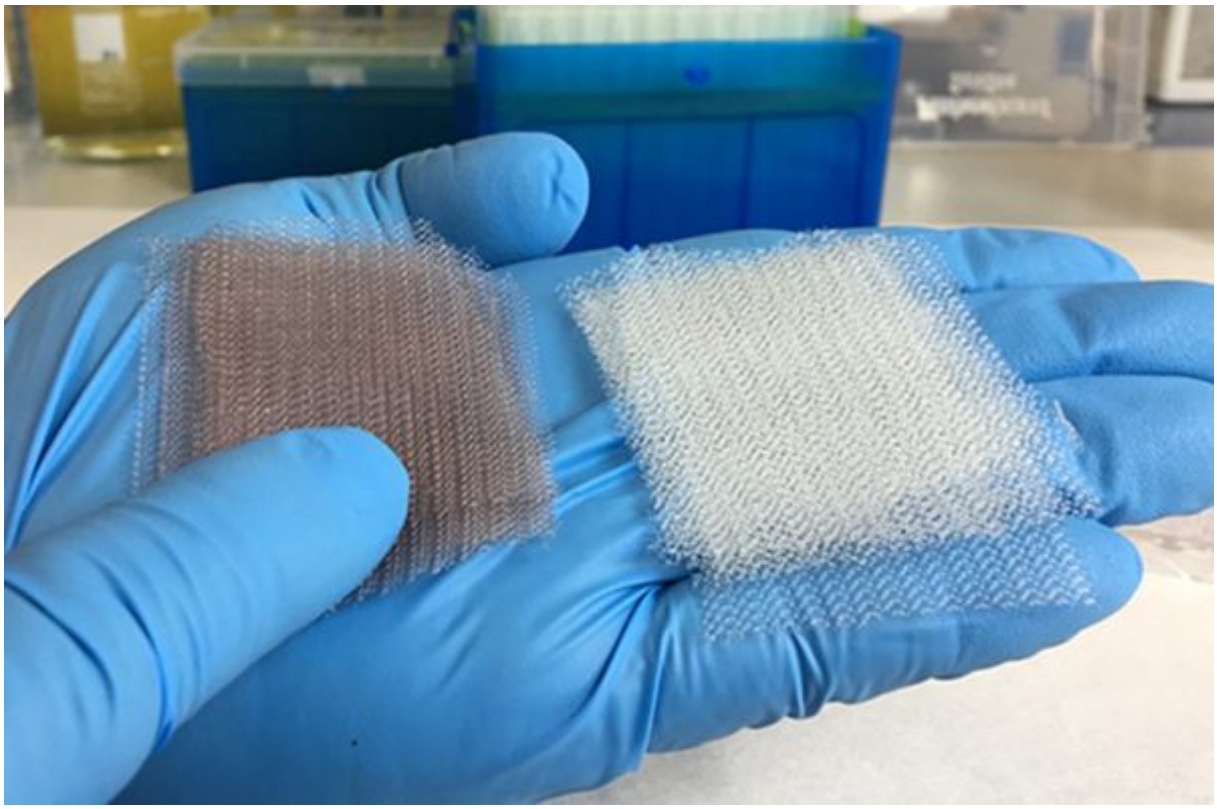


Light and nanotechnology combined to prevent biofilms on medical implants

An ICFO and B. Braun Surgical, S.A. study published in Nano Letters and highlighted in Nature Photonics reports on a new technique that could prevent bacterial contamination and infection in medical implants by using light combined with gold nanoparticles.

May 23, 2019

Invented approximately 50 years ago, surgical medical meshes have become key elements in the recovery procedures of damaged-tissue surgeries, the most frequent being hernia repair. When implanted within the tissue of the patient, the flexible and conformable design of these meshes helps hold muscles tight and allows patients to recover much faster than through the conventional sowing and stitching surgery . ?

However, the insertion of a medical implant in a patient's body carries alongside the risk o bacterial contamination during surgery and subsequent formation of an infectious biofil

over the surface of the surgical mesh. Such biofilms tend to act like an impermeable coating impeding any sort of antibiotic agent to reach and attack the bacteria formed on the film i order to stop the infection. Thus, antibiotic therapies, which are time-limited, could fai against these super resistant bacteria and the patient could end up in recurring surgeriestha could even lead to death. As a matter of fact, according to the European Antimicrobia Resistance Surveillance Network (EARS-Net), in 2015 more than 30,000 deaths in Europ were linked to infections with antibiotic-resistant bacteria

In the past, several approaches have been sought to prevent implant contamination durin surgery. Post-surgery aseptic protocols have been established and implemented to figh these antibiotic-resistant bacteria but none have entirely fulfilled the role of solving thi issue

In a recent study published in Nano Letters and highlighted in Nature Photonics, ICF researchers Dr. Ignacio de Miguel, Arantxa Albornoz, led by ICREA Prof. at ICFO Romai Quidant, in collaboration with researchers Irene Prieto, Dr. Vanesa Sanz, Dr. Christine Wei and Dr. Pau Turon from the major medical device and pharmaceutical device company B Braun, have devised a novel technique that uses nanotechnology and photonics t dramatically improve the performance of medical meshes for surgical implants

Through an ongoing collaboration since 2012, the team of researchers at ICFO and B. Brau Surgical, S.A.., developed a medical mesh with a particular feature: the surface of the mes was chemically modified to anchor millions of gold nanoparticles. Why? Because gol nanoparticles have been proven to very efficiently convert light into heat at very localize regions

The technique of using gold nanoparticles in light-heat conversion processes had alread been tested in cancer treatments in previous studies. Even more, at ICFO this technique ha been implemented in several previous studies supported by the Cellex Foundation, thu being another salient example of how early visionary philanthropic support addressed a tackling fundamental problems eventually leads to important practical applications. For thi particular case, in knowing that more than 20 million hernia repair operations take plac every year around the world, they believed this method could reduce the medical costs i recurrent operations while eliminating the expensive and ineffective antibiotic treatment that are currently being employed to tackle this problem

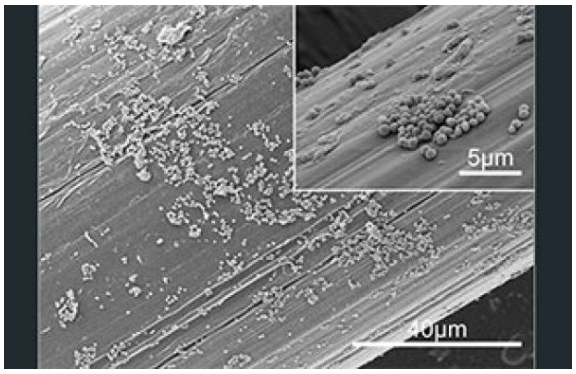
Thus, in their in-vitro experiment and through a thorough process, the team coated th surgical mesh with millions of gold nanoparticles, uniformly spreading them over the entir structure. They tested the meshes to ensure the long-term stability of the particles, th non-degradation of the material, and the non-detachment or release of nanoparticles into th surrounding environment (flask). They were able to observe a homogenous distribution of th nanoparticles over the structure using a scanning electron microscope

Once the modified mesh was ready, the team exposed it to S.aureus bacteria for 24 hour until they observed the formation of a biofilm on the surface. Subsequently, they bega

exposing the mesh to short intense pulses of near infrared light (800 nm) during 30 second to ensure thermal equilibrium was reached, before repeating this treatment 20 times with seconds of rest intervals between each pulse. They discovered the following: Firstly, they sa that illuminating the mesh at the specific frequency would induce localized surface plasmo resonances in the nanoparticles-a mode that results in the efficient conversion of light int heat, burning the bacteria at the surface. Secondly, by using a fluorescence confoca microscope, they saw how much of the bacteria had died or was still alive. For the bacteri that remained alive, they observed that the biofilm bacteria became planktonic cells recovering their sensitivity or weakness towards antibiotic therapy and to immune syste response. For the dead bacteria, they observed that upon increasing the amount of ligh delivered to the surface of the mesh, the bacteria would lose their adherence and peel off th surface. Thirdly, they confirmed that operating at near infrared light ranges was completel compatible with in-vivo settings, meaning that such a technique would most probably no damage the surrounding healthy tissue. Finally, they repeated the treatment and confirme that the recurrent heating of the mesh had not affected its conversion efficiency capabilities

As ICREA Prof at ICFO Romain Quidant comments**¡¿½the results of this study have paved t e way towards using plasmon nanotechnologies to prevent the formation of bacterial biofilm t the surface of surgical implants. There are still several issues that need to be addressed but t is important to emphasize that such a technique will indeed signify a radical change n operation procedures and further patient post recoveri¿**

? Dr. Pau Turon, Director of Research and Development at B. Braun Surgical, S.A. explains, **i¿½our commitment to help healthcare professionals to avoid hospital related infectio s pushes us to develop new strategies to fight bacteria and biofilms. Additionally, the resear h team is exploring to extend such technology to other sectors where biofilms must e avoided.i¿½**



SEM micrographs of the S. aureus biofilm formed on the surgical mesh surface. (Image credit: ICFO)