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Superhydrophobic plasma separator for point-of-care diagnostics

Blood is a complex, heterogeneous fluid containing red blood cells, white blood cells, platelets and plasma. Blood is a mirror of health and disease since it contains numerous diagnostic biomarkers that are indicators of infectious diseases, cancer, genetic maladies, and metabolic disorders. In clinical diagnosis, doctors need to test the biomarkers lurking in blood plasma. Blood cells and blood proteins can inhibit downstream analysis such as polymerase chain reaction (PCR) reaction that doctors use to detect biomarkers. In a laboratory setting, separating the yellowish plasma from whole blood is usually done with a centrifuge, a relatively expensive instrument requiring electricity that is not suitable for point of care diagnostics in resource-poor regions of the world – where funds, trained personnel and laboratory facilities are in short supply – and in settings lacking electrical power. In fact, the FDA guidelines for out-of-laboratory tests stipulate that no centrifugation should be used.

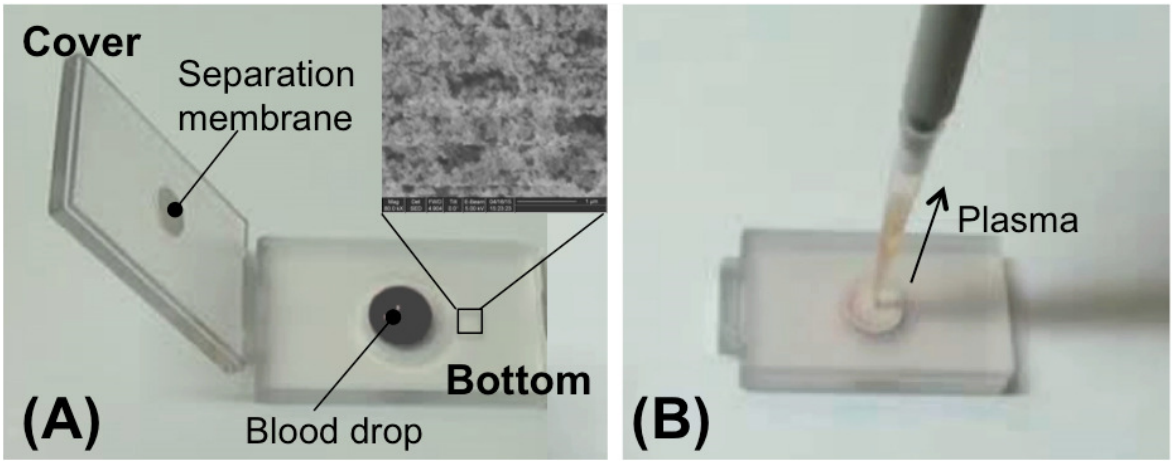

Fig. 1. (A) Blood sample was loaded into the superhydrophobic plasma separator. Inset is the SEM image of the substrate with the spray-on superhydrophobic coating. (B) Plasma was collected through the plasma exit port.

We developed a new high efficiency superhydrophobic plasma separator (Fig. 1) that combines two different separation principles: size exclusion-based filtration and gravitational sedimentation. The combined separation strategy helps to reduce blood clogging often found in existing membrane-based plasma separation devices and greatly improve membrane separation capacity. Especially, inspired by lotus leaves (Fig. 2A), superhydrophobic coating (Inset of Fig. 1A) is used to minimize biomolecular adhesion to device surfaces and facilitate the formation of well-defined blood droplet with high contact angle (Fig. 2B).

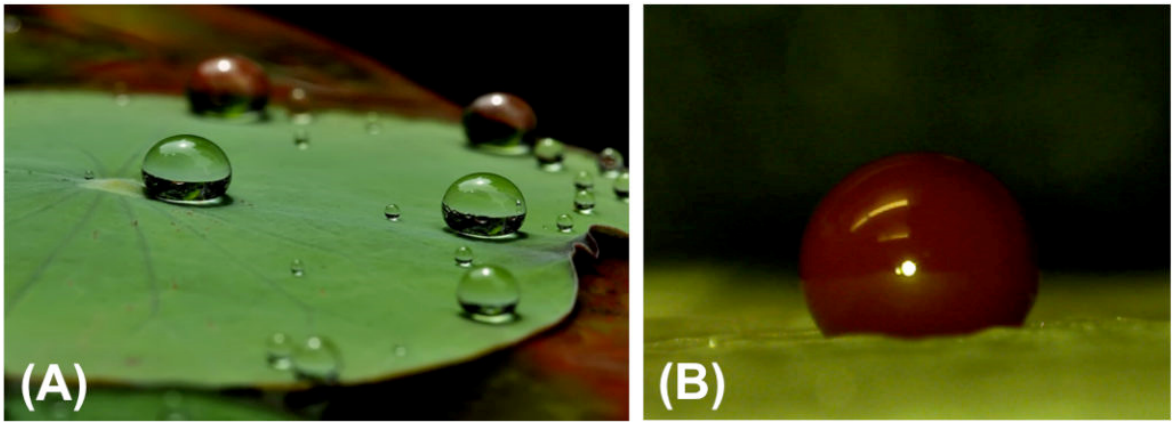

Fig. 2. (A) Water droplets on lotus leaf. (B) Blood droplet on artificial lotus leaf.

In use, finger-prick blood is loaded in a hemispherical well in the bottom substrate (Fig. 1A), and sandwiched between cover and bottom when the separator closes. The separation membrane on the cover is horizontally oriented and the sandwiched whole blood is contained underneath the separation membrane, which reduces clogging as the cells sediment. After allowing 5 minutes for settling, the plasma is drawn up through the membrane (Fig. 1B). The superhydrophobic plasma separator can extract 65 µL of plasma from 200 µL of whole blood. The utility of this plasma separator for molecular diagnostics application is demonstrated by separating plasma from whole blood containing cell-free DNA of *Schistosoma mansoni*, which is the main cause of the neglected tropical disease schistosomiasis. The *S. mansoni* genomic DNA in the separated plasma is successfully tested on our custom-made molecular diagnostic chip.

The superhydrophobic, easy-to-use plasma separator can also be used for other pathogen detection (i.e., HIV viral load) as a stand-alone separation device at home, in the clinic, as well as in resource-constrained settings where funds and trained personnel are in short supply. Moreover, the simplicity of the format, non-instrumented operation and the ability to integrate with existing diagnostic devices will provide for convenient uses in downstream processing and analysis.

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Publication

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