Probing of biofilms on copper under anoxic conditions considering corrosion processes

B. Sc. Kilkku Katariina[1], Dr. rer. nat. Thomas Ohligschläger[2], D. Sc. Pauliina Rajala[2]

[1]Department of Life Technologies, University of Turku, [2]VTT Technical Research Centre of Finland Ltd.

BIOTECHNOLOGY (TECH.)

Introduction

In nuclear waste disposal the fuel storage canister has two main components: a cast iron inner capsule and a copper outer capsule. The canisters are placed in deep holes bored on bedrock and packed with bentonite clay. Compared to cast iron, copper is resistant to corrosion in anoxic saline deep groundwater. Bentonite clay absorbs groundwater from the bedrock and prevents the flow of microbes.

In the case that microbes come in contact with the copper surface, they can attach on to it and form biofilms (Fig. 1). The environment inside and under the biofilms can be very different from the surrounding. The microbes in the biofilms can use up oxygen, alter the pH and produce corrosive compounds. This process is called microbially induced corrosion (MIC).

Biofilms can be studied with different microsensors.

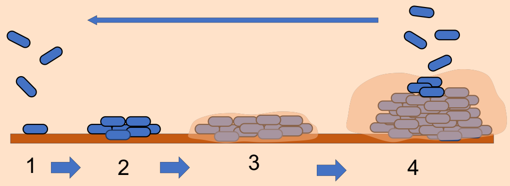

Figure 1. Main steps of biofilm formation: attachment (1), adhesion (2), maturation (3), dispersion (4).

Aim of the study

The aim of the study is to introduce the use of microsensor technology in the studying of biofilms on copper, considering their relevancy to copper corrosion. The most relevant sensors were chosen; O_2, pH, redox and H_2S.

Materials and methods

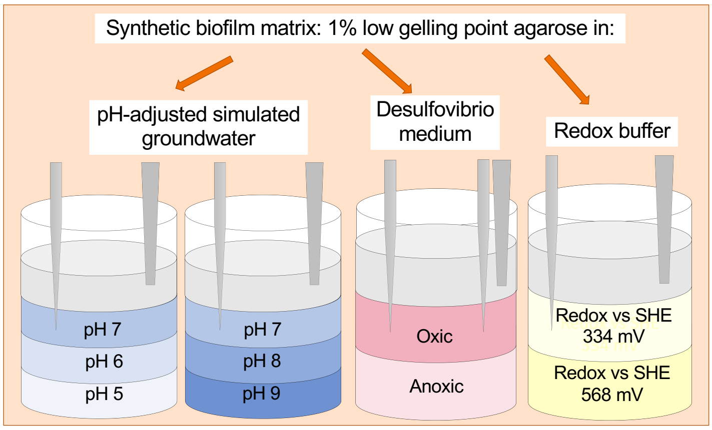

Figure 2. Initial microsensor testing procedure with chemical gradients. Two gels were made for each analyte with three parallel measurement for each gel. The measured analytes were pH (blue), oxygen and redox (pink), and redox (yellow). Each gel was topped with a layer of simulated groundwater (grey layer).

Copper coupons (9 pcs, 25 cm x 75 cm) were wet sanded with 1200 grit sandpaper. To form an oxide layer to the surface, they were heat-treated in the oven at 90°C for one week. The effect of the biofilm is tested with microsensors (Fig 3).

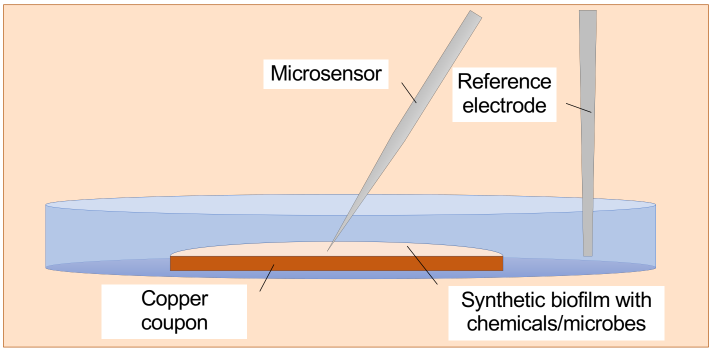

Figure 3. Experimental setup for studying local environments in synthetic biofilms on copper surface.

Preliminary results and conclusions

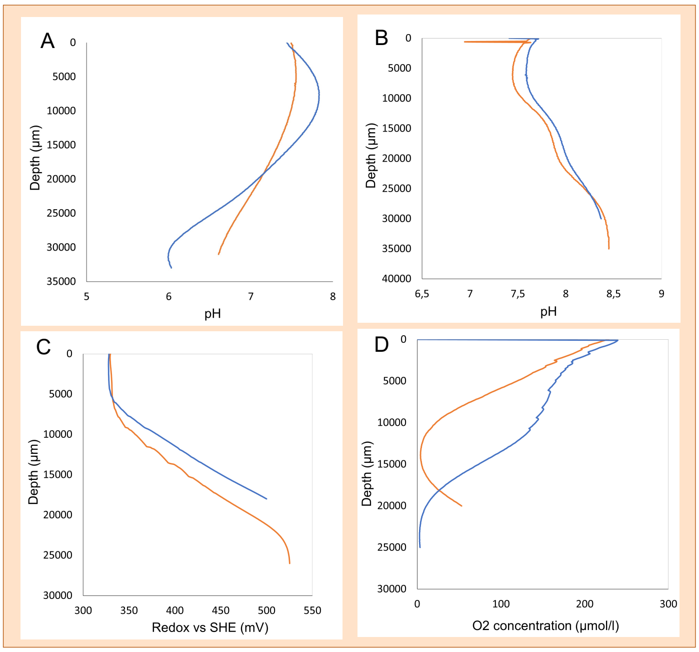

Figure 4. Microsensor measurements of chemical gradients. For each analyte, pH 5-7 (A), pH 7-9 (B), redox (C), and oxygen (D), two gels were measured. The orange (gel 1) and blue (gel 2) lines represent the average of three parallel measurements.

Preliminary results (Fig. 4) from the testing of microsensors with chemical gradients (Fig. 2) with overlapping 1% agarose gels indicate, that the chosen synthetic biofilm matrix does not notably interfere with the used chemicals. The microsensors can clearly detect the differences between the gradients.

The testing of biofilms on top of copper (Fig. 3) with microsensors is still ongoing with no results at this point. There has also been no testing of H_2S-microsensors as of yet. The final results are expected to show how well the microsensors can detect the environmental gradients under the rather thin biofilm.

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Contact: Katariina Kilkku, Research Trainee
Tel. +358 505707011, ext-katariina.kilkku@vtt.fi