



Lab-on-Blu-ray

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LAB-ON-BLU-RAY: LOW-COST ANALYTE DETECTION ON A DISK

Marco Donolato¹, Paula Antunes¹, Robert Burger¹, Filippo Bosco¹, Mattias Olsson¹, Jaeyoung Yang², Ching-Hsiu Chen³, Qiao Lin², En Te Hwu³, Anja Boisen¹, Mikkel F.Hansen¹

¹DTU Nanotech, Building 345 East, DK-2800 Kongens Lyngby, Denmark

²Department of Mechanical Engineering, Columbia University, New York, NY 10027, United States

³Academia Sinica, Taipei, Taiwan

In this work, we present for the first time a centrifugal microfluidic system for the detection of analytes in blood using a low cost (< 10\$) blu-ray pickup head for detection. The microfluidic operations are carried out on a disk, while the detection method is based on optical measurements of the rotation dynamics of functionalized magnetic nanobeads (MNBs) in an oscillating uniaxial magnetic field. The system has been demonstrated both for antibody based protein detection, aptamer based ATP detection and amplified oligonucleotide detection^[1].

The readout method is based on the light modulation due to the formation and disruption of chains of MNBs^[2]. As in traditional latex particle-based immuno-agglutination assays, the MNBs form clusters if the target is present in the sample. Since the beads are magnetic the agglutination process can be accelerated and the optically detected MNB response to an external AC field is used instead of traditional turbidimetric variation. This provides higher sensitivity, as the detection of few MNB-clusters is not interfered by background signals from single MNBs.

Figure 1 shows the set-up configuration, where a Sony blu-Ray pickup head (the same as in Playstation 3) is used as a laser source ($\lambda=405\text{nm}$) and as a reader, as the light beam is reflected back through a mirror. Two electromagnets are used to produce the AC modulated field and a data acquisition card is used to analyze the signal. The process of blood separation on-disk is shown in Fig. 2(a). The plasma is mixed with MNBs in the detection chamber and the optomagnetic signal is measured after a magnetic incubation step. Fig. 2(b) and 2(c) present two different readout approaches. In the first case, antibody coated MNBs agglutinate due to the presence of an antigen and the amount of clusters is then quantified and related to the target protein concentration. In the second case, a reverse approach is used to detect small molecules as adenosine-5'-triphosphate (ATP). Aptamer-functionalized MNBs and MNBs with linker strands (linker-MNPs) are mixed; the linker hybridizes with a region of the aptamer sequences in the absence of ATP, forming MNP-clusters. Conversely, when aptamers are preoccupied by ATP inhibiting the hybridization, the cluster formation is hindered.

Fig. 3(a) shows the results of the first approach for the detection of a biotinylated IgG antibody spiked in blood. In the spectra, when increasing the target concentration, a second peak appears at low frequencies. This indicates the formation of a sub-population of clustered MNBs having a different ("slower") dynamics than free MNBs. The contrary happens for the ATP detection case (Fig. 3(c)), where peaks indicating different cluster size dynamics disappear in presence of ATP. Corresponding dose-response curve are shown in Figs. 3(b) and 3(d). Detection of inflammatory biomarkers (C-reactive protein and suPAR) comparing the different approaches, the use of different wavelengths (blu Ray and DVD) and also other readout methods^[3] will be discussed. This work paves the way to an innovative low-cost platform for multiple analyte detection, combining the advantage and simplicity of centrifugal microfluidics, MNB-based biosensing and commercial electronic components.

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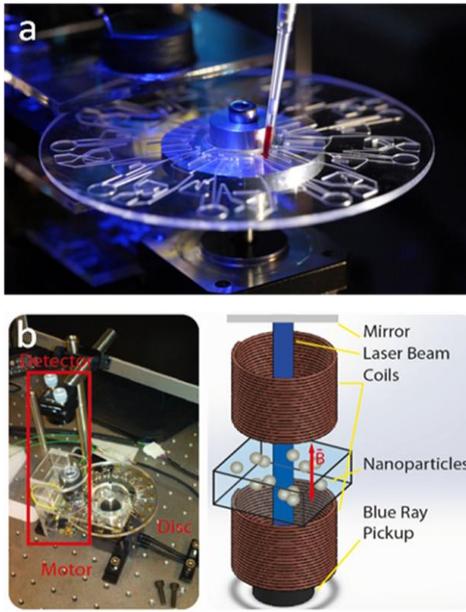


Figure 1: (a) Disk for blood separation with 9 sensing chambers. (b) Overall platform comprising a motor, a Sony Blu Ray pickup head, coils for magnetic field excitation and a mirror used to reflect the light back to the photodetector. Customized electronics is used to extract the signal from the Blu-ray photodetector

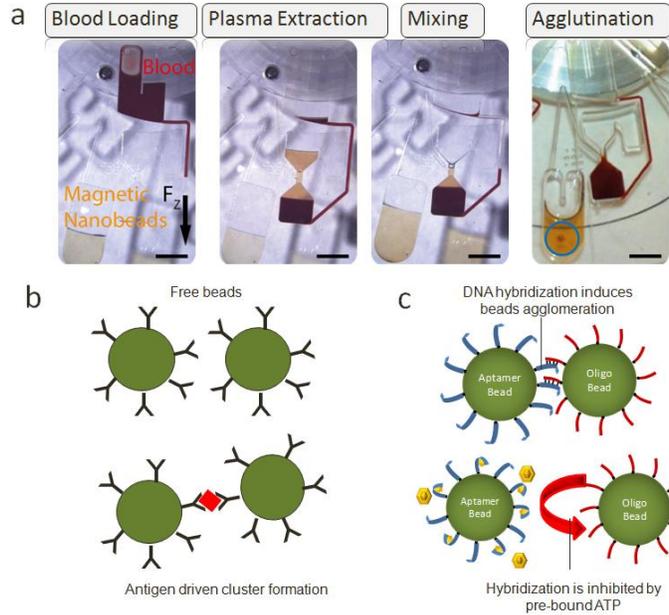


Figure 2: (a) Process steps of blood separation and protein detection on disc. Scale bars are 5mm. (b) Schematic of analyte driven cluster formation approach for antigen detection and (c) cluster inhibition approach for small molecules detection (ATP).

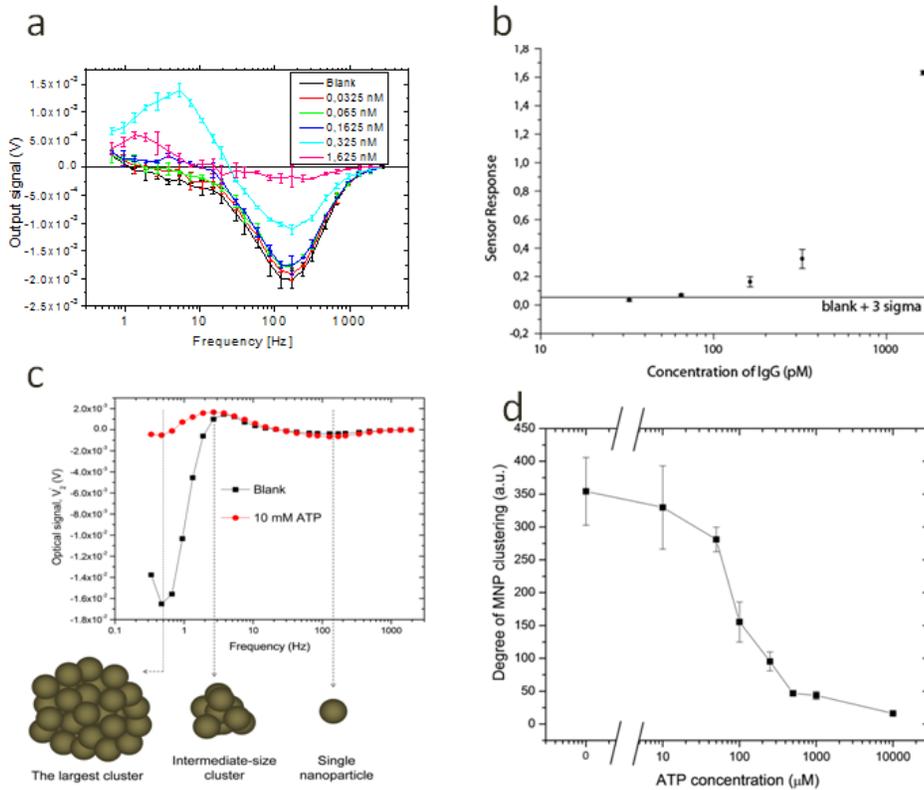


Figure 3: (a) Detection of IgG antibody in plasma using the approach in Fig. 2(b) and corresponding calculated dose-response curve. (c) Difference in the signal in the presence of 10 mM of ATP using the cluster inhibition approach shown in Fig 2(c). ATP detection in the range 10-10000 μM.