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RESEARCH NEWS STORY

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Chiba University

Detecting Cancer Cells in Blood: The Development of Microchannel Devices with Microcone Arrays

Researchers utilize engraved polycarbonate sheets and antibody coatings to efficiently capture cancer cells

Despite significant advancements in biosensing technologies, the early and accurate diagnosis of cancer remains challenging. In a recent study, researchers from Japan have developed a novel microfluidic device containing arrays of microcones to detect cancer cells in the blood. Their device leverages cancer-specific antibodies as coatings to accurately detect cancer cells. Furthermore, the microchannel device maintained a high capture efficiency of more than 90%, even at high flow rates.

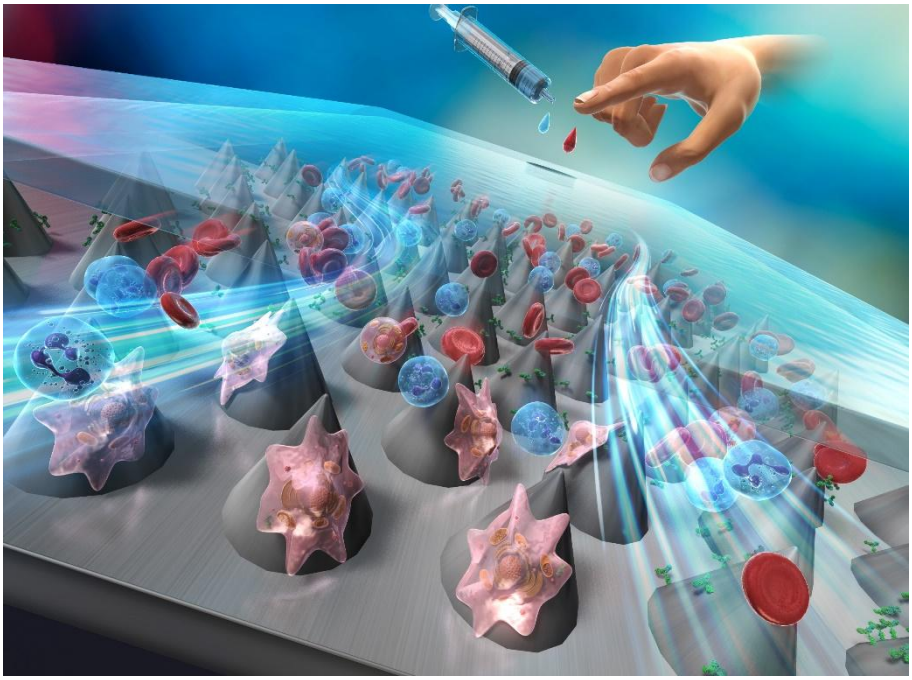

Image title: Microchannel device to detect cancer cells in blood
Image caption: By imprinting microcones on polycarbonate sheets followed by coating with human epithelial cell adhesion molecule antibodies, scientists from Japan have developed a microchannel-based diagnostic tool. Their device demonstrated high sensitivity while maintaining a capture efficiency of more than 90% at high flow rates.
Image credit: Professor Masumi Yamada from Chiba University, Japan
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Circulating tumor cells (CTCs) refer to cancer cells that have broken off from a primary tumor. These tumor cells can travel through the blood in the circulatory system and lodge themselves in other organs to cause secondary tumors. Therefore, the detection and subsequent characterization of CTCs from blood can help in the clinical diagnosis and treatment of various cancers. However, the efficient capture of CTCs from blood has been proven to be difficult.

Advancements in micro/nanofabrication technologies, along with newer polymer-based materials, have given rise to microfluidic systems that can detect CTCs. Recent reports indicate that by utilizing antibodies as capture molecules, CTCs can be trapped within the microfluidic systems. But then again, incorporating antibodies into specific areas within micro-sized devices requires complex chemical reactions and ultimately increases the costs of producing CTC-sensing microdevices on a large scale.

To enable the efficient capture of CTCs from blood via a cost-effective sensing platform, a team of scientists led by Professor Masumi Yamada from the Graduate School of Engineering, Chiba University, Japan, has developed novel microfluidic devices that incorporate microcones, comparable in size to biological cells. The team comprised Mr. Yuhei Saito from the Graduate School of Science and Engineering, Chiba University, and Dr. Shuhei Aoyama from Denka Innovation Center, Denka Co., Ltd., Japan. Their research findings were published online in the journal *Lab on a Chip* on May 28, 2025.

Initially, the researchers utilized polycarbonate (PC) sheets with the microcone arrays with nanometer-sized roughness by employing thermal nanoimprint lithography (T-NIL)—a heat-based fabrication technology. Specifically, T-NIL allowed the preparation of microcones that were around 30 micrometers in dimensions and packed in a hexagonal pattern. Owing to their surface chemistry- and morphology-based interactions, the micro/nanoengineered PC sheet could easily bind to and adsorb antibodies.

To develop a functional microdevice, the scientists coated the fabricated PC sheets with anti-human epithelial cell adhesion molecule antibodies, which could capture cancer cells. The PC sheets were then sandwiched between a flat plate and a glass slide to form microfluidic channels. *"To investigate the impact of the microcone arrangement on the capture behaviors of the cancer cells, we controlled the orientation angles of the microcone array in the microgap channels,"* says Prof. Yamada, providing finer details about the study.

During experimental analysis, the microfluidic device demonstrated highly selective capture of human breast cancer (MCF-7) cells and human lung cancer (A549) cells from the blood samples. Notably, in devices where the orientation angles of microcones were 15° or 30°, the capture efficiency of MCF-7 cells remained more than 90% even at high flow rates. This finding showed that the microcone arrangement was key to the sensing applications of the microfluidic device.

Finally, to highlight the clinical diagnostic capability of the device, the researchers conducted an immunostaining study using fluorescent dyes to detect specific proteins. Despite using multiple reagents to fluorescently label cells, they found that the cancer cells remained trapped within the micro-channels and did not escape. Moreover, during observation under fluorescent light, the captured cancer cells could be easily distinguished from the normal cells.

Prof. Yamada concludes by describing the potential applications of the novel microcone-containing diagnostic system, *"There are many technologies for detecting cancer, but it has been a long-standing challenge to detect cancer cells with high sensitivity using minimally invasive methods. We hope that through our new microfluidic system, even simple blood tests can be utilized to aid in the early diagnosis of cancer. It may also be useful for verifying the effectiveness of cancer treatment and monitoring recurrence after treatment."*

Taken together, this study reveals a simple, cost-efficient, and highly sensitive diagnostic tool to detect circulating cancer cells in blood. Let us hope that this novel device will be used in practical settings sooner for the efficient diagnosis of cancer.

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About Professor Masumi Yamada from Chiba University
Dr. Masumi Yamada currently serves as a Professor at the Graduate School of Engineering, Chiba University, Japan. He received his Ph.D. from The University of Tokyo in March 2006. His research mainly focuses on microfabrication techniques for applications in materials development, biotechnology, and clinical diagnostics. Over the years, he has published 131 papers that have been cited more than 4,600 times. Furthermore, he is affiliated with prestigious academic societies such as the Society for Chemistry and Micro-Nano Systems and the Society of Chemical Engineers, Japan.

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