PORTABLE OPTICAL DEVICE FOR MICROFLUIDIC HEMATOCRIT LEVEL MONITORING

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ABSTRACT

A new and improved optical measuring method for hematocrit level monitoring devices with a lab chip with a very limited channel height (∼100 μm) height and a very small volume (~10 μL) is designed by merging the LEDs to one body packaged light sources and the scattering-compensating parts. The preliminary optical module composition and analysis was reported in Lab Chip [1]. Our method differs from that of group Sobaszek [2] in the specific method of optical module compositions, basic design, microfabrication methods, and the one-body structure we are using. Finally, we have compared with a clinical laboratory instrument and confirmed that it has worked well with a coefficient of determination (R²) of 0.981 and done the analysis within thirty seconds.

KEYWORDS: Hematocrit, Portable, Optical device, Oxy-hemoglobin, Smartphone-communicable

INTRODUCTION

A portable optical device with a disposable sensor seems to be the most promising approach for the platform that meets the demands for remote settings [3]. Hematocrit (HCT) is a basic blood test for medical diagnostics and used for screening for anemia [2,4]. Conventionally, HCT is measured from automated laboratory hematology analyzers. For analysis of biological samples in the labchip with a very-limited height, it is necessary to consider the sedimentation speed and the spatial uniformity of blood cells in the chip for precise and accurate measurement. Here, we have designed and fabricated a very simple and microfabricated one-body optical module, targeting for one spot measurement with two chromatic light-emitting diodes, a silicon photodiode, and a scattering-reducing design, and a wireless near field communication unit, which can be communicated with a smart-phone.

EXPERIMENTAL

The block diagram of the wireless hematocrit system with the optical module is shown in Fig. 1. We have investigated the optical enhancement through performance comparisons in case of the separated LEDs light sources and one-body merged LEDs. In order to merge two LEDs (wavelengths; 530 nm and 880 nm), a chemical mechanical polishing processing of two LEDs and their bonding with a UV epoxy are employed. The photographs of the fabricated portable wireless hematocrit meter are shown in Fig. 2. It shows the system profile and the case of loading the PMMA plastic biochip with a 10 μL whole blood sample. We also investigated the effects of light scattering on the performance by comparing the intensity of the optical signals between the transmission beam and the scattering beam at two wavelengths, respectively through the biochip (Figure 3). The scattering intensity is only under 1.7 % of the transmission value. It looks like that the scattering light intensity is negligible comparing to the transmission light intensity in the device.
RESULTS AND DISCUSSION

Figure 4 shows the measured and normalized transmission intensity ratio at two wavelengths versus the real hematocrit level. There is a very linear relation between the values and a calibration curve of the device is prepared by comparing results obtained from a standard clinical laboratory test instrument (ADVIA 1650, Siemens). The designed optical module showed a good precision and reproducibility with a coefficient of determination ($R^2$) of 0.981 and good improvement of sensitivity comparing with the spatially separated light sources, rapid results analysis within thirty seconds. Finally, we have implemented a NFC module in the device for communicating with a smart android tablet and showed the device worked wirelessly (Figure 5). And using the portable device, the low cost, simple, mass-producible, precise blood analysis makes it possible to be for the point of care testing applications.
Figure 3: Intensity of the optical signals between the transmission beam and the scattering beam at 880 nm and 530 nm wavelengths, respectively through the biochip with a 10 µL-volume whole blood sample (a) and the intensity variation as a function of measuring time (b).

Figure 4. The normalized transmission intensity ratio at two measuring devices versus the real hematocrit level (a) and calibration of the microsystem comparing results obtained from the developed devices with a reference measurement carried out by standard clinical laboratory test instrument (ADVIA 1650, Siemens) (b).

Figure 5: Wireless communication demonstration of the HCT device with a NFC module for wireless communicating with a smart android tablet.
CONCLUSION
We have designed, fabricated and characterized a new and improved optical measuring method for hematocrit level monitoring devices with a lab chip with a very limited channel height ($\leq 100 \mu m$) height and a very small volume (~10 $\mu L$), which is designed by combining the LEDs to one body packaged light sources and the scattering-compensating parts. We have compared the device with a clinical laboratory instrument and confirmed that it has worked well with a coefficient of determination ($R^2$) of 0.981 and done the analysis within thirty seconds. Finally, we have implemented a NFC module in the device for communicating with a smart android tablet and showed the device worked wirelessly. And the portable oxy-hematocrit device, with the merits of the low cost, simple, mass-producible, precise blood analysis, makes it possible to be a point of care testing instruments for resource-limited country applications.

ACKNOWLEDGEMENTS
This work supported by Research and Development program (K13282, Development of Diagnostic Equipment for Blood Stasis) supported by Ministry of Science, ICT and Future Planning (MSIP), Republic of Korea.

REFERENCES

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