Development of Cell-Based Chip Integrated with Dissolved Oxygen Electrodes and Its Application in the Estimation of Adipocyte Metabolism

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Adipocyte activity determines the metabolism of carbohydrate and fatty acid of human being, related to the formation of diabetes. Evaluation of adipocyte activity allows the researchers to realize the causes of type II diabetes and therapeutic methods [1]. Adipocytes uptake glucose and consumes oxygen to produce energy, such as adenosine triphosphate (ATP), during the metabolic process of glucose. Therefore, the adipocyte activity can be estimated by the consumption rate of oxygen. In the study, a microfluidic chip containing dissolved oxygen (DO) sensors of three-electrode electrochemical system was integrated with a peristaltic pump for the measurement of DO around the cultivated adipocytes, as shown in Figure 1. All gold electrodes were made by the lift-off microfabrication process. Moreover, the iridium oxide (IrOx) layer was electrodeposited on a gold electrode as the reference electrode. The DO sensing chip was fixed by the home-made polymethylmethacrylate (PMMA) clamp with 3M adhesive tape. Figure (b) shows that the adipocytes were estimated by the in situ DO ultramicrosensors with the stimulation of different glucose concentration (0 mM, 11 mM) and insulin, and then the DO signal was analyzed by three kinds of methods (called M1, M2 and M3) to evaluate the respiratory activity, respectively. The M1 derived from Bionas calculates the slope (pA/s) of current curve (10 to 200 sec) [2]; the M2 records the current value of 100th second (nA) after dropping a testing solution; the M3 obtains a relative DO concentration (C’) from the current of 50-200 s period via the quasi steady state diffusion of band ultra-microelectrode simulation. The respiratory activity can be defined as a DO consumption ratio of the drug-stimulated adipocytes to the normal adipocyte. The results show that the respiratory activity obtained by the M3 presented high reproducibility (<8%) and good physiological behavior. The DO microfluidic chip has a great promise in the application of estimating the effect of drugs on the cellular physiological behavior to replace some animal and clinical experiments.
