Sensors and Materials, Vol. 23, No. 1 (2011) 53–70
MYU Tokyo

S & M 0826

Amperometric Electrochemical Sensor with Multiple Working Electrodes to Determine Direction of Chemical Flow

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(Received June 1, 2010; accepted August 2, 2010)

Key words: electrochemical sensor, amperometric sensor, shielding effect, disk electrode

A new method of detecting the flow direction of an aqueous solution of a chemical substance is proposed. The detection mechanism is based on the shielding effect that appears between multiple working electrodes of an amperometric electrochemical sensor. When the sensor is exposed to the flow of a chemical solution, a smaller response current is obtained at the downstream electrode than at the upstream electrode since a portion of the chemical substance is consumed at the upstream electrode. The response characteristics of amperometric sensors with dual, triple, and quadruple disk working electrodes were compared using an empirical model equation of the shielding effect with a constant shielding factor. The results showed that the quadruple disk electrodes are ideal in resolving the two-dimensional angle of the flow. A sensor probe with quadruple carbon disk electrodes was then fabricated. Its response characteristics were tested by placing the sensor in a laminar flow generated in a flow-through cell and in a turbulent flow generated in a water tank. The results of the experiments show that the fabricated sensor consistently responds to the local flow near the sensor surface. The potential applications of the proposed sensor include tracking of chemical plumes to find their sources and analyzing the flow around an object in fluid dynamics experiments.

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