

Development of intergrated and miniaturized analytical system fabricated on compact disc-type microfluidic platform

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論文要旨

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論文題名 Development of integrated and miniaturized analytical system fabricated on compact disc-type microfluidic platform (コンパクトディスク型マイクロ流体基板を用いる高集積化および小型化分析システムの開発)			

論文内容の要旨

In last decades, micro total analytical system (μ -TAS) keeps attracting attention from researchers, and has already been highly developed and applied to various analytical fields such as DNA microarray, immunoassay, blood separation/analysis and so on. In this doctoral thesis, we attempt to develop a highly integrated and miniaturized analytical system for the detection of one kind of widely used nonionic surfactant, alkylphenol polyethoxylates (APnEOs), by using one kind of μ -TAS, namely, centrifugal or compact disc (CD)-type microfluidic platform. Compared with the sequential injection analytical (SIA) system developed for the same target in our laboratory previously, the novel analytical system fabricated on the CD-type microfluidic platform has the advantages of integration, pump-free, down-size, potable and of low-cost, with the comparative analytical performance to the previous work. The proposed system in this research has the potential to be applied for monitoring the small molecular pollutants in environmental water surroundings.

In Chapter 1, the background information of CD-type microfluidic platform is introduced, including the examples of the realized fundamental laboratorial functionalities on-chip as well as the outstanding applications of CD-type microchip in biosensing and bioanalysis.

In Chapter 2, the protocol of fabricating the CD-type microfluidic platform is described, and the fundamental performances of the prepared device for the delivery of solutions by the centrifugal force generated from the rotation are estimated, which fit very well with the theory, and a sequential solution delivery can be realized by adjusting the related parameters of the device as well as the rotation speed. The behavior of the chemiluminescence detection using a horseradish peroxidase (HRP) solution and a luminol solution on-chip during the rotation is estimated, indicating the possibility of carrying out the chemiluminescence immunoassay

for the target, alkylphenol polyethoxylates (APnEOs).

In Chapter 3, the specially designed CD-type microfluidic platform for fully automating and integrating the chemiluminescence immunoassay process for APnEOs on-chip is prepared, and the sequential solution delivery for the sample solution, the washing solution as well as the luminol solution required in the chemiluminescence immunoassay protocol is successfully realized. On the other hand, for fully automating the analytical process on-chip, the rotation program for flowing the washing solution is optimized for increasing the washing efficiency to overcome the problem of the high physical adsorption of enzyme on the chip surface, which is greatly obstructive to the quantification of the target. The analytical performance of the proposed system is estimated, and a typical sigmoidal calibration curve for APnEOs is obtained, with a similar detection limit compared with that obtained from the sequential injection analytical (SIA) system for the same target developed in our laboratory previously.

In Chapter 4, another detection method, namely, the electrogenerated chemiluminescence (ECL) is attempted to be carried out on the CD-type microfluidic platform for the quantification of the same target, in order to improve the analytical performance through increasing the sensitivity as well as decreasing the time-to-result. The electrochemical detection cell is successfully fabricated on the CD-type microchip, and the behavior of the generated ECL photon signal along with the sweeping of the applied potential at the working electrode surface in the detection cell is estimated, which shows a maximum intensity when the applied potential of -2 V. The performance of the washing procedure on-chip is greatly concerned, and is estimated by measuring the ECL signal intensity after different washing conditions and comparing with that of the control experimental result. Since the results indicate a relatively high remain amount of the physical adsorption of enzyme at the detection cell in all conditions, the improvement of the electrochemical detection cell is necessary and has been proposed. The developed system is believed to have the potential to be applied for the simultaneous multi-targets detection required in the monitoring of water quantities in environmental surroundings.

In Chapter 5, all experimental results and conclusions are summarized.

In conclusion, the possibility and the applicability of the compact disc-type microfluidic platform for monitoring the small molecular targets through chemiluminescence immunoassay or electrogenerated chemiluminescence immunoassay are exhibited in this thesis, which is a valuable and useful contribution to the development of centrifugal type or CD-type microfluidic device. The practically applicable or even the commercially available product of CD-type microfluidic platforms for monitoring the water quantities as well as in various other analytical fields are worth investing and expecting.