DUCTILE BARRIER MATERIAL FOR ECO-DISPOSABLE MICROFLUIDIC DEVICE AND METHOD OF FABRICATION THEREOF

IITM Technology Available for Licensing

Problem Statement

- **Paper microfluidics-based point-of-care diagnosis devices (Pμ-POC)** have gained significant attention in the diagnostic field due to their "ASSURED" (affordable, sensitive, specific, user-friendly, and rapid, equipment-free, delivered to those in need)" nature.
- **Conventional fabrication techniques** capable of retaining surfactants and organic solvents — such as photolithography or inkjet printing — are **often costly, technically complex, toxic, and require specialized equipment and skilled personnel**.
- Conversely, simpler, toxic free and more affordable barrier materials—such as **wax crayons, correction pens, and commercial laser-printed hydrophobic layers frequently fail to retain analytes** when exposed to organic solvents or surfactants.
- There is a need for **a barrier material and fabrication method that offers superior chemical retention**, simplicity, toxic free and cost-efficiency while addressing limitations of conventional methods.

Intellectual Property

- IITM IDF Ref 2799
- **IN 202441043226 Patent Application**

TRL (Technology Readiness Level)

TRL 4 Technology validated in Lab

Technology Category/ Market

Category- Micro & Nano Technologies
Industry Classification:
Medical Devices and Diagnostics; Biotechnology and Laboratory Equipment; Environmental Monitoring and Testing
Applications:
Rapid, affordable, and user-friendly fabrication of eco-disposable microfluidic devices for Point-of-Care Diagnostics; Environmental Monitoring; Food Safety and Quality Control; Forensic Science: Clinical and Biomedical Applications

Market report:
The global paper diagnostics industry was valued at USD 14,966 million in 2023 and is projected to grow to USD 22,455 million by 2030 with a CAGR 6%.

Research Lab

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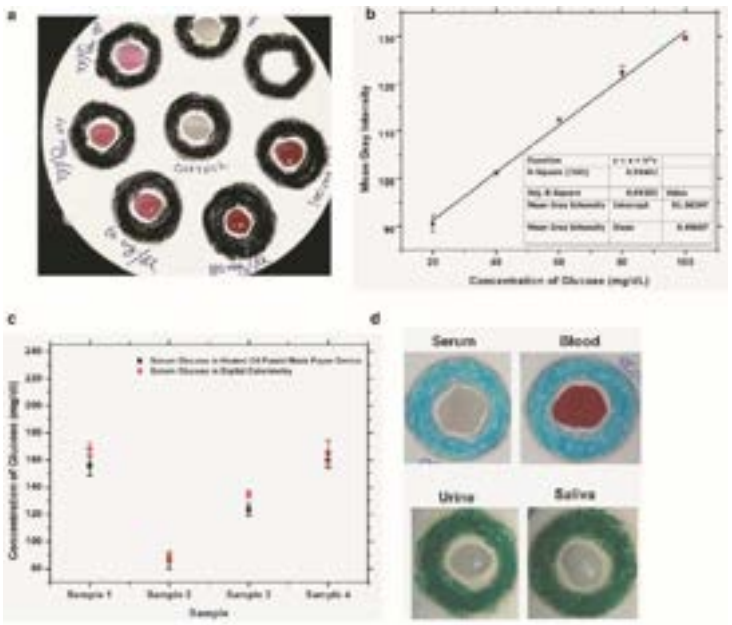

Figure: Glucose assay (the data points are the average value (n=3) ± standard deviation) **(a)** Variation in colour intensity for different concentrations of standard glucose (20, 40, 60, 80 and 100 mg/dL) mixed with glucose reagent mixture in oil pastel made paper device, **(b)** Calorimetric based glucose assay plot (relationship between mean gray intensity and know concentration of standard glucose - 20, 40, 60, 80 and 100 mg/dL) in paper device, **(c)** Comparison of blood glucose measured using two different methods (calorimetric paper device – current method and digital calorimetric method), **(d)** Barrier efficiency testing using body fluids such as serum, blood, urine and saliva**. None of the chemicals/reaction mixtures/body fluids could breach the heated oil pastel made barriers. This demonstrates the applicability of the oil pastel-based fabrication method for the design of paper microfluidic based POC systems.**

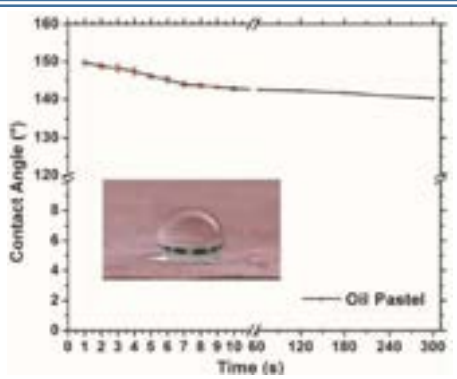

Figure: Water contact angle on heated oil pastel patterned paper surface at different time intervals. The data points are the average value (n=3) ± standard deviation. This portrays the near-superhydrophobic properties of the oil pastel barriers

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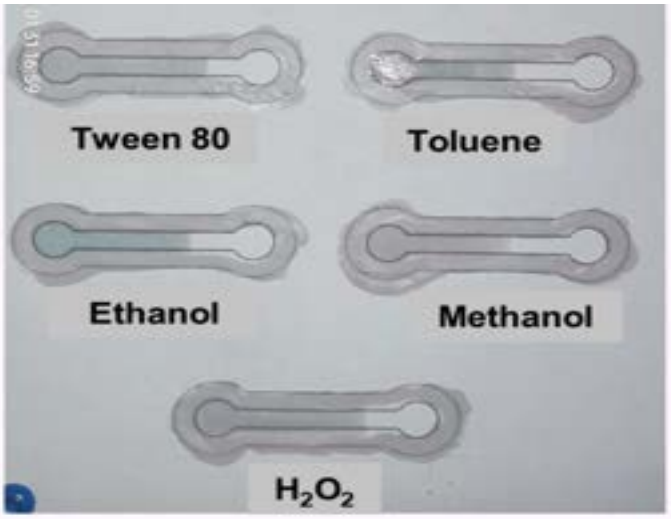

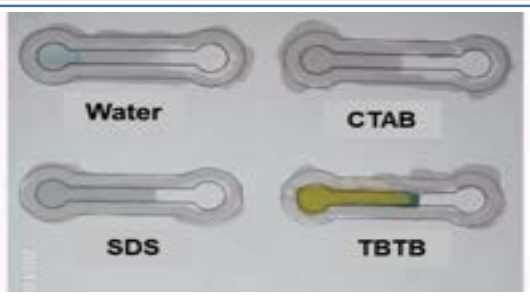

Figure: Chemical retaining ability of oil (12%) + wax mixture made barrier (n=3). Oil and glycerol are the additional ingredients present in the oil pastel. Both oil and glycerol are known for their highly viscous nature. Hence, it can be said that mixing of paraffin wax with highly viscous fluids such as oil and glycerol will significantly increase the barrier efficiency to retain wide range of chemicals. The images give strong evidence that oil-wax mixture is the better agent to create barriers for paper microfluidic device fabrication than using wax alone.

Technology

A rapid, affordable, and eco-friendly method for fabricating paper-based microfluidic devices (P-µFDs) using oil pastel/oil-wax barriers that are thermally resilient, ductile, and hydrophobic—effectively retaining diverse chemicals, including organic solvents and surfactants.

Free-hand drawing of barrier channels on Grade 1 Whatman filter paper using oil pastels, followed by 1 minute of heating on a hot plate (60 °C) or low flame, forming robust and chemical-resistant microchannels.

Heating: 1 min at low flame or **hot plate (60 °C)**; Fabrication Cost: <$0.006 per device; Compatible with a wide range of chemicals, including alcohols, surfactants, organic solvents, and various body fluids.

Hydrophobic with water contact angle of 149° ± 1° (oil pastel) and 113° ± 2° (oil-wax mixture) . Chemical Retention is superior to wax/wax crayon barriers, preventing leakage of ethanol, SDS, and toluene

Suitable for diagnostics (e.g., glucose assay), environmental monitoring, and education - requiring no specialized equipment or skilled labor, making it ideal for resource-limited settings.

Key Features / Value Proposition

- The technology utilizes heated oil pastel/oil-wax mixture as a barrier, offering **thermally resilient, ductile/flexible, and hydrophobic properties** that effectively retain chemicals, including challenging substances like ethanol, SDS, and organic solvents.
- Devices are fabricated using free-hand drawing on filter paper and minimal heating (1 minute), costing <$0.006 per device. This makes it highly affordable and accessible compared to existing techniques.
- Unlike wax or wax crayon barriers, oil pastel/oil-wax mixture barriers withstand chemicals like toluene, surfactants, and alcohols without leakage, providing enhanced versatility for microfluidic applications.
- The materials used are non-toxic, widely available, and environmentally safe, unlike some conventional methods that involve toxic chemicals or specialized equipment.

Figure: Chemical retaining ability of different material sketched channels on Grade 1 Whatman(R) cellulose filter paper with 1 min heating at low flame (n=3). The figure demonstrates the superior chemical retention capability of oil pastel barriers compared to conventional alternatives.

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