SUPPORTING INFORMATION

Liquid Crystal Based Sensing Device using a Smartphone

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1. Experimental Details

1.1 Materials

N,N-Dimethyl-N-octadecyl-3-aminopropyltrimethoxysilyl chloride (DMOAP), Sulfuric acid and hydrogen peroxide (30% w/v) were purchased from Merck. Ethanol was obtained from Jebsen & Jenssen GmbH and Co., Germany. The 5CB, Lipopolysaccharide (LPS), human hemoglobin (Hb), bovine serum albumin (BSA) and Tris buffered saline (pH 7.4) were obtained from Sigma Aldrich. Sodium dodecyl sulfate (SDS) and Fischer's Finest Premium Grade glass slides were obtained from Fischer Scientific. Deionization of a distilled water source was performed using a Milli-Q-system (Millipore, bedford, MA). Gold specimen grids (20 μm thickness, 50 μm wide bars, 283 μm grid spacing) were obtained from Electron Microscopy Sciences (Fort Washington, PA).

1.2 Preparation of DMOAP coated of glass substrates

First, glass microscope slides were cleaned according to published procedures using 'piranha' solution [70:30 (% v/v) H_2SO_4: H_2O_2(30%)].[1] Briefly, the glass slides were immersed in a piranha bath at 100°C for 1 h and then rinsed in running deionized (DI) water for 10 min. Then the slides were rinsed thrice sequentially in ethanol and dried under a stream of nitrogen. The cleaned slides were stored in an oven at 100 °C for overnight. The cleaned glass slides were dipped into 0.1% (v/v) DMOAP solution in DI water for 5 min at room temperature and were then rinsed with DI water to remove unreacted DMOAP from the surface. The DMOAP coated glass slides were dried under a stream of nitrogen gas and kept in oven at 100ºC for 4 h to allow crosslinking of DMOAP.

1.3 Preparation of optical cells

The DMOAP coated glass slides were cut into squares (1cm x 1cm) for sensing experiment. Then, a gold grid was placed on the slide, and approximately 0.3 µL of 5CB was dispensed onto the grid. Excess amount of LC on the grid was removed by using a capillary tube. Then LC filled TEM grid on DMOAP coated slide are immersed into 150 µL aqueous solution of interest.

1.4 Formation of the Self-Assembled Monolayers of LPS

LCs laden with LPS monolayers were prepared by previously published procedures.[2] Briefly, powdered LPS (endotoxin) was dissolved in water at room temperature to obtain the required concentration. The resulting solutions were then sonicated for 10 min and vortexed for 10 min at room temperature. The LPS monolayer was formed by contacting 5CB filled grid to the solution of LPS for a period of 2 h. The LPS monolayer was washed twice with Tris buffer (pH 7.4) prior to use.

1.5 Optical characterization with conventional microscope

The orientational ordering of the LC was determined using a conventional Zeiss polarising microscope Scope.A1 with crossed polars with 5X objective. All images were captured with an exposure time of 80 ms at pixel dimension of 2056 x 2056 and a shutter speed of 1/10 s. For investigation of 3D intensity and scale of the images were processed using Image J free access software (developed by U. S. National Institutes of Health, Bethesda, MD). Textures were quantified by interpreting them through gray scale of intensities and their luminosities were analyzed using image processing software Adobe Photoshop.

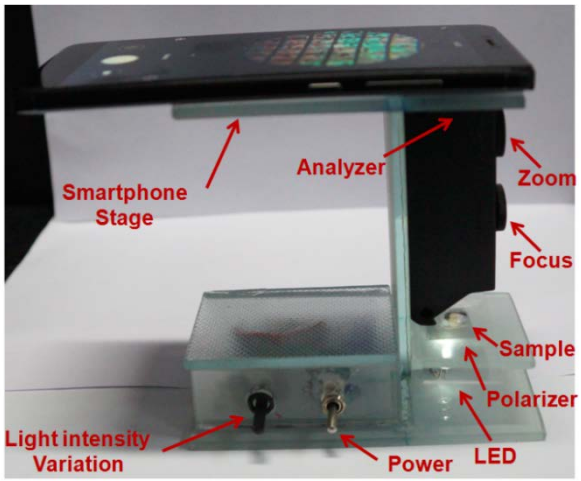

Fig. S1. Photograph of the smartphone based sensing device made by glass.

2. Resolution of the fabricated device

We have measured the spatial resolution of the fabricated smartphone based sensing device by taking image of Hemocytometer in reflecting mode. Hemocytometer has been frequently used to count cell density by knowing volume of the squares.[3] Hemocytometer contains a grid pattern in which the smallest square was 50µm x 50µm. The resolution and FOV are calculated according to previously published procedure.[4,5] We have plotted the intensity of a line as a function of position which is shown in Fig. S2. The constructed line was drawn vertically from the black background across the white bar edges (Fig. S2). Using the plot values command, the line x (position) and y (intensity) values were generated. These values were plotted in Origins from analyzing the shape of the output profile at the edge between the dark and light boundary. The plotted curve of the boundary was fitted with a sigmoid function using a Boltzmann function relationship. Using the generated sigmoid fit function, a new plot resulted consisting of the derivative of the sigmoid function. From the derivative curve plot, a non-linear fit function with a Gaussian fit was used to generate the derivative curve. From this fit, a FWHM of the spatial resolution was generated (Fig. S3).

One disadvantage of smartphone based optical microscopy is that the optical image often suffers from radial distortion and aberration effects, introduced by the optical lenses as shown in Fig. S4 in edge side of the grids. However we have got clear image of 16 square of grid after excluding radial distortion effect on the image having effective field of view as 1.24 mm x 1.24 mm, which is comparable similar to image taken by POM.

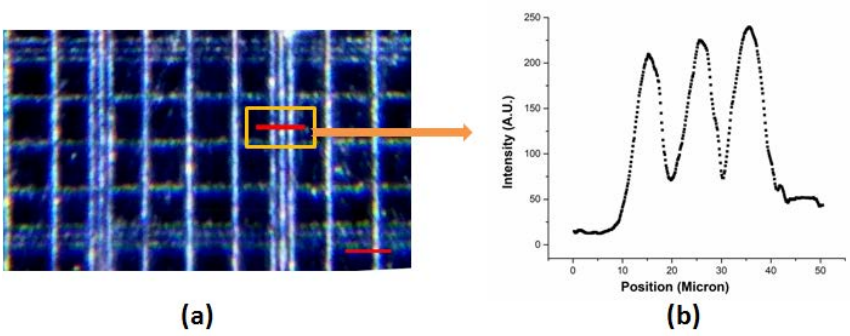

Fig. S2. (a) Photos of a hemocytometer under the fabricated smartphone based sensing device microscope. Red line is a scanning line. Scale bar~ 50 µm. (b) Intensity profile as a function of position along the scanning line.

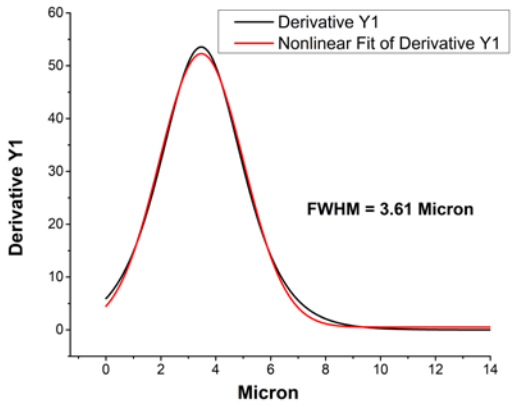

Fig. S3. The calculated derivative for a line spread across black and bright intensity.

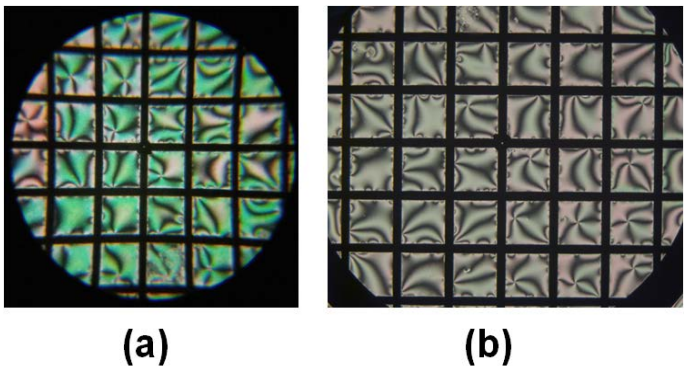

Fig. S4. The image with full FOV of 5CB in TEM grid at LC/water interface taken by using (a) smartphone based fabricated device and (b) Zeiss POM (282 µm square grid size; 20 µm depth).

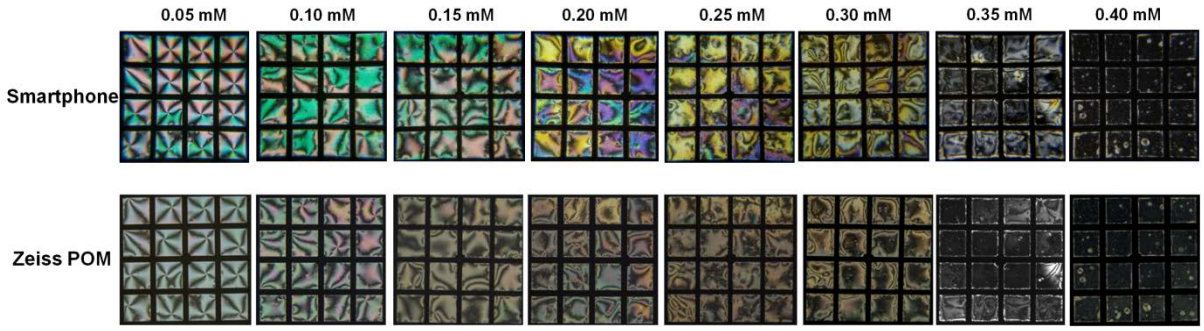

Fig. S5. The image of 5CB in grid are taken by using smartphone based sensing device and Zeiss POM at different concentration of SDS aqueous solution. All textures are taken after 5 min of stabilization of LC/aqueous interface (282 µm square grid size; 20 µm depth).

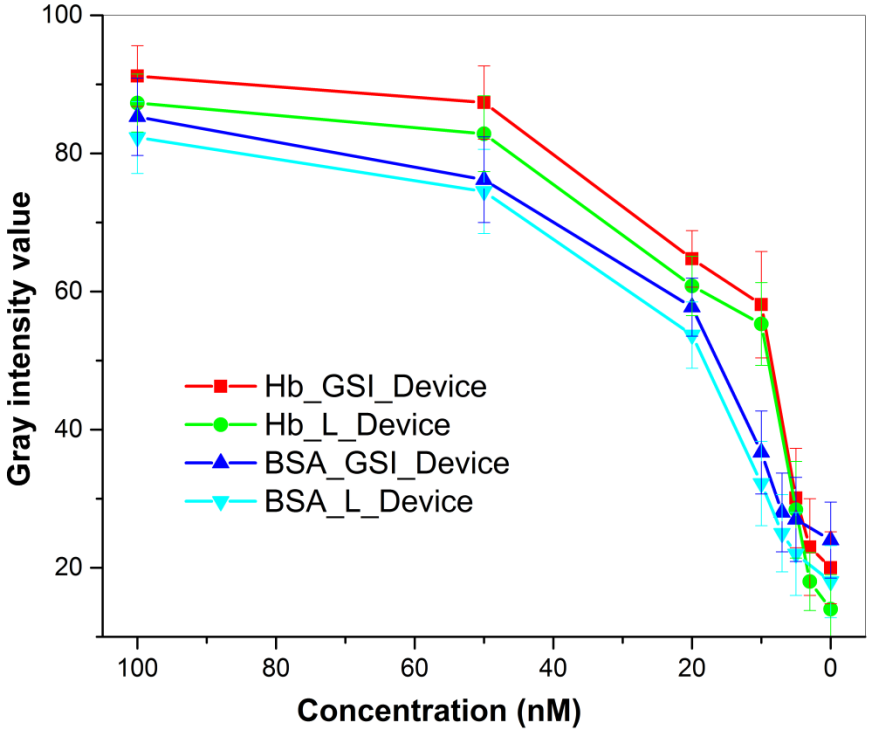

Fig. S6. Grayscale intensity values of optical images of 5CB films taken from smartphone based device at different concentrations of Hb and BSA on the LPS decorated LC/aqueous interface.

References

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