Preventing biofilm formation by developing a novel coating on pipe materials in drinking water distribution systems

Olga Sójka

olga.sojka@wetsus.nl

wetsus
european centre of **excellence** for sustainable **water technology**

Motivation

The purpose of the drinking water treatment facilities is to produce and to deliver high quality drinking water to the consumer. Water leaving the purification plant generally fulfils all the requirements for potable water, but it is often the case that during the distribution, its quality significantly deteriorates. One of the main causes is biofilm's growth on the pipe walls of drinking water distribution systems' (DWDS). The biofilms' presence significantly influences not only drinking water safety and aesthetics but also, by increasing the flow resistance, the distribution process itself [1]. A number of environmental and engineering parameters have been found to affect biofilm formation. Especially interesting in terms of modification possibilities, is the pipe material that significantly influences the process. Until now, all the materials utilized in DWDS construction have been found to harbour biofilm to a greater or lesser extent (Fig. 1) and no effective preventive strategy has yet been provided.

This project proposes the approach in which a novel anti-adhesive hydrogel coating for materials commonly applied in the DWDS will be developed and tested.

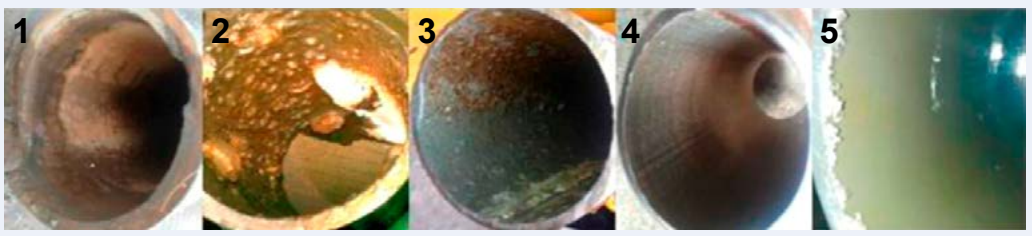
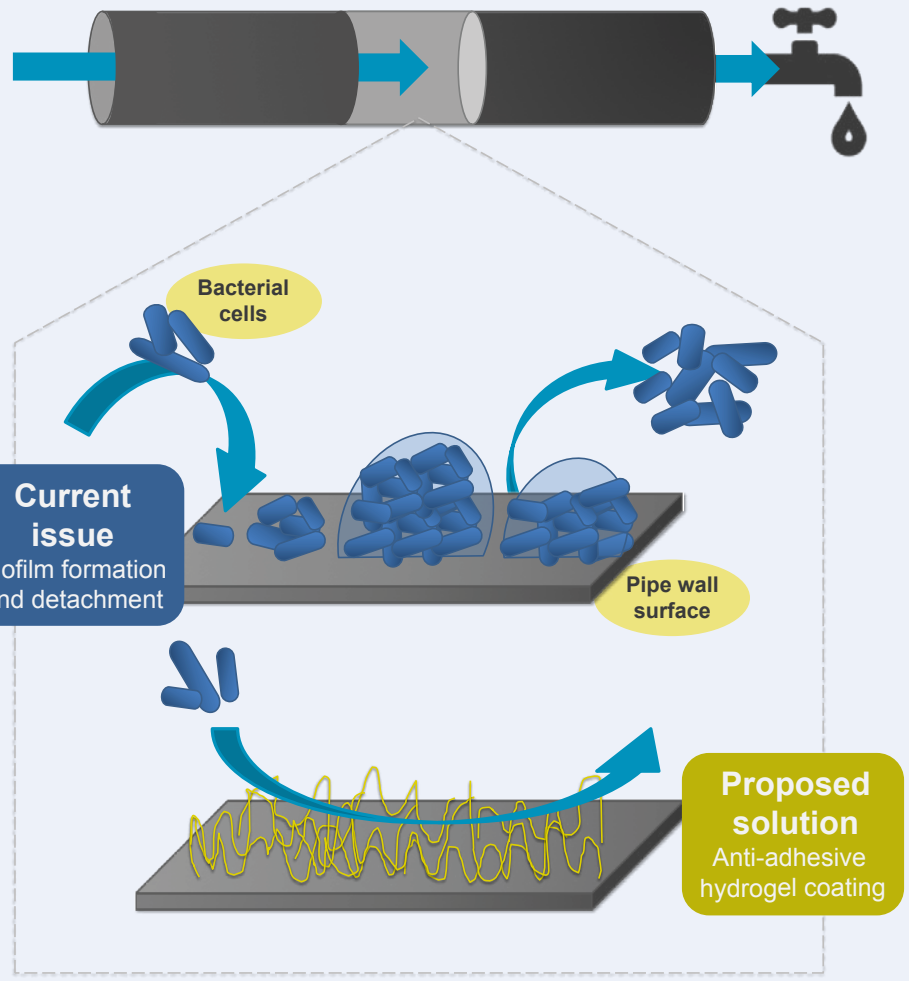


Figure 1: Biofilm growth on different pipe materials, 1 – ductile cast iron pipe, 2 – gray cast iron pipe, 3 – galvanized steel pipe, 4 – stainless steel clad pipe, 5 – polyvinyl chloride (adapted from [1])



Research goals

This research project aims to:

- unravel the mechanisms of initial bacterial adhesion, biofilm formation and detachment on commonly applied DWDS pipe materials, such as PVC and PE,
- develop a novel non-adhesive coating applicable in real DWDS, especially on selected *hotspots*.

Technological challenge

A number of polymer coatings with anti-adhesive properties has been studied in the medical field, where biomaterial associated infection caused by application of surgical implants and in-body devices limits the effectiveness of the treatment [2]. The challenge of this project is the translation of these anti-adhesive strategies from biomedical to DWDS application, considering not only the differences in the operational conditions, but also the robustness and cost-efficiency of such a solution.

To address those challenges, a simple method based on photo-initiated free radical polymerization (Fig. 2) will be used to coat the surfaces of commonly applied materials for DWDS piping, such as PVC and PE. A dedicated lab-scale setup will simulate DWDS conditions, especially targeting physio-chemical parameters of hotspots, where most biofilm growth has been observed (longer stagnant periods, higher temperatures, etc.). Microbial biofilms developed in time will be monitored to evaluate the efficiency of the selected strategy.

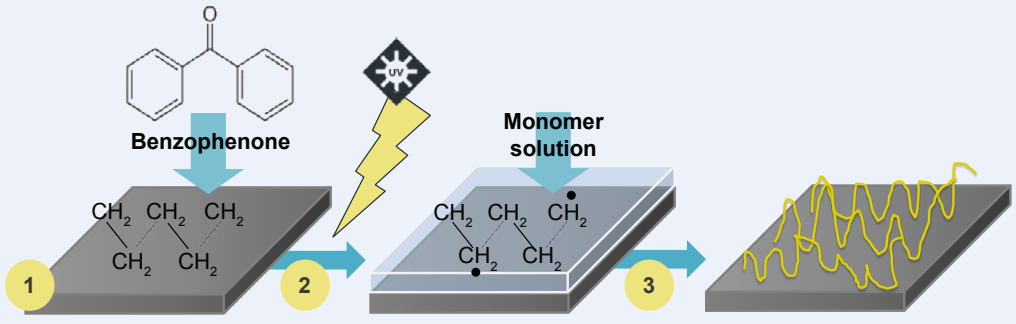


Figure 2: Anti-adhesive hydrogel coating formation on a polymer surface; 1 – surface infusion with benzophenone, 2 – surface free radicals formation through UV irradiation, 3 – coating formation in the presence of monomer (method adapted from [3])

References:

[1] Liu, Sanly, et al. "Understanding, monitoring, and controlling biofilm growth in drinking water distribution systems." *Environmental science & technology* 50.17 (2016): 8954-8976.

[2] Busscher, Henk J., et al. "Biomaterial-associated infection: locating the finish line in the race for the surface." *Science translational medicine* 4.153 (2012): 153rv10-153rv10.

[3] Keskin, Damla, et al. "The relationship between bulk silicone and benzophenone-initiated hydrogel coating properties." *Polymers* 10.5 (2018): 534.

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