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CONSERVATION OF PIPE WORKS AND MEMBRANES WITH ENERGY EFFICIENT WATER TREATMENT*

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Abstract

Cooling circuits are one of the most important parts in industrial production lines. However, when using water for cooling applications it is very important to take care of pipework surfaces. The change of material properties increases undesired side effects. For example microbial growth (e.g. fouling), scale deposits as well as corrosion can significantly compromise cooling effects with regard to dwell time and COC (cycles of concentration). Furthermore, increasing surface roughness and hydrophobicity require more pumping power, higher water flow rate, and ultimately higher costs of operation.
This paper is reporting on energy efficient water treatment in compliance with water quality regulations along with reducing the risk of bio-contamination for example from Legionella. The paper will address bacteria proliferation, microbial capacity in pipe works, and technological strategies for reducing the microbiological population capacity in pipe works without increasing maintenance efforts.

Keywords: biofilm elimination, catalysis, catalytic water treatment, energy efficient, MOLLIK

1. Bacteria and biofilm in technical water circuits

Free bacteria are normally no technical problem, as long as biofilm formation is prevented. Biofilm formation is a complex process. In literature is described (Freitag et al., 2012) that residues of bacterial cell walls are in particular phospholipids and fatty acids, which are playing a key role in this case. However, adenosine triphosphate (ATP), which is ubiquitous in all living things, can play an important role. Such residues are known to be available when bacteria die and cannot be reused immediately substantially.

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On the walls of heat exchangers bacteria are exposed to elevated temperatures leading to their death. If bacteria are retained in filters and concentrated, while the nutrients can pass through the filter unit, then a part of the concentrated bacteria "starves" to the point where bacteria count and nutrients coincide again. In case of dead bacteria are not removed residues from their cell walls serve to develop a biofilm.

Hydrogen bonds play an important role for the formation and development of biofilms. The proton permanently oscillates between two partially negatively charged partners without bonding to either one of them. Consequently, it is relatively easy to replace one of the partners without chemical changes. An equilibrium at the boundary of the material surface is achieved between removal of phospholipid and ATP and substances replacing them. Ideally, these substances are able to mask surfaces in such a way that the reattachment of biofilms becomes considerably more difficult.

2. The natural power of water molecule and return to use by catalysis

In liquid water, the proton oscillates - driven by infrared radiation of the sun - constantly at a rate of several hundred m/s (more than 1 000 km/h) between different partners. Preferred "partners" are the partially negatively charged oxygen atoms of the water. However, the proton energy is also sufficient to degrade other dissolved matter that causes aging and corrosion on surfaces. While this self-cleansing function of water occurs permanently, the process is too slow for technological use and requires a suitable catalyst in order to speed it up and achieve relevant removal rates. A requirement is that these catalysts have structures, which are able to convert the kinetic energy of the protons into usable chemical energy without destroying at the end.

On the surface of special alloys built from nickel, chromium, iron and containing mineral-metal-catalysts, it is possible to selectively and efficiently support the self-cleaning effect from the protons. Another key factor in this process are hydroxyl radicals, which are homolytically linked to the surface of the alloy. They are thermodynamically stabilized and due to their surface charge attract biomolecules. By using visible light they can be activated and lead to the decomposition of the biomolecules describing the technology as "light-induced catalysis". Currently technological embodiments so called MOLLIK-catalyst modules (Fig. 1).

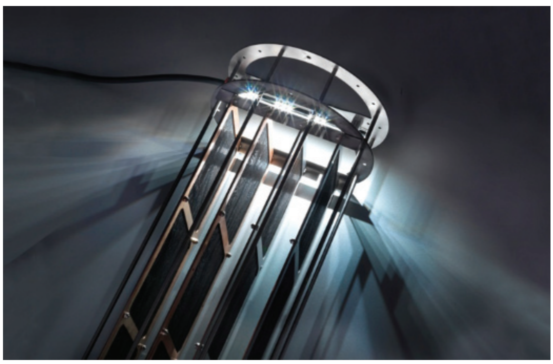

Fig. 1. MOLLIK-catalyst module with integrated LED unit (visible light spectrum)

3. Biocide-free removal of biofilm

In the presence of MOLLIK-catalyst modules ATP and other components or metabolites of living and/or dead bacteria are converted – under action of water and modicum of visible light – into biosurfactants. These are products, which are not able reducing any living harmful organisms and/or asset impair the vitality, but they are adapted to exchange binding partner of hydrogen bonds.

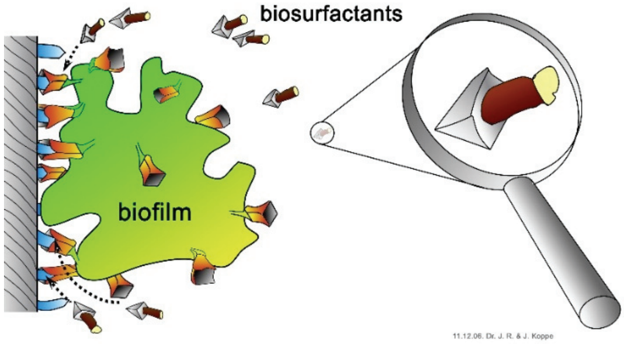

Fig. 2. Principle of biofilm removal by biosurfactans

Providing suitable alternative structures – instead of the material surface – on the hydrogen bonding may interact with these substances by receiving a new hydrogen bond. The biofilm is not chemical modified by this purely physical process. However, he loses contact with the material surface and can discharge easily from water. Here occurs no biocidal effect on the biosurfactants, too.

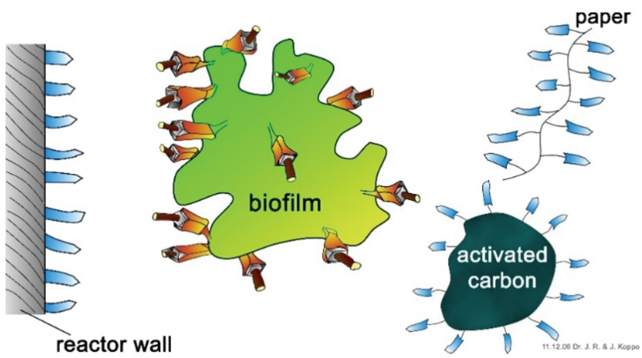

Fig. 3. Detached biofilm

Under technical conditions the concentration of biosurfactants is wet chemically inaccessible in the water, cause of the fact that their concentration is very low and biosurfactans are adsorbed on the pipe work surface and filter materials. Because of this adsorption the hydrophilicity of the surfaces increases, which inter alia results in saving pump energy. At the same time biosurfactant adsorption prevents the formation of biofilms and existing biofilms are removed.

In the presence of MOLLIK the biofilm detachment occurs as a purely physical process, where free bacteria and other living organisms are neither destroyed nor quenched or otherwise made harmless. A biocidal effect does not exist. That is preservation by adsorptive coating of surfaces at the molecular level. This adsorption is a reversible process, so a permanent use of MOLLIK technology is recommended for ensuring the facility performance.

4. Technical examples of energy-efficient catalytic water treatment

Typical technological applications are:

a) Integration of MOLLIK-modules in technical circuits,
for example, in cooling circuits, in swimming pools and pretreatment tanks.

b) Integration of MOLLIK-modules at once through applications,
for example in feed water lines of RO-plants, industry complexes and power plants.

Due to the action of biosurfactants formed far from the place of origin, it is possible to use the MOLLIK for partial flow treatment (about 20% of the total water flow).

- Catalytic water treatment at cooling circuit of a pharmaceutical company in Bitterfeld/Germany (Körner et al., 2015), means an *open cooling circuit,* with the following characteristics: system volume: 3.5 m³; circulation rate: 100 m³/h; COC: 3.0 till 4.0; make-up: portable water; 1x MOLLIK-module: weight: 4.9 kg, size: ∅ 250 / L: 600 mm, power consumption: 60 Watt*h/day (12 V DC) (Fig. 4).

Fig. 4. MOLLIK-module installed at cooling basn (Körner et al., 2015)

- Working at cooling circuit of refinery (Fig. 5), **(**Ernhofer, 2014) means an *open cooling circuit,* with the following characteristics: volume: 2000 m³; circulation: 3500 m³/h; COC: 3.0 till 4.0; make-up: well water (partial-softened); 2x MOLLIK-module: weight: 85 kg, size: (L x B x H), 1200 x 800 x 910 mm; power consumption: 350 Watt*h/day (12 V DC).

- Catalytic water treatment at public swimming pool (Fig. 6) (Maurer et al., 2013) means a *hot whirlpool* with the following characteristics: temperature: 36°C; pool volume: 10 m³; circulation: 100 m³/h; make-up: portable water; 1x MOLLIK-module: weight: 4.9 kg, size: ∅ 250 / L: 600 mm, power consumption: 60 Watt*h/day (12 V DC)

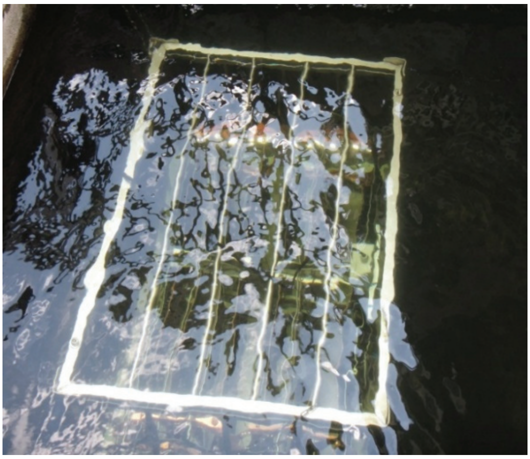

Fig. 5. MOLLIK-module installed at cooling basin

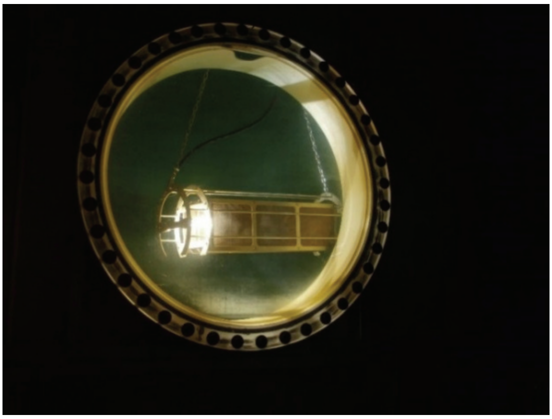

Fig. 6. MOLLIK-module installed at storage water tank of whirlpool

- Application at pretreatment of automotive painting lines (Fig. 7) (Klimkewitz et al., 2014). At VBH 10 (*clear water tank after bonderizing)* there is only a bypassing flow of 15 % main flow treated by MOLLIK, with the following characteristics: temperature: RT; volume: 50 m³; circulation: 80 m³/h; make-up: demineralized water; 1x MOLLIK-vessel at bypass: weight: 90 kg, size: ∅ 360/L: 1500 mm, power consumption: 100 Watt*h/day (12 V DC), bypassing flow: 12 m³/h.

- Usage at storage water tanks for fouling prevention (Fig. 8) (Koppe et al., 2011), means an *UF-permeate storage tank,* with the following characteristics: volume: 10 m³; flow rate: 30 m³/h; make-up: bank filtration; 1x MOLLIK-module: weight: 3.9 kg; size: ∅ 250 / L: 370 mm; power consumption: 60 Watt*h/day (12 V DC).

Fig. 7. MOLLIK-Module with stainless steel vessel

Fig. 8. MOLLIK-module during installation at feed water tank of RO

- Once-though application at make-up of a power plant (Fig. 9) (Hagen et al., 2015). *Make-up supply (installation point before filtration unit)* has the following characteristics: tank volume: 50 m³; flow rate: ≤ 1000 m³/h; make-up: seawater; 2x MOLLIK: weight: 60 kg, size: (L x W x H):1200 x 800 x 910 mm, power consumption: 350 Watt*h/d (12 V DC).

Fig. 9. MOLLIK-module at make-up supply of power plant

5. Concluding remarks

In evidence to numerous technical applications in cooling and process water systems, catalytic water treatment with energy efficient MOLLIK-technology is removing biofilms on pipe works, container walls and even on activated carbon in filter units. Based on the degradation of these microbiological shelters, the aerobic colony units according to Drinking Water Ordinance and for pathogens – such as Legionella – reduced significantly.

Finally, microbiological concentration is sustainably falling below the intervention value of the relevant technical regulations. As a result the heat transfer performance of the cooling circuit is rising. Furthermore availability and lifetime of the facility are increased.

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