Investigation on compatibility between ink-jet printed microdisk and protein analyte

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1 Introduction

Whispering gallery mode (WGM) microcavities (including microsphere, microdisk, microrod, etc.) were reported by many researchers, because they show high sensitivity [1] and good adaptability for biosensors [2]. Especially, microdisk cavity is suitable for developing biosensors, because microdisk can provide ease of integration and small mode volume which results a high sensitivity [3]. However, it is difficult to develop the next generation organic microdisk biosensors pre-doped with protein assay directly, since the microdisk is generally fabricated in high temperature. Recently, we proposed a hyper-branched polymer (HBP) microdisk fabricated by ink-jet technique in room-temperature [4]. In this study, we investigated on a compatibility between the HBP and the protein analyte for biosensors.

2 Experiment and results

2.1 Preparation

In order to evaluate the compatibility between the HBP and protein analyte, we investigated the adsorb reaction rate of protein analyte on ink-jet printed microdisks. In the fabrication, the cladding pedestal was firstly printed with HBP of FZ-001 (n = 1.45). Then, the waveguiding disk was printed with an ink solution in which dissolved TZ-001 (n = 1.78) and Rhodamine590 of 5 mM. The Bovine Serum Albumin (BSA) water solution was prepared in the concentration of 5, 10, 15, 20 mg/ml, respectively.

2.2 Experiment

Firstly, adsorption of BSA was confirmed by the red shift of WGM spectrum. As a pumping source, a passively Q-switched and frequency-doubled Nd:YAG laser (PNG-002025-040, Nanolase Corp.) was used. The pulse pumping repetition rate was 10 Hz. WGM lasing spectra were observed by spectrometer with integration of 300 shots. Figure 1 shows the spectrum peak shift of WGM caused by adsorption of BSA in the case of 5 mg/ml. The spectrum was measured every 3 minutes. The first 3 points were measured in water. The last 5 points were measured, after exchanging water to BSA solutions. The spectrum shift can be fitted and given by

$$\lambda = \begin{cases} \alpha t + \lambda_m + \Delta\lambda\left(1 - e^{\frac{-(t-t_{ex})}{\tau}}\right), & t \geq t_{ex} \\ \alpha t + \lambda_m, & 0 < t < t_{ex} \end{cases}$$

where degradation rate α = −0.033 was assumed, t, t_{ex}, λ, λ_m, $\Delta\lambda$ and τ are reaction time, the time of exchange water to BSA solution, the peak wavelength, the offset of the peak wavelength of WGM, the total shift, and the time constant of spectrum shift, respectively. The total shift $\Delta\lambda$ = 0.5 nm can be estimated, where $\Delta\lambda$ is the spectrum shift at the saturated time of BSA adsorption.

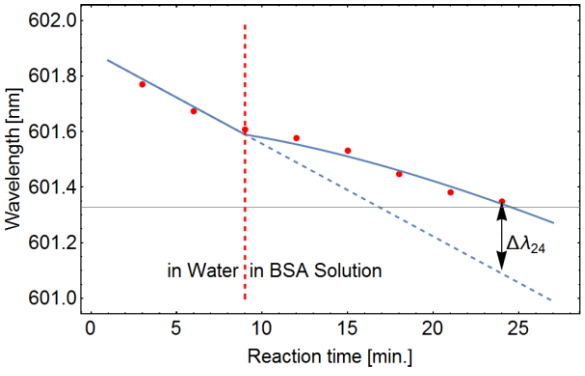

Fig.1. An example of peak wavelength as a function of reaction time by BSA concentration of 5 mg/ml. $\Delta\lambda_t$ is net spectral shift.

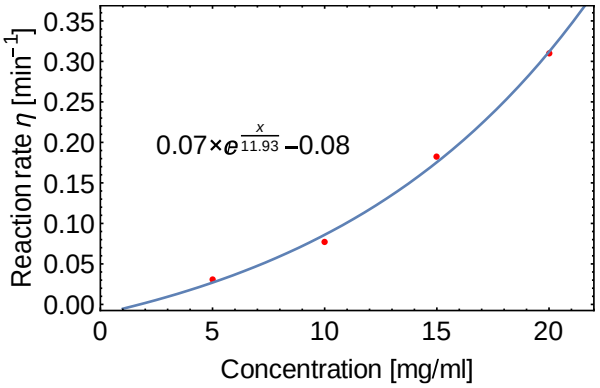

Fig.2. Estimated reaction rate τ at BSA concentration of 5, 10, 15, 20 mg/ml.

Secondly, the concentration of BSA solution was changed in range of 5~20 mg/ml to obtain reaction rate η, where η is the reciprocal of adsorption time constant τ. The reaction rate η can be exponentially fitted as a function of concentration of BSA solution as showing in Fig. 2. It can be interpolated by $0.07 \times e^{x/11.93} - 0.08$, where x is the concentration of BSA solution.

3 Conclusion

The compatibility between the HBP and the protein analyte was investigated by evaluating the adsorb reaction. It was confirmed that the total spectrum shift caused by adsorption of BSA was approximately 0.5 nm and adsorbing time constant of 5 min was obtained for 15 mg/ml.

References

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