nanoSeminar Series 2022

Institute for Materials Science

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Institute for Integrative Nanosciences, Leibniz IFW Dresden
Center for Molecular Bioengineering (B CUBE), TU Dresden

Medical microbots:
A paradigm shifting in assisted reproduction

Thursday, August 18th 2022
13:00 – 14:00

Normal: Seminar Room 115, Hallwachsstr. 3 (HAL)

Conference link: https://tinyurl.com/nanoSeminar-GA

Several concepts have been pursued by different research groups worldwide to realize untether propulsion on a small size scale. A biocompatible alternative towards microrobotic motion is to rely on the external power supply such as magnetic fields or ultrasounds which are not harmful to the human body. For instance, a small magnetic microhelix that rotates around its long axis by following the rotation of an applied magnetic field, results in an efficient forward movement through viscous fluids, like a screw propeller. Another possibility would be to directly mimic the beating flagellum motion of mammalian sperm cells. Hybrid micro-biorobots which are driven by powerful microorganisms (e.g. bacteria) or motile cells (e.g. sperm cells) are also a promising approach as they combine the advantage of biological components to the functionality of man-engineered microparts. To this end, our group has developed medical microbots to assist sperms with motion deficiencies to reach the oocyte, envisioning them for future in vivo assisted fertilization. We have proven the potential to guide sperms with engineered magnetic microtubes by aligning them along the external magnetic field. Sperm release was also possible using thermoresponsive polymer microtubes by a temperature change which was tuned to operate at physiological levels as well as to prepare sperms in-situ prior oocyte fertilization. We have also reported the use of helical micro-carriers, driven by an external magnetic field to transport and release captured immotile sperm cells. This is particularly interesting when sperms have no motility but are still functional and able to fertilize an oocyte (asthenozoospermia). However with this approach there are major challenges such as identifying the most fertile sperm among the “low quality sperms”, improving the coupling efficiency, the possibility to transport multiple sperms to improve the probability of fertilization, their control and imaging in vivo. In the last years, we have been working on making such sperm carriers more biocompatible, biodegradable, and functional. We have redesigned them to operate more efficiently in real oviduct fluids and intricate environments, as well as enable them to carry multiple sperm to increase the chances of fertilization. Finally, we have made some contributions in the field of imaging and control, employing infrared, ultrasound and photoacoustic imaging modalities, which facilitate the visualization of the microrobots from in vitro to in vivo, with high spatio-temporal resolution, giving the first steps towards their implementation in biomedical-relevant scenarios.

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Dr. Mariana Medina Sánchez studied Mechatronics Engineering at the University of San Buenaventura, in Bogotá-Colombia, where she designed, simulated and fabricated a didactic automatic plastic injection machine for milli-metric parts moulding. After finishing her Diploma studies, she worked as assistant professor and researcher for almost 5 years at the same university, with both teaching and research responsabilities. In parallel she performed postgraduate studies on education and biomedical engineering. Then she moved to Spain to pursue her Master and PhD studies, under the supervision of Prof. Arben Merkoçi, at the Catalan Institute of Nanoscience and Nanotechnology (Barcelona-Spain), where she worked on the development of nanomaterials-based and inkjet-printed electrochemical biosensors for diverse analyte detection. After finishing her PhD Thesis, she joined the Leibniz Institute in Dresden-Germany, as postdoctoral researcher, where she worked in two main projects: the development of magnetically-actuated microcarriers for immotile sperm transport, and the development of ultrasensitive rolled-up microsensors for DNA detection. After two years, she was promoted as group leader, under the mentoring of Prof. Oliver Schmidt. Since then, she has pushed forward the activities related to medical microrobots in particular toward in vivo assisted fertilization and targeted drug delivery, including optimal microbots designs, studies of sperm-based micromotors in complex environments and recently on the real time and deep-tissue tracking of those micromotors, which are key steps toward their application in living animals. Recently, she was one of the selected researchers to be granted by the European Research Commission, in the Category of ERC Starting, and since 2020 she is independent group leader at the same Institute. This year she extended her research activities by a Joint Dresden Concept group constituted by both IFW Leibniz and the Center for Molecular Bioengineering (B CUBE) and Technische Universität Dresden.

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