Ultrafast, On-Chip PCR Could Speed Diagnosis during Current and Future Pandemics

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Researchers have developed a plasmofluidic chip that can perform PCR in only about 8 minutes, which could speed diagnosis during current and future pandemics.

Reverse transcription-polymerase chain reaction (RT-PCR) has been the gold standard for diagnosis during the COVID-19 pandemic. However, the PCR portion of the test requires bulky, expensive machines and takes about an hour to complete, making it difficult to quickly diagnose someone at a testing site. Now, researchers reporting in ACS Nano have developed a plasmofluidic chip that can perform PCR in only about 8 minutes, which could speed diagnosis during current and future pandemics.

Rapid diagnosis of COVID-19 and other highly contagious viral diseases is important for timely medical care, quarantining and contact tracing. Currently, RT-PCR –– which uses enzymes to reverse transcribe tiny amounts of viral RNA to DNA, and then amplify the DNA so that it can be detected by a fluorescent probe –– is the most sensitive and reliable diagnostic method.

But because the PCR portion of the test requires 30–40 cycles of heating and cooling in special machines, it takes about an hour to perform, and samples must typically be sent away to a lab, meaning that a patient usually has to wait a day or two to receive their diagnosis. Ki-Hun Jeong and colleagues wanted to develop a plasmofluidic PCR chip that could quickly heat and cool miniscule volumes of liquids, allowing accurate point-of-care diagnosis in a fraction of the time.

This tiny PCR chip can amplify DNA much more quickly than conventional, benchtop PCR systems.

The researchers devised a postage stamp-sized polydimethylsiloxane chip with a microchamber array for the PCR reactions. When a drop of sample is added to the chip, a vacuum pulls the liquid into the microchambers, which are positioned above glass nanopillars with gold nanoislands. Any microbubbles, which could interfere with the PCR reaction, diffuse out through an air-permeable wall. When a white LED is turned on beneath the chip, the gold nanoislands on the nanopillars quickly convert light to heat, and then rapidly cool when the light is switched off.

The researchers tested the device on a piece of DNA containing a SARS-CoV-2 gene, accomplishing 40 heating and cooling cycles and fluorescence detection in only 5 minutes, with an additional 3 minutes for sample loading. The amplification efficiency was 91%, whereas a comparable conventional PCR process has an efficiency of 98%. With the reverse transcriptase step added prior to sample loading, the entire testing time with the new method could take 10-13 minutes, as opposed to about an hour for typical RT-PCR testing. The new device could provide many opportunities for rapid point-of-care diagnostics during a pandemic, the researchers say.

Read the original article on American Chemical Society (ACS).