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Stimuli Responsive Fluidics Controls on a Paper-based Bacterial Detection Platform

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ABSTRACT

Infectious diseases are the leading causes of death around the world. Point-of-care devices using nucleic acid amplification are sensitive enough to diagnose these diseases, however, often require complex and time-intensive sample preparation steps that are not integrated with the detection process. A rapid, sensitive, and integrated sample-to-result diagnostic device will permit disease treatment planning at the point-of-care. Paper-based detection assays are a promising platform to integrate the sample preparation and detection, with minimal infrastructure, equipment, and user involvement. To integrate sample preparation with detection on paper-based assays, timing and delivery of sample fluid flow needs to be controlled. Here we use thermally responsive materials (e.g. wax) to create a micro valve on a nitrocellulose membrane in order to automate fluid flow and minimize user involvement. The ease-of-fabrication, lot-to-lot variability and consistency of the dispensing methods are compared. After multiple trials, dispensing the wax material, PureTemp 68X, using a stamp made of polydimethylsiloxane (PDMS) is able to direct the sample flow with the highest consistency. Thermally responsive valves fabricated by stamping PureTemp 68X are found to block the sample fluid to flow for a sustained time when cool. When heated above the melting temperature (68°C), the valve opens and allows fluid flow without interfering with downstream assay binding reactions. These valves can be actuated multiple times simply by heating and cooling again. As a proof of concept, we use the valve to control sample delivery time of nucleic acid amplicons in a lateral flow immunoassay. Amplicons dispensed onto one side of the assay are incubated and bind to gold nanoparticles. They are then released through the valve by applying heat to open the valve. Nanoparticle nucleic acid amplicons will bind to recognition antibodies at the far side of the valve and become visible bands for detection.

KEYWORDS

Phase changing material, Microfluidic control, Bacterial detection, Valve, Point-of-care diagnostic