Supplementary Information

The optical setup of the optofluidic system is shown. The light source is laser (λ = 632.8 nm, 800 mW, Thor Lab, USA). The beam is reflected by a beam splitter and focused on the micordroplets at the detection area in the microfluidic chip. The light scattered from the droplets is collected at a distance of 80 mm with a CCD line-scan camera (Nikon digital sight DS F-11) and pass to the signal processor for the further analysis.

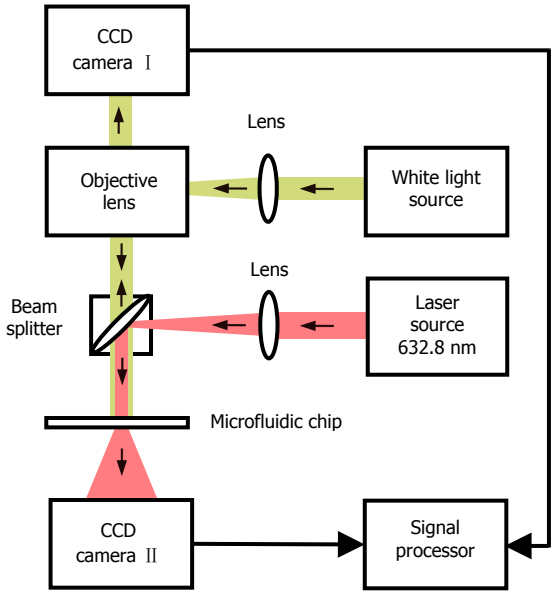

***Figure S1**: Schematic of the optical setup of the optofluidic system.*

The diffraction pattern of the microdroplet containing *E.coli* is a combination of single circular aperture Fraunhofer diffraction by the shape of the droplet and the scattering signal of the content inside the droplet. The circular diffraction pattern appearance is determined by the diameter of the single droplet. The pattern intensity distribution is determined by the refractive indices of the two immiscible liquid. When the diameter of the droplet is constant, the pattern distribution is mainly influenced by the content of the droplet. The volume ratio of a single *E.coli* to the single microdroplet carrier is lower than 0.01%. Therefore, the bacteriophage volume can be nearly neglected due to very small picoliter size. The effective refractive index of the mixture changes very slightly from droplet carrying very high concentration. However, the scattering pattern is significantly influenced by the concentration of the cells due to multi-time reflection and refraction of the light incident into the droplet.

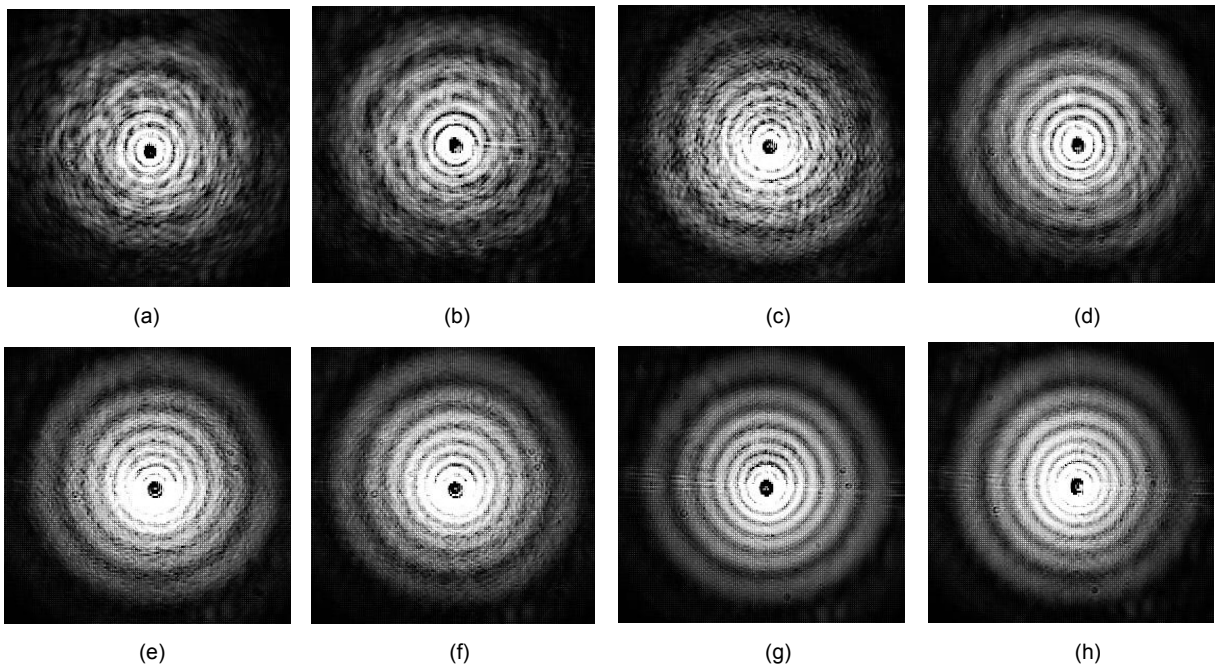

Figure S2: *The scattering pattern of microdroplets containing different concentration of E.coli (a) 1 ×10⁹ cell/ml (b) 5 ×10⁸ cell/ml (c) 2 ×10⁸ cell/ml (d) 1 ×10⁸ cell/ml (e) 5 ×10⁷ cell/ml (f) 2 ×10⁷ cell/ml (g) 1 ×10⁷ cell/ml and (h) control group.*

Numerical methods

The calculate the mean power frequency of a scattering pattern of microdroplets, the Fast Fourier Transform (FFT) for the frequency spectrum of the scattering patternis, which is expressed as

$$IF = \sum_{u=1}^{M} \sum_{v=1}^{M} Is(x,y) \exp\left(-i\frac{2\pi ux}{M}\right) \exp\left(-j\frac{2\pi vy}{M}\right) \tag{1}$$

where *Is* is the two-dimensional distribution of the scattering light. The power spectrum is

$$\phi(f) = IF * IF \tag{2}$$

where *f* is the frequency of intensity variation. The mean power frequency is the normalized first order power spectral moment. It can be expressed as

$$MPF = \frac{\int_0^{\infty} f \cdot \phi(f) df}{\int_0^{\infty} \phi(f) df} \tag{3}$$

The mean power frequency is used to analyze the variation of frequency of the scattering pattern.

Threshold determination based on statistical results

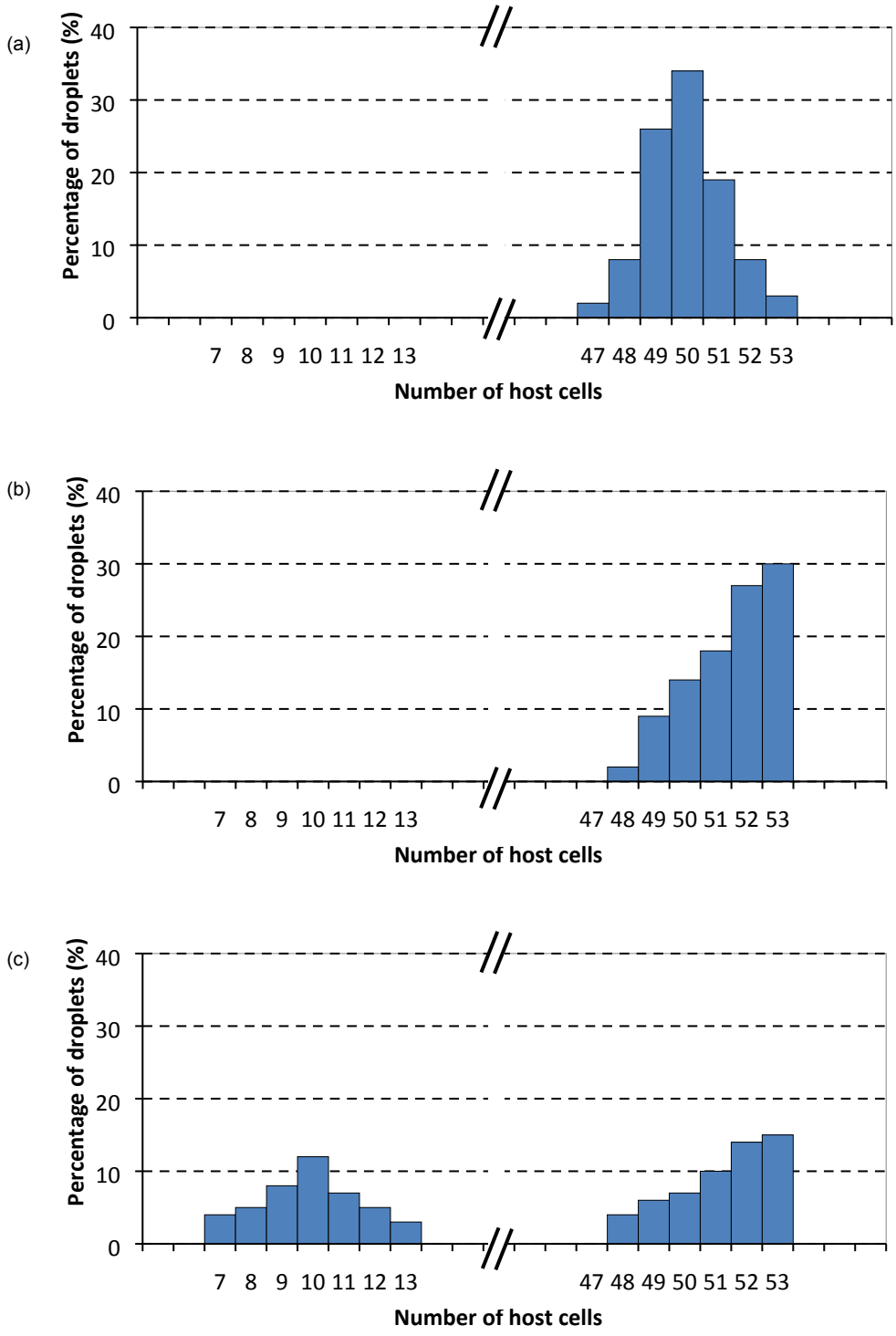

Figure S3: Histogram distribution of microdroplets based on the measured number of host cell in the microdroplets at (a) t = 0 hr, (b) t = 4 hrs without mixing bacteriophage as negative control, and (c) t = 4 hrs with mixing bacteriophage at a concentration of 5×10^6 pfu/ml.

The threshold value of 20 cells per drop is chosen based on the statistical data of the measurement results. Here, we show the data of 1×10^4 microdroplets (1 μL). Initially, each of the microdroplet has approximately 50 host cells as shown in Fig S3(a). As a negative control, the microdroplets are measured after 4-hour incubation as shown in Fig. S3(b). For the bacteriophage detection, the host cells are mixed with the water sample with high concentration (5×10^6 pfu/ml) of bacteriophages (such that approximately half of the droplets will contain bacteriophage). After 4-hour incubation, the host cell concentration is measured and shown in Fig S3(c). Based on the statistical results, without bacteriophage, the number of host cells in the microdroplets is above 40. With bacteriophage, the number of host cells is dropped below 20. Therefore, the threshold level is set at 20.