Microchim Acta (2017) 184:491–497
DOI 10.1007/s00604-016-2029-7

ORIGINAL PAPER

Carbon nanoparticle modified screen printed carbon electrode as a disposable electrochemical immunosensor strip for the detection of Japanese encephalitis virus

Suk Fun Chin[1] · **Lih Shan Lim**[1] · **Suh Cem Pang**[1] · **Magdline Sia Henry Sum**[2] · **David Perera**[2]

Received: 8 August 2016 / Accepted: 24 November 2016 / Published online: 5 December 2016

Abstract The authors describe a disposable electrochemical immunosensor strip for the detection of the Japanese encephalitis virus (JEV). The assay is based on the use of a screen printed carbon electrode (SPCE) modified with carbon nanoparticles (CNPs) that were prepared from starch nanoparticles and deposited on the SPCE working electrode whose surface was functionalized with 3-aminopropyl triethoxysilane. Next, antibody of JEV was immobilized on the surfaces of the CNPs. The analytical performance of immunosensor strip was characterized using cyclic voltammetry (with hexacyanoferrate as the redox probe) and electrochemical impedance spectroscopy. The deposition of CNPs enhances the electron transfer kinetics and current intensity of the SPCE by 63% compared to an unmodified SPCE. Under optimized conditions, the calibration plot is linear within the 5–20 ng·mL^{-1} JEV concentration range, the limit of detection being 2 ng·mL^{-1} (at an S/N ratio of 3), and the assay time is 20 min. This immunosensor strip was successfully applied to the detection of JEV in human serum samples. It represents a cost-effective alternative to conventional diagnostic tests for JEV.

Keywords Biosensor · Immunoassay · Cyclic voltammetry · Electrochemical impedance spectroscopy · Hexacyanoferrate · Nyquist plot · Disposable · Point-of-care · Nanomaterials

Introduction

Japanese encephalitis virus (JEV) is a member of the genus *flavivirus* of the family *Flaviviridae* which is closely related to dengue, yellow fever and West Nile viruses [1]. JEV is known to cause mortality rates as high as 40%, and with 30 to 50% of survivors suffering from severe neurological sequelae [2]. There are approximately 35,000 clinical cases of JEV and 10,000 mortality cases reported annually in the southern and eastern Asia [3]. Rapid detection of JEV infection is crucial for timely diagnosis and treatment of JEV patients, as well as effective control of JEV outbreak.

Conventional diagnostic methods for JEV infection include enzyme-linked immunoglobulin assay (ELISA) [4], reverse transcription polymerase chain reaction (RT-PCR) [5], plaque reduction neutralization test (PRNT) [6] and virus isolation [7]. However, these methods are tedious, require expensive equipment and specialized skills to operate and they are time consuming [8]. Since most of the JEV cases happen at rural settings in Southern and Eastern Asian countries, where diagnostic laboratory facilities are very limited, a portable diagnostic system that can provide point-of-care, rapid, sensitive and economical diagnosis is highly desirable.

Electrochemical biosensors based on screen printed carbon electrode (SPCE) have attracted intense attentions as diagnostic tools as they are disposable, portable, rapid and produce comparable results as conventional methods. SPCE based electrochemical biosensor system have been reported for cancer biomarker detection [9], uric acid sensing [10], amyloid beta biomarker for Alzheimer's disease diagnosis

Electronic supplementary material The online version of this article (doi:10.1007/s00604-016-2029-7) contains supplementary material, which is available to authorized users.

✉ Suk Fun Chin
sukfunchin@gmail.com

[1] Department of Chemistry, Faculty of Resource Science and Technology, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia

[2] Institute of Health and Community Medicine, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia