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GERM-FREE ULTRAPURE WATER WITH DIAMOND ELECTRODES

Demineralized, ultrapure water is an essential raw material for many industrial products, whether in the medical and pharmaceutical industry, in semiconductor manufacture or in the production of foodstuffs. However, systems for producing and delivering ultrapure water are frequently colonized over time by germs and biofilms. This lowers water quality and leads to unstable production processes or losses in product quality. The problem can be remedied by time-consuming and costly cleaning processes using chemicals or applying high temperatures. One environmentally friendly and cost-effective alternative in the sanitization of ultrapure water systems is the cold sanitization process optimized at the Fraunhofer IST which uses boron-doped diamond films. It is based on an electrochemical process and requires no additional chemicals or increased temperatures. The work, financially supported by the Deutsche Bundesstiftung Umwelt DBU (German Federal Environmental Foundation) is helping our client, the Dessau company MTJ Medizintechnik & Service GmbH, to create a new innovative product with an important unique selling point.

Using diamond to kill germs and remove biofilms

In many respects diamond is a very special material. Even its electrochemical properties are extraordinary, as can be seen from its extremely high anodic overpotential of approx. 2.8 V. If a diamond-coated electrode pair is immersed in water and a voltage applied, OH radicals and other strong oxidants such as ozone (O_3), which is a highly potent disinfectant even at the lowest concentrations, form on the anode surface directly from the water molecules and without the use of additives. On the basis of this principle, an electrochemical ozone generator has been developed and optimized with respect to killing germs (sanitization) in a real ultrapure-water circulation system. Furthermore, in a first field test it was possible to recondition successfully an ultrapure-water installation heavily burdened with biofilms. Attempts to do this with state of the art methods failed repeatedly.

Procedure and project results

The development work was carried out in an industrial ultrapure-water ring-main system set up by MTJ Medizintechnik & Service GmbH in which the pipe circuit measured 200 m and had a total volume of 240 l (see Figures 1 and 2). The electrochemical ozone generator was equipped with four diamond electrodes with dimension of 2.5 x 5 cm^2 (Figure 3). The diamond electrodes came from CONDIAS GmbH, a spin-off company of the Fraunhofer IST.

To enable multifactorial optimization of the operating conditions of the ozone generator and the electrode system the design of experiments was applied. Under optimized process conditions, O_3 concentrations above 100 µg/l were achieved throughout the total pipe system in less than 10 minutes (see opposite graphic). With ozone concentrations like this the relevant bacterial strains are killed within a brief period of contact. When the ozone generator is switched off the ozone still dissolved in the water decomposes completely and even after

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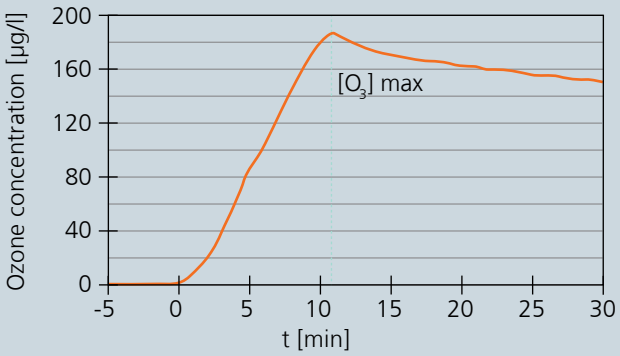
a relatively short time can no longer be detected. The time constant of ozone decomposition depends on temperature and the components installed in the system. After a few hours the sanitized ultrapure-water circuit was again operational and, without any rinsing processes, free of residues.

Advantages as compared with state of the art procedures

- Environmentally-friendly and resource-efficient
- No added chemicals
- No residues and no waste to be disposed of
- Minimal energy consumption (typically 10 Wh per treatment)
- Minimal downtime of the ultrapure-water systems to be sanitized
- Fully automatic operation allows pre-emptive use during night hours to prevent biofilm formation
- Compact, easily retrofittable system with low operating costs.

Electrochemical generation of ozone and decomposition after the ozone generator is switched off; total current: 4 A; cell voltage: 10–12 V, temperature: 20 °C.



1 *Ultrapure-water test facility: tanks and measurement equipment.*

2 *Ultrapure-water test facility: closed circuit water pipe, length 200 m.*

3 *Preassembled diamond electrode stack for installation in the ozone generator.*

CONTACT

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