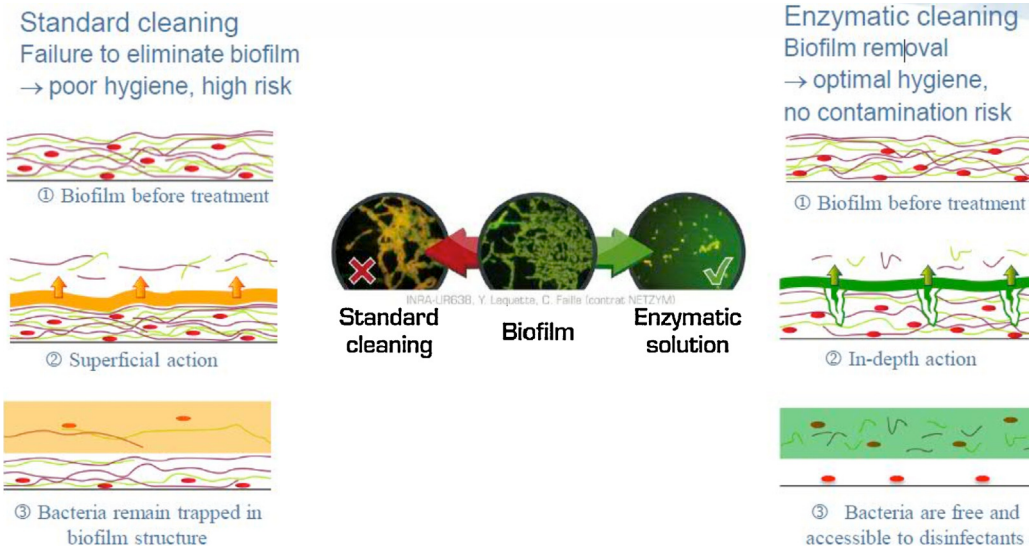

Fig. 1. Comparison of effectiveness between the traditional CIP and enzyme cleaning technique.