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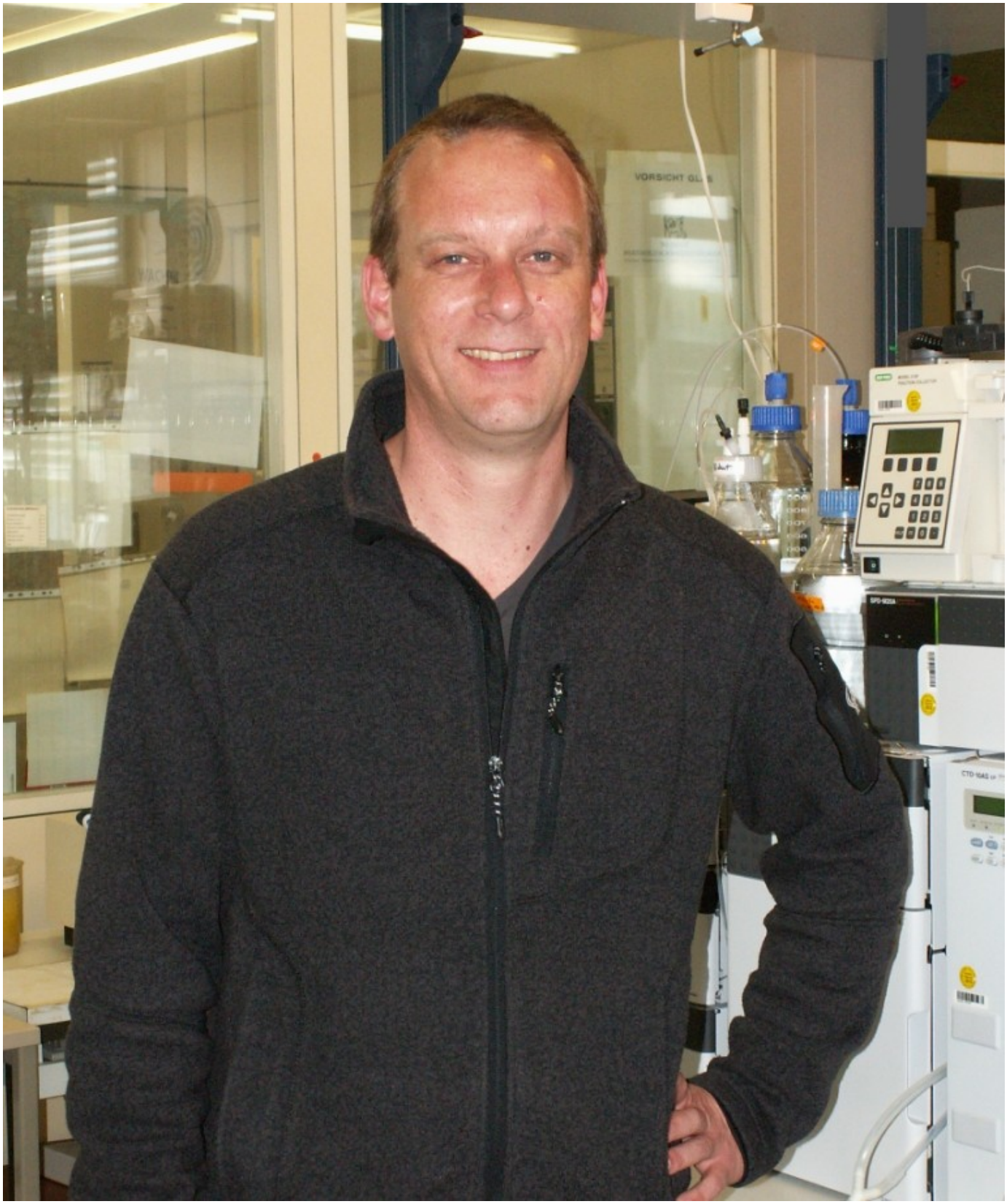
Bioeconomy BW

David Schleheck: exploring the effective degradation of surfactants

Linear alkylbenzene sulphonate (LAS) is omnipresent in our daily lives, despite its rather complicated name. Around three million tons of this surfactant are used every year in laundry detergents. On the one hand, LAS has an excellent washing performance, but on the other it can become a problem. It is toxic for bacteria with the result that the detergent cannot be degraded properly. David Schleheck, biologist at the University of Konstanz, focuses on the bacterial degradation of surfactants, and LAS in particular. The results of his research are of huge importance for the recycling of grey water, in areas including home sewage treatment systems, for example.

"The degradation of LAS is far more complex than previously assumed," said David Schleheck reporting on his research. However, it is essential to understand these processes in greater detail in order to prevent damage to the environment. The ineffective degradation of LAS in sewage treatment plants can lead to the development of foam on lakes and rivers. Schleheck has shown that the degradation of LAS is accomplished in two steps: first-tier bacteria initially degrade the aliphatic hydrocarbon chains into short-chain sulphophenylcarboxylates (SPC, without surfactant effect) which are secreted; second-tier bacteria then mineralize SPC. Schleheck used two different bacterial strains derived from sewage sludge for his investigations. However, the results showed that a far larger number of bacterial strains are necessary in order to achieve the complete degradation of LAS: LAS can be composed of 38 individual congeners, which in turn can be degraded into different sulphophenylcarboxylates. "Very complex bacterial communities and biochemical reactions are found in the environment and in sewage plants in particular, which guarantee the complete degradation of LAS and SPC," Schleheck highlighted.

Parvibaculum lavamentivorans is one of the most important bacteria for the degradation of LAS. It is mainly involved in the first step of the degradation process, i.e. the degradation of LAS into SPC, but is also able to catalyze this first step in 15 other commercially important surfactants. Schleheck has come up with highly interesting results regarding the growth of P. lavamentivorans bacteria: he found that glass and polyester particles are an important prerequisite for the growth of the bacteria. The bacteria are only able to form a biofilm in the presence of glass and polyester particles. "The bacteria thrive in biofilm. We therefore need to promote the formation of biofilm in the initial phase in order to enable the bacteria to degrade the surfactants," Schleheck explained. Well functioning sewage treatment plants have plenty of this kind of surfaces available, so there is no need to intervene. However, Schleheck's findings are of key importance in situations when a sewage treatment plant starts operating with only low quantities of bacteria present, or in plants with



David Schleheck carries out research on the bacterial degradation of detergent surfactants.
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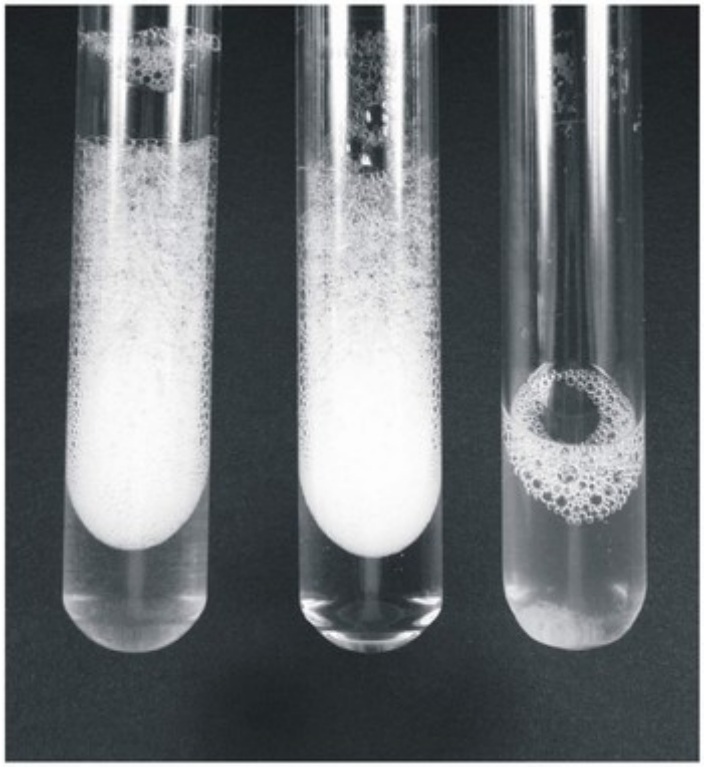
strongly fluctuating quantities of surfactant.

Home sewage treatment systems: problems occur when homeowners return from their holidays

In addition to his research on the biochemistry and genetics of bacterial surfactant degradation, Schleheck is particularly focused on the practical application of grey-water recycling in smaller, home



The figure highlights the role of glass fibres in the development of Parvibaculum lavamentivorans. The photo shows a mixture of LAS and water without the addition of bacteria and glass fibres (left), a mixture to which bacteria but no glass fibres have been added (centre), and a mixture to which both bacteria and glass fibres have been added. P. lavamentivorans can only grow and degrade LAS in the presence of glass fibres.

sewage treatment plants in which the presence of LAS and other surfactants fluctuates greatly. Such small plants are used to clean the grey wastewater from washing basins, washing machines and showers in order to reuse it for irrigation, cleaning or as so-called "black" water for flushing the toilets. Problems arise due to the irregular use of the plants: "At times when the wastewater treatment system is idle, for example when a family is on holiday, the bacteria do not receive any food and cannot grow," David Schleheck explained. The bacteria starve and are no longer able to efficiently degrade the surfactants when showers and washing machines are used again. This produces foam. "In terms of home sewage treatment, I believe it would be interesting to work with specialized companies in order to obtain more detailed insights into the surfactant-toxicity interplay, dormant state, bacterial growth as a prerequisite for the degradation of surfactant, the formation of biofilm in growth phases and the dissolution of biofilms during periods of starvation," said Schleheck.

The adaptability of bacteria – a blessing or a curse?

Schleheck is frequently astonished that LAS can be degraded so effectively. The molecule is xenobiotic, which means that it does not occur in nature, but is a synthetic product. The question that Schleheck is investigating is how bacteria have specialized in the degradation of LAS over the course of evolution. "This relates to how the bacteria have managed to use LAS as a food source, which new genes and enzymes have been recruited in order to carry out the biochemical reactions required for the degradation of LAS. Another important aspect associated with research into the degradation of LAS relates to the bacteria's ability to rapidly adapt to new situations. This rapid adaptation is certainly a curse with regard to the development of antibiotic-resistant pathogens in hospitals. However, it is a blessing with regard to the development of new pathways that enable bacteria to degrade potentially toxic compounds," Schleheck explained. Could his research eventually

be used to produce detergents that can be degraded more easily than current ones? David Schleheck is slightly sceptical: “The improvement of bacteria’s ability to degrade surfactants has its limits.” If a detergent is degraded too efficiently, the bacteria might potentially reproduce in the washing machine, and this is the absolute opposite of the desired effect. In addition to LAS, which is produced from petrol, other surfactants are produced from plants. “But here as well, the question relating to washing performance, toxicity and effective degradation still remains,” said Schleheck.

About
After studying biology in Heidelberg and Konstanz, David Schleheck was awarded his doctoral degree from the University of Konstanz in 2004 for his thesis in the field of microbial ecology dealing with the biodegradation of synthetic surfactants. He then spent his postdoctoral period at the University of New South Wales in Sydney, Australia focusing on research into bacterial biofilm formation and the bacterial degradation of polychlorinated hydrocarbons. He has been head of a research group working on a DFG-funded project at the University of Konstanz since 2011.

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