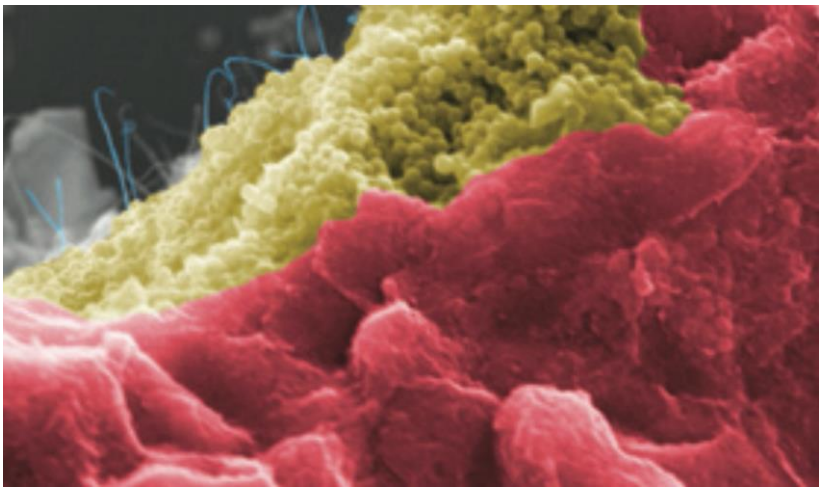
Programmable Nests for Cells

KIT Researchers Develop Novel Composites of DNA, Silica Particles, and Carbon Nanotubes – Properties Can Be Tailored to Various Applications



Bacteria cells (red) on a programmable composite of silica nanoparticles (yellow) and carbon nanotubes (blue). (Photo: Niemeyer-Lab, KIT)

Using DNA, smallest silica particles, and carbon nanotubes, researchers of Karlsruhe Institute of Technology (KIT) developed novel programmable materials. These nanocomposites can be tailored to various applications and programmed to degrade quickly and gently. For medical applications, they can create environments in which human stem cells can settle down and develop further. Additionally, they are suited for the setup of biohybrid systems to produce power, for instance. The results are presented in *Nature Communications* and on the bioRxiv platform.

Stem cells are cultivated for fundamental research and development of effective therapies against severe diseases, i.e. to replace damaged tissue, for instance. However, stem cells will only form healthy tissue in an adequate environment. For the formation of three-dimensional tissue structures, materials are needed, which support cell functions by perfect elasticity. New programmable materials suited for use as substrates in biomedical applications have now been developed by the group of Professor Christof M. Niemeyer of the Institute

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Further materials:

Publication in *Nature Communications:* https://www.nature.com/articles/s41467-019-13381-1

Publication on the bioRXiv biosciences platform: https://www.biorxiv.org/content/10.1101/864967v1?rss=1

for Biological Interfaces 1 – Biomolecular Micro- and Nanostructures (IBG 1) of KIT, together with colleagues from the Institute of Mechanical Process Engineering and Mechanics, the Zoological Institute, and the Institute of Functional Interfaces of KIT. These materials can be used among others to create environments, in which human stem cells can settle down and further develop.

As reported by the researchers in *Nature Communications*, the new materials consist of DNA, smallest silica particles, and carbon nanotubes. “These composites are produced by a biochemical reaction and their properties can be adjusted by varying the amounts of the individual constituents,” Christof M. Niemeyer explains. In addition, the nanocomposites can be programmed for rapid and gentle degradation and release of the cells grown inside, which can then be used for further experiments.

New Materials for Biohybrid Systems

According to another publication by the IBG 1 team on the bioRxiv bioscience platform, the new nanocomposites can also be used for construction of programmable biohybrid systems. “Use of living microorganisms integrated within electrochemical devices is an expanding field of research,” says Professor Johannes Gescher from the Institute for Applied Biosciences (IAB) of KIT, who was involved in this study. “It is possible to produce microbial fuel cells, microbial biosensors, or microbial bioreactors in this way.” The biohybrid system constructed by KIT researchers contains the bacterium *Shewanella oneidensis*. It is exoelectrogenic, which means that when organic substance is degraded under the lack of oxygen, an electric current is produced. When *Shewanella oneidensis* is cultivated in the nanocomposites developed by KIT, it populates the matrix of the composite, whereas the non-exoelectrogenic *Escherichia coli* bacterium remains on its surface. The Shewanella-containing composite remains stable for several days. Future work will be aimed at opening up new bioengineering applications of the new materials.

Original publications:

Yong Hu, Carmen M. Domínguez, Jens Bauer, Simone Weigel, Alessa Schipperges, Claude Oelschlaeger, Norbert Willenbacher, Stephan Keppler, Martin Bastmeyer, Stefan Heißler, Christof Wöll, Tim Scharnweber, Kersten S. Rabe, & Christof M. Niemeyer: Carbon-nanotube reinforcement of DNA-silica nanocomposites yields programmable and cell-instructive biocoatings. Nature Communications, 2019. DOI: 10.1038/s41467-019-13381-1 (Open Access)

https://www.nature.com/articles/s41467-019-13381-1

Yong Hu, David Rehnlund, Edina Klein, Johannes Gescher, & Christof M. Niemeyer: Cultivation of Exoelectrogenic Bacteria in Conductive DNA Nanocomposite Hydrogels Yields a Programmable Biohybrid Materials System. bioRxiv, 2019. DOI: 10.1101/864967 (Open Access)

https://www.biorxiv.org/content/10.1101/864967v1?rss=1

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This year's **anniversary logo** recalls the milestones reached by KIT and its long tradition in research, teaching, and innovation. On October 1, 2009, KIT was established by the merger of its two predecessor institutions: the Polytechnic School and later University of Karlsruhe was founded in 1825, the Nuclear Reactor Construction and Operation Company and later Karlsruhe Research Center in 1956.