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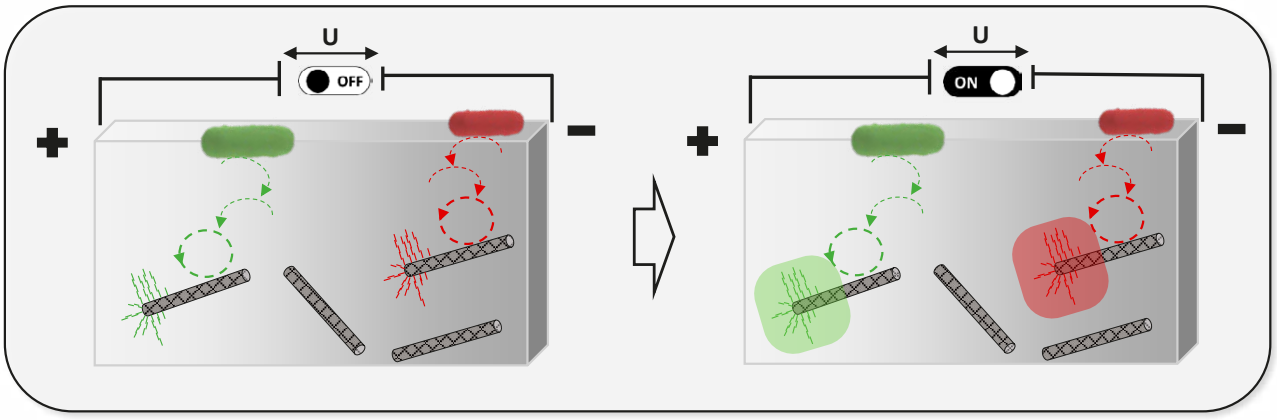
Multiplex rapid detection of hygiene-relevant germs and total bacterial count using nanoemitter-based 3D electrochemiluminescence

The quality of disinfectant processed textiles from the health care sector, food industry, etc. must be checked regularly by determining the total bacterial count and hygiene-relevant germs. Conventional sampling is carried out using contact (RODAC) plates and quantification is based on culturing the bacteria. Hygiene-relevant pathogens must be detected by culturing them on various selective media, a process that can only be carried out in external laboratories and is therefore both time-consuming and costly.

The aim of the research project carried out by the wfk-Cleaning Technology Institute e.V. was to develop a rapid in-house detection system for the quantification of hygiene-relevant microorganisms and the total bacterial count by generating electrochemiluminescence (ECL) signals using functionalised nanoemitters in a three-dimensional hydrogel.

As part of the research project, an aptamer switch was designed whose aptamer binds to target bacteria relevant to hygiene, such as S. aureus. The release of a specific switch oligonucleotide was simulated. This switch oligonucleotide enabled signal amplification by triggering a hybridisation chain reaction (HCR). Fluorescence signals were generated via a HCR of DNA oligonucleotides functionalised with an electrochemiluminescent chromophore ($[Ru(bpy)_3]^{2+}$) and a quencher. Optimised reaction conditions for signal generation via ECL, including suspended carbon nanotubes, were determined. Like HCR, ECL was also successfully carried out in hydrogels. However, it was not possible to demonstrate any additional amplification of the ECL signals by coupling luminophor-functionalised DNA oligonucleotides to carbon nanotubes (nanoemitters). The results demonstrate the successful initiation of signal amplification cascades based on HCR to generate ECL signals in storage-stable hydrogel sampling systems equivalent to contact plates. Based on the results obtained, further development can lead to the creation of new ECL-based rapid detection methods for specific hygiene-relevant microorganisms. Such methods enable rapid, cost-effective and self-administered hygiene monitoring, allowing potential hygiene risks to be identified at an early stage

The research report is available on request from the wfk - Cleaning Technology Institute.



Schematic representation of the electrochemiluminescence of nanoemitters with formed luminescent-functionalised hybridisation chains when a voltage is applied

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