New lab-on-a-chip measures mechanics of bacteria colonies

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(PhysOrg.com) -- Researchers at the University of Michigan have devised a microscale tool to help them understand the mechanical behavior of biofilms, slimy colonies of bacteria involved in most human infectious diseases.

Most bacteria in nature take the form of biofilms. Bacteria are single-celled organisms, but they rarely live alone, said John Younger, associate chair for research in the Department of Emergency Medicine at the U-M Health System. Younger is a co-author of a paper about the research that will be the cover story of the July 7 edition of *Langmuir*.

The new tool is a microfluidic device, also known as a "lab-on-a-chip." Representing a new application of microfluidics, the device measures biofilms' resistance to pressure. Biofilms experience various kinds of pressure in nature and in the body as they squeeze through capillaries and adhere to the surfaces of medical devices, for example.

"If you want to understand biofilms and their life cycle, you need to consider their genetics, but also their mechanical properties. You need to think of biofilms as materials that respond to forces, because how they live in the environment depends on that response," said Mike Solomon, associate professor of chemical engineering and macromolecular science and engineering, who is senior author of the paper.

Mechanical forces are at play when our bodies defend against these bacterial colonies as well, Younger says.

"We think a lot of host defense boils down to doing some kind of physical work on these materials, from commonplace events like hand-washing and coughing to more mysterious processes like removing them out of the bloodstream during a serious infection," he said. "You can study gene expression patterns as much as you want, but until you know when the materials will bend or break, you don't really know what the immune system has to do from a physical perspective to fight this opponent."

Researchers haven't studied these properties yet because there hasn't been a good way to examine biofilms at the appropriate scale.

The U-M microfluidic device provides the right scale. The channel-etched chip, made from a flexible polymer, allows researchers to study minute samples of between 50 and 500 bacterial cells that form biofilms of 10-50 microns in size. A micron is one-millionth of a meter. A human hair is about 100 microns wide.

Such small samples behave in the device as they do in the body. Tools that require larger samples don't always give an accurate picture of how a particular substance behaves on the smallest scales.

The researchers found that the biofilms they studied had a greater elasticity than previous methods had measured. They also discovered a "strain hardening response," which means that the more pressure they applied to the biofilms, the more resistance the materials put forth.

If doctors and engineers can gain a greater understanding of how biofilms behave, they could perhaps design medical equipment that is more difficult for the bacteria to adhere to, Younger said.

The experiments were performed on colonies of Staphylococcus epidermidis and Klebsiella pneumoniae, which are known to cause infections in hospitals.

The new microfluidic device could also be used to measure the resistance of various other soft-solid materials in the consumer products, food science, biomaterials and pharmaceutical fields.

More information: The paper is called, "Flexible Microfluidic Device for Mechanical Property Characterization of Soft Viscoelastic Solids Such as Bacterial Biofilms." The first author is Danial Hohne, a recently-graduated Ph.D. student in the Department of Chemical Engineering.

Source: University of Michigan (news : web)