Paper based microfluidics: Capillary-Driven Free Surface Flow

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The recent developments in paper microfluidics aim at applications in diagnostics for medical testing, veterinary health testing, food quality and environmental monitoring. Paper diagnostics has a potential to transform the medical preventive industries by providing simple, affordable and robust tests as well as providing low cost tests for home and point-of-care testing [1]. The preference of paper as a substrate for these applications include: significantly reduced cost, simplified fabrication, elimination of the requirement for pumps or power, and removal of problems associated with bubbles [2]. Paper-based microfluidic devices are built by demarcating hydrophilic paper by walls of hydrophobic material such as polymer and wax. This is done so as to use small sample volumes and to control the delivery of the sample to the detection region. Paper-based microfluidics uses capillary force to drive liquids, therefore, achieving steady control over flow rates and time of detection is crucial for obtaining reproducible results and consistent sensitivity. Unlike flows driven by external forces, capillary driven flow is dominated by the interfacial phenomena and therefore, it is sensitive to the geometry of the channel and chemical composition (surface energy along the channel). This work presents a fabrication technique for creating a paper-based microfluidics channel based on UV irradiation of TiO_2-nanoparticle coated paper and controlling capillary liquid flow on the paper surface.

A number of patterning methods for paper-based microfluidic devices (µPADs) have been proposed in the literature, including the following: photolithography, inkjet etching, plasma etching, polydimethysiloxane (PDMS) plotting, knife cutting, laser cutting and wax printing and dipping. We propose a method for creating microfluidic channels by utilising the photocatalytic property of titanium dioxide. Paper coated with thin layer TiO_2 nanoparticles exhibits superhydrophobicity, and by irradiating it with UV light through a photomask, the exposed TiO_2 regions become hydrophilic while the unexposed region retains its initial condition. This technique offers clear potential for continuous high-speed and large volume industrial production of µPADs utilising currently existing production lines. To demonstrate the applicability of the approach for paper-based microfluidics, flow rates of model liquids at different channel widths were measured. Transport time of fluids was controlled by altering the width of the channel and surface energy along the strip. The surface flow control was achieved by creating channels with expansion and constriction at different position along the channel.

References

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