Karen Lienkamp: intelligent surface materials fight off microbes

Resistant germs are tough and will settle anywhere. They grow on all types of surface, which is a major cause for concern for medical doctors and industrial researchers alike. The chemist Dr. Karen Lienkamp, Junior Fellow at the Freiburg Institute for Advanced Studies (FRIAS) and head of a group of junior researchers at the University of Freiburg, develops surface materials for biomedical applications and industrial production facilities. The goal is to prevent microorganisms from multiplying in catheters, tubes or on implants. Lienkamp's project involves the use of an innovative kit for assembling biomimetic polymers which selectively combat bacteria.

Dr. Karen Lienkamp
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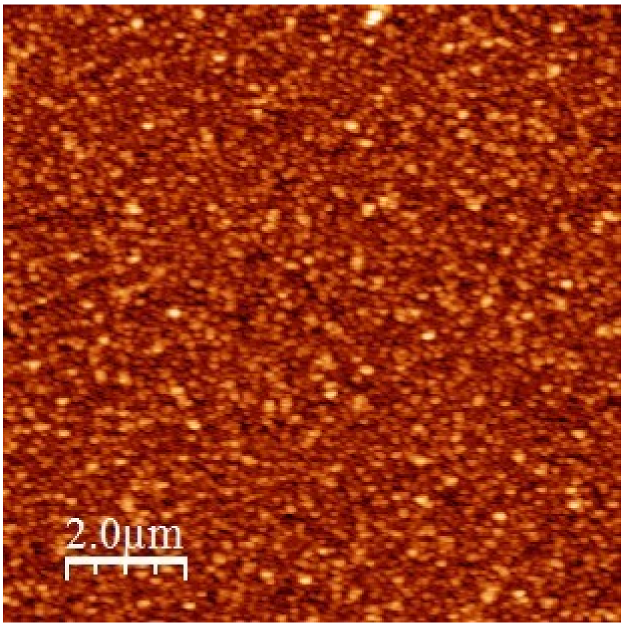
In Karen Lienkamp's laboratory at the Department of Microsystems Engineering (IMTEK) at the University of Freiburg there is always lots of laughter while the doctoral students wait for the quietly humming magnetic stirrers, rotary evaporators and liquid chromatographs to do their job. Once the machines have finished, the students return to their benches and are totally concentrated on their work. "I have been very lucky with my research group," says Karen Lienkamp. "Despite the fact that we have had to set up a brand new laboratory over the last six months, we have already been able to do some initial tests." The chemist, who was born in Freiburg in 1978 and grew up in Frankfurt am Main, returned to Germany from the USA in mid-2010. At the end of 2010, Lienkamp was made Junior Fellow at the Freiburg Institute for Advanced Sciences (FRIAS) and soon after was awarded one of the much sought-after grants from the German Research Foundation's (DFG) Emmy Noether Programme to set up a group of young researchers at IMTEK. The relaxed atmosphere in Lienkamp's laboratory belies the fact that the project is extremely important and highly promising.

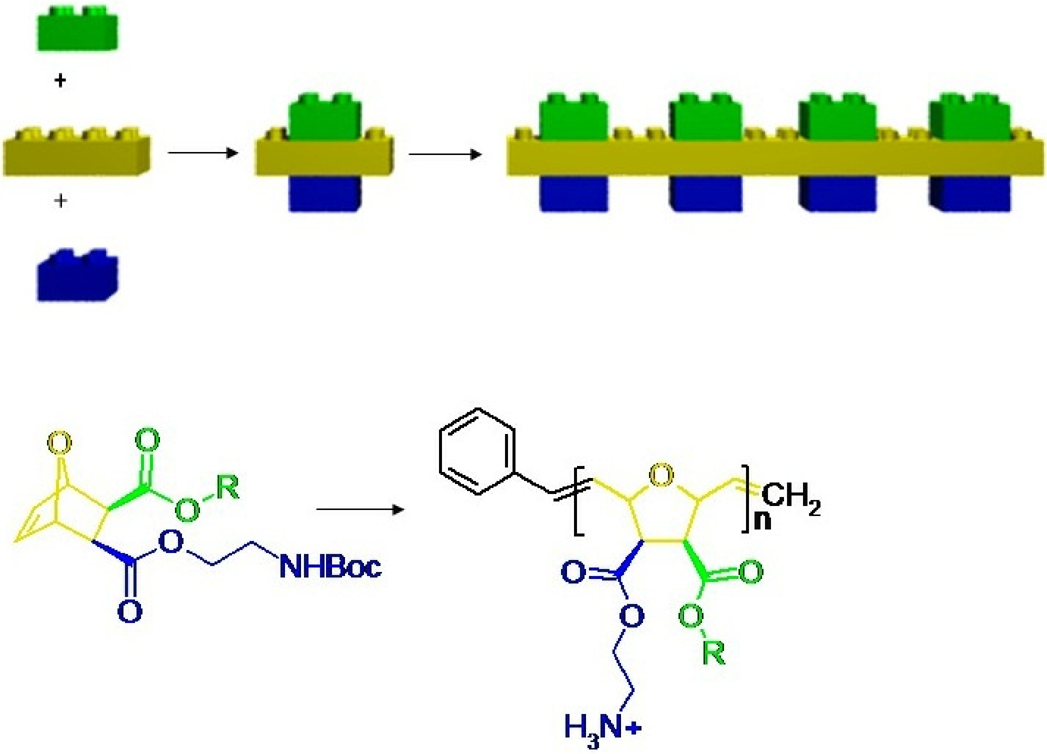
The danger begins on the surface



Antimicrobial surface seen under the atomic force microscope, AFM.

Lienkamp is developing novel surfaces for medical applications. "Many patients with a weakened immune system contract lethal bacterial infections from catheters, infusion tubes and implants in hospitals," Lienkamp explains. "We use a construction kit for biologically active molecules, which works on the same principle as LEGO. We are aiming to use this kit to produce materials which either fight off microbes or kill them before they get a chance to form biofilms." Bacteria use receptors in their membrane to scan the chemical properties of a surface before attaching themselves to it. If the conditions are suitable, the bacteria attach, multiply and eventually form colonies which are covered by a film. This stable biofilm protects the bacteria against antibiotics. The goal of the project is to develop novel surfaces that are able to prevent both occurrences, i.e. the accumulation of bacteria and the formation of biofilms.

During her postdoctoral research period at the University of Massachusetts in Amherst, USA from 2007 to 2010, Lienkamp started thinking about ways to effectively fight bacteria. Most antibiotics have a specific target within a bacterial cell. For example, they might inhibit the receptors that are involved in cell wall synthesis. These receptors can be rapidly altered by slight mutations, with the result that drugs no longer have any effect. This is why many bacteria become resistant to antibiotics. Karen Lienkamp therefore decided to address the problem from another angle, through non-specific attacks on the cell membrane, an organ with a complex structure that prevents it from changing as quickly as receptors or similar antibiotic targets.



LEGO kit principle used for the construction of artificial antimicrobial polymers

Using her “construction kit”, Lienkamp worked with her former colleagues from the University of Massachusetts to develop a set of artificially synthesised polymers (known as synthetic mimics of antibicrobial peptides or SMAMPs). The kit consists of a structural molecule to which hydrophilic (water-loving) or hydrophobic (water-repellent) branches can be attached. These elements are the components that form macromolecules with a positive charge on their hydrophilic side. This positive charge enables the macromolecules to accumulate on the negatively charged bacterial membrane before breaking through and thus tearing it. This is fatal for microorganisms. The bacteria are very unlikely to be able to adapt to this situation as a large number of simultaneous mutations would be required to change the protective biofilm while allowing the bacteria to survive. “Despite the non-specific effect on the membrane, such polymers are extremely selective – the cell membranes of other organisms do not carry a negative charge, which is essential for any applications in human medicine,” Karen Lienkamp explains.

Optimally structured surfaces – topography of mountains and valleys

The kit of artificial biomimetic building blocks allows the researchers to produce polymers with anti-fouling properties. Molecule chains of this kind swell up hugely in water, which means that a surface covered with molecules would also be covered with a film of water. And bacteria dislike that kind of surface. “The ultimate goal is to create a surface that is as hostile as possible to bacterial cells,” Karen Lienkamp says, adding “any bacteria that still decide to attach to this surface will be killed by it.”

At present, Karen Lienkamp and her team at IMTEK are testing various structuring methods for the production of such surfaces. For example, they are building polymer patterns that are just a few nanometres in size on smooth surfaces. The topography of mountains and valleys created can then be visualised through an atomic force microscope. In future, such topographies may well have a chessboard pattern of squares alternating between microdomains with antimicrobial properties and others with anti-biofouling characteristics. “As far as ideal topography is concerned, we are still just starting out with our research,” said Lienkamp, “but we are hoping to initiate some cell tests in around a year’s time. The tests are being planned in collaboration with research groups at Freiburg University Hospital.” There is still a lot of work to be done before then. For Karen Lienkamp, who has just become a mother, organising all that will be a real challenge. “I have the best husband in the world, so I am sure I will manage,” said the chemist with a smile. Now that the laboratory has been set up and the group is complete, she can’t wait to fully concentrate on the work with her doctoral students. She also has plans to intensify the cooperation and exchange of thoughts with her FRIAS colleagues. Interdisciplinary exchange will definitely be a major source of inspiration for this project located at the interface of chemistry, medicine and the material sciences.

Further information:

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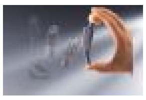

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