



SIMBAS - SELF POWERED INTEGRATED MICROFLUIDIC BLOOD ANALYSIS SYSTEM

Kaushik Vishnu Rajkumar¹, Dr. Palati Sinduja^{2*}, Dr. Priyadharsini³

Article History: Received: 12.12.2022

Revised: 29.01.2023

Accepted: 15.03.2023

Abstract

Blood tests provide important diagnostic information regarding many diseases. A main and important factor that interferes with the precision and accuracy of blood tests is the presence of red blood cells; however, the traditional methods of blood separation are often complicated and time-consuming. During this study, an easy but high-efficiency blood separation system on a self-strained microfluidic device that separates 99.7% - 99.9% of the plasma during a jiffy. Principles like rate of blood flow, structure of the filter trench, and therefore the relative positions of the filter trench and channel, were optimized with the assistance of microscope monitoring. Moreover, this device which is driven by an air difference uses an economical and straightforward to use heater device that makes a low-pressure environment within the microchannel within minutes. With the aforementioned advantages, this blood separation device might be another platform choice for testing and identification of the many pathologies in a person. The aim of this study is to review a novel technique SIMBAS and its methodology.

Keywords: SIMBAS, device, low pressure, plasma separation, RBC and WBC filter, innovative technique.

¹Department of Pathology, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technological Science [SIMATS], Saveetha University, Chennai, India.

^{2*}Assistant Professor, Department of Pathology, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technological Science [SIMATS], Saveetha University, Chennai, India.

³Assistant Professor, Department of Pathology, Saveetha Dental College and Hospitals, Saveetha Institute of Medical and Technological Science [SIMATS], Saveetha University, Chennai, India.

DOI: 10.31838/ecb/2023.12.s2.153

1. Introduction

Self-powered integrated microfluidic blood analysis system [SIMBAS]. It is a self-powered integrated microfluidic blood analysis system [SIMBAS] that does not require any external connections, tethers, or tubing to deliver and analyze a raw whole blood sample. SIMBAS just requires the client to put a 5 μL drop of entire blood at the gulf port of the gadget, whereupon the independent SIMBAS performs on-chip expulsion of red and white cells, without outer valving or siphoning instruments, trailed by dissecting discovery in platelet containing plasma. (1)Five complete biotin-streptavidin tests to answer measures are acted in 10 min; the restriction of identification is 1.5 pM. Red and white platelets are taken out by catching them in a necessary channel structure. Reenactments and test information show 99.7% to 99.9% platelet maintenance in the latent design. Controlled by pre-clearing of its PDMS substrate, SIMBAS's directing plan guideline is the reconciliation of the negligible number of parts without forfeiting viability in performing quick complete bioassays, a basic advance towards the point of care atomic diagnostics. (2)

Indications

Analyze detection was demonstrated using an avidin-biotin assay. An example of 15 μm bars of avidin was immobilized in the detecting territory of the chip. Entire blood tests were spiked with various centralization of fluorescently named biotin. The consequences of the tubeless SIMBAS [self-powered integrated microfluidic blood analysis system] show that the picomolar location of investigations in the entire blood can be promptly accomplished. Fluorescent readout of the gadget was performed by embedding its top glass cover into a standard microarray scanner.(3) One benefit of our gadget is that it doesn't need irreversible bonding between the PDMS and glass

Procedure and Principles

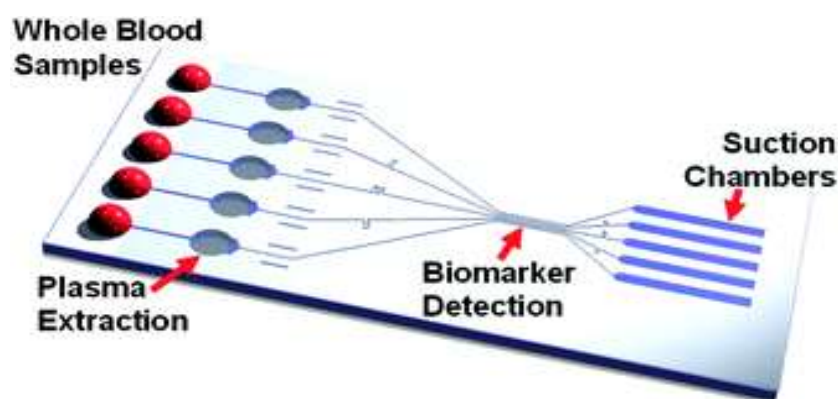


Figure 1: Working of the device [SIMBAS]

layers, so it very well may be handily dismantled, and the glass layers with the caught investigations utilized for other examination like PCR or MS. Also, for multi dissect location, each avidin bar could be supplanted with an alternate test, permitting the discovery of a few thousand analytes in each blood test. (4)

Advantages

SIMBAS [Self-powered integrated microfluidic blood analysis system] just requires the client to put a 5 μL drop of entire blood at the channel port of the gadget. Reenactments and trial information show 99.9% to 100% platelet maintenance in the detached design.(4) Fueled by the pre-clearance of its PDMS substrate, SIMBAS's controlling plan rule is the reconciliation of the negligible number of parts without forfeiting adequacy in performing quick complete bioassays, a basic advance towards the point of care sub-atomic diagnostics. (5–7)Five complete biotin-streptavidin tests to answer examinations are acted in 10 min; the constraint of discovery is 1.5 pM. One of the benefits of our gadget is that it doesn't need irreversible bonding between the PDMS and glass layers, so it tends to be handily dismantled, and the glass layers with the captured analytes utilized for other examination like PCR or MS (8) and with minimal manual operation, the portable chip performs digital quantitative nucleic acid detection directly from the whole blood samples of humans in approximately 30mins or less with the help of isothermal recombinase polymerase amplification.

Disadvantages

The SIMBAS [Self-powered integrated microfluidic blood analysis system] is a device that is used to analyze blood for information of the working of the body at the molecular level. The device does not have any major disadvantages, except that the knowledge and awareness of this system are not widespread.

The device was manufactured by keeping a 2 mm thick PDMS layer between two glass magnifying instrument slides. The 2 mm thick PDMS layer contains the microfluidic channels and the separating channels. The microfluidic channels face the top slide. The base slide fills in as a help layer just as a base seal to the channel. (9,10) To forestall platelets from streaming past the channel, the top slide was physically covered with a hydrophobic pen just on the area that covers the channel channels. Protein designing Preceding gathering the gadget, the bio acknowledgment site on the top glass slide was designed by miniature contact printing to make 15 mm wide lines of avidin. The kept lines were opposite to the stream course. Designed substrates were utilized regularly upon the arrival of the arrangement. (11)

Blood assortment and test readiness:

Entire blood tests were gathered from finger pricks utilizing a hairlike blood assortment framework as indicated by the maker's guidelines. Blood tests were utilized on the miniature gadget inside 20 min of drawing from patients. (12). Microfluidic innovation is viewed as a promising way to deal with taking care of the previously mentioned issues. It scales down and coordinates the greater part of the lab advances into a solitary little chip and investigates limited quantities of tests in a brief length. Also, its straightforward activity decreases the complex multistep test pretreatment methods and investigation into a solitary advance; consequently, a microfluidic framework can be utilized by people without proficient preparation. (13)Microfluidic innovation is consequently urgent for accomplishing point-of-care testing [POCT].

The upsides of warm closeout framework are, for example, straightforward device design and instrument, little framework size, which shows its potential in creating with compact gear(14). Also, subsequently, the created chip empowers to perform analytic tests at or close to a patient and at the site where care or treatment is given. Therefore, an expanding number of blood testing gadgets are presently founded on microfluidic innovation. The microfluidic chip is exceptionally appropriate for accomplishing POCT on the grounds that it incorporates numerous monotonous research facility procedures into a small chip. (15)In any case, a legitimate power system has been the significant test to genuine application. As of late, a few examination bunches have received the standard of the differential pressing factor for working microfluidic gadgets without outer siphons; be that as it may, movability and commercialization have not been accomplished as a result of the troubles associated with establishing and keeping up low-pressure conditions. (16)

The utilization of the temperature of the air to influence air thickness is a basic however compelling strategy for establishing and keeping up low-pressure conditions.[figure-1](17) We applied the radiator gadget with the miniature channel to accomplish a similar impact as a vacuum generator. (9)Also, the force wellspring of the warmer gadget was a couple of dry cells, which are cheap, convenient, and reusable (18,19). The SIMBAS [self-powered integrated microfluidic blood analysis system] gadget is initiated by keeping it in a low pressing factor condition for at any rate 15 min. The low pressing factor condition can be accomplished either by putting the gadget in a standard vacuum desiccator at 200 Torr. To play out a measure, the client essentially eliminates the gadget from the low pressing factor climate and afterward stacks the entire blood test onto the channels of the gadget. (18)No further advances are needed by the client. In the current execution, test stacking must be done within 2 min of eliminating the SIMBAS from the low pressing factor climate. (12,20)

Roughly 5 mL of entire blood gathered straightforwardly from a finger prick is adequate for a total measure. The measure is done when the blood plasma fills the attraction chamber and arrives at the end channel. For these underlying lab exhibitions, the readout is cultivated by withdrawing the PDMS slab from the upper glass slide to allow its readout in a fluorescent scanner. Fluorescent powers of the pictures were dissected utilizing ImageJ programming

The limitation of this device is that 1.5 pM, as the device can't perform functions when the limit exceeds that value. Our team has extensive knowledge and research experience that has translate into high quality publications (21–30))

In the future, this device can be used to deduct more pathologies on the human body using a minimal amount of blood and almost instantaneously.

2. Conclusion

In summary, we have demonstrated a self-priming tubeless SIMBAS [Self-powered integrated microfluidic blood analysis system] that efficiently extracts blood plasma from less than 5 μ L of whole blood and performs multiplexed sample to answer assay with picomolar sensitivity without any external pumping mechanisms. Our integrated device is well suited for point-of-care applications because of its self-powering mechanism, disability, and simplicity of use. In this review, we have seen the indications, advantages, disadvantages, its procedure, and

principles of SIMATS [self-powered integrated microfluidic blood analysis system]

Acknowledgement

The authors are thankful to Saveetha Institute of Medical and Technical Sciences, Saveetha Dental College and Hospitals, Saveetha University for giving a platform to conduct the study.

Conflict of interest

The authors would like to declare no conflict of interest in the present study.

Funding

The present project is supported by:

- SARKAV health services.
- Saveetha Dental College and Hospitals,
- Saveetha Institute of Medical and Technical Sciences,
- Saveetha University.

3. Reference

- Branstetter J, von Fraunhofer JA. The physical properties and sealing action of endodontic sealer cements: a review of the literature [Internet]. Vol. 8, Journal of Endodontics. 1982. p. 312–6. Available from: [http://dx.doi.org/10.1016/s0099-2399\(82\)80280-x](http://dx.doi.org/10.1016/s0099-2399(82)80280-x)
- Trope M. BDS Private Practice in Endodontics Philadelphia, PA USA. Endodontic Topics. 2006;14(1):131–131.
- Zhou HM, Shen Y, Zheng W, Li L, Zheng YF, Haapasalo M. Physical Properties of 5 Root Canal Sealers [Internet]. Vol. 39, Journal of Endodontics. 2013. p. 1281–6. Available from: <http://dx.doi.org/10.1016/j.joen.2013.06.012>
- Garrido ADB, Lia RCC, França SC, da Silva JF, Astolfi-Filho S, Sousa-Neto MD. Laboratory evaluation of the physicochemical properties of a new root canal sealer based onCopaifera multijugaoil-resin [Internet]. Vol. 43, International Endodontic Journal. 2010. p. 283–91. Available from: <http://dx.doi.org/10.1111/j.1365-2591.2009.01678.x>
- Duarte MAH, Ordinola-Zapata R, Bernardes RA, Bramante CM, Bernardineli N, Garcia RB, et al. Influence of Calcium Hydroxide Association on the Physical Properties of AH Plus [Internet]. Vol. 36, Journal of Endodontics. 2010. p. 1048–51. Available from: <http://dx.doi.org/10.1016/j.joen.2010.02.007>
- Brundha MP, Pathmashri VP, Sundari S. Quantitative Changes of Red Blood cells in Cancer Patients under Palliative Radiotherapy- A Retrospective Study. Research Journal of Pharmacy and Technology. 2019;12(2):687–92.
- Timothy CN, Samyuktha PS, Brundha MP. Dental pulp Stem Cells in Regenerative Medicine--A Literature Review. Research Journal of Pharmacy and Technology. 2019;12(8):4052–6.
- Zhang H, Shen Y, Dorin Ruse N, Haapasalo M. Antibacterial Activity of Endodontic Sealers by Modified Direct Contact Test Against Enterococcus faecalis [Internet]. Vol. 35, Journal of Endodontics. 2009. p. 1051–5. Available from: <http://dx.doi.org/10.1016/j.joen.2009.04.022>
- Silva EJNL, Emmanuel J N, Rosa TP, Herrera DR, Jacinto RC, Brenda P F, et al. Evaluation of Cytotoxicity and Physicochemical Properties of Calcium Silicate-based Endodontic Sealer MTA Fillapex [Internet]. Vol. 39, Journal of Endodontics. 2013. p. 274–7. Available from: <http://dx.doi.org/10.1016/j.joen.2012.06.030>
- Harsha L, Brundha MP. Prevalence of Dental Developmental Anomalies among Men and Women and its Psychological Effect in a Given Population. Journal of Pharmaceutical Sciences and Research; Cuddalore. 2017 Jun 20;9(6):869–73.
- Candeiro GT de M, de Miranda Candeiro GT, Correia FC, Duarte MAH, Ribeiro-Siqueira DC, Gavini G. Evaluation of Radiopacity, pH, Release of Calcium Ions, and Flow of a Bioceramic Root Canal Sealer [Internet]. Vol. 38, Journal of Endodontics. 2012. p. 842–5. Available from: <http://dx.doi.org/10.1016/j.joen.2012.02.029>
- (Akdeniz) BGB, Güniz Baksı (Akdeniz) B, Eyüboğlu TF, Şen BH, Erdilek N. The effect of three different sealers on the radiopacity of root fillings in simulated canals [Internet]. Vol. 103, Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2007. p. 138–41. Available from: <http://dx.doi.org/10.1016/j.tripleo.2005.11.032>
- American National Standards Institute / American Dental Association Specification No. 14* for Dental Base Metal Casting Alloys / Revised American National Standards Institute / American Dental Association Specification No. 14* for Dental Base Metal Casting Alloys*ANSI/ADA specification no. 14, 1982. Approved April 15, 1982 [Internet]. Vol. 105, The Journal of the American Dental Association. 1982. p. 686–7. Available from: <http://dx.doi.org/10.14219/jada.archive.1982.0428>
- Okabe T, Sakamoto M, Takeuchi H, Matsushima K. Effects of pH on Mineralization Ability of Human Dental Pulp Cells [Internet]. Vol. 32, Journal of Endodontics. 2006. p. 198–201.

- Available from:
<http://dx.doi.org/10.1016/j.joen.2005.10.041>
- Preethikaa S, Brundha MP. Awareness of diabetes mellitus among general population. *Research Journal of Pharmacy and Technology*. 2018;11(5):1825–9.
- Resende LM, Rached-Junior FJA, Versiani MA, Souza-Gabriel AE, Miranda CES, Silva-Sousa YTC, et al. A comparative study of physicochemical properties of AH Plus, Epiphany, and Epiphany SE root canal sealers. *Int Endod J*. 2009 Sep;42(9):785–93.
- Stuart C, Schwartz S, Beeson T, Owatz C. *Enterococcus faecalis: Its Role in Root Canal Treatment Failure and Current Concepts in Retreatment* [Internet]. Vol. 32, *Journal of Endodontics*. 2006. p. 93–8. Available from: <http://dx.doi.org/10.1016/j.joen.2005.10.049>
- Stock CJ. Calcium hydroxide: root resorption and perio-endo lesions [Internet]. Vol. 158, *British Dental Journal*. 1985. p. 325–34. Available from: <http://dx.doi.org/10.1038/sj.bdj.4805601>
- Desai S, Chandler N. Calcium Hydroxide-Based Root Canal Sealers: A Review [Internet]. Vol. 35, *Journal of Endodontics*. 2009. p. 475–80. Available from: <http://dx.doi.org/10.1016/j.joen.2008.11.026>
- Mchugh C, Zhang P, Michalek S, Eleazer P. pH Required to Kill *Enterococcus faecalis* in Vitro [Internet]. Vol. 30, *Journal of Endodontics*. 2004. p. 218–9. Available from: <http://dx.doi.org/10.1097/00004770-200404000-00008>
- Ramesh A, Varghese S, Jayakumar ND, Malaiappan S. Comparative estimation of sulfiredoxin levels between chronic periodontitis and healthy patients - A case-control study. *J Periodontol*. 2018 Oct;89(10):1241–8.
- Vijayashree Priyadharsini J. In silico validation of the non-antibiotic drugs acetaminophen and ibuprofen as antibacterial agents against red complex pathogens. *J Periodontol*. 2019 Dec;90(12):1441–8.
- Priyadharsini JV, Vijayashree Priyadharsini J, Smiline Girija AS, Paramasivam A. In silico analysis of virulence genes in an emerging dental pathogen *A. baumannii* and related species [Internet]. Vol. 94, *Archives of Oral Biology*. 2018. p. 93–8. Available from: <http://dx.doi.org/10.1016/j.archoralbio.2018.07.001>
- Teja KV, Ramesh S, Priya V. Regulation of matrix metalloproteinase-3 gene expression in inflammation: A molecular study. *J Conserv Dent*. 2018 Nov-Dec;21(6):592–6.
- Manohar MP, Sharma S. A survey of the knowledge, attitude, and awareness about the principal choice of intracanal medicaments among the general dental practitioners and nonendodontic specialists. *Indian J Dent Res*. 2018 Nov-Dec;29(6):716–20.
- Nandakumar M, Nasim I. Comparative evaluation of grape seed and cranberry extracts in preventing enamel erosion: An optical emission spectrometric analysis. *J Conserv Dent*. 2018 Sep-Oct;21(5):516–20.
- Varghese SS, Ramesh A, Veeraiyan DN. Blended Module-Based Teaching in Biostatistics and Research Methodology: A Retrospective Study with Postgraduate Dental Students. *J Dent Educ*. 2019 Apr;83(4):445–50.
- Panchal V, Jeevanandan G, Subramanian E. Comparison of instrumentation time and obturation quality between hand K-file, H-files, and rotary Kedo-S in root canal treatment of primary teeth: A randomized controlled trial. *J Indian Soc Pedod Prev Dent*. 2019 Jan-Mar;37(1):75–9.
- Nair M, Jeevanandan G, Vignesh R. Comparative evaluation of post-operative pain after pulpectomy with k-files, kedo-s files and mtwo files in deciduous molars-a randomized clinical trial. *Braz Dent J* [Internet]. 2018; Available from: <https://bds.ict.unesp.br/index.php/cob/article/view/1617>
- Deena, S. R., Kumar, G., Vickram, A. S., Singhaniam, R. R., Dong, C. D., Rohini, K., ... & Ponnusamy, V. K. (2022). Efficiency of various biofilm carriers and microbial interactions with substrate in moving bed-biofilm reactor for wastewater treatment: A review. *Bioresource Technology*, 127421.
- Felicita AS. Orthodontic extrusion of Ellis Class VIII fracture of maxillary lateral incisor - The sling shot method. *Saudi Dent J*. 2018 Jul;30(3):265–9.