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ORIGINAL PAPER

Development of a Cr_2AlC MAX phase/g-C_3N_4 composite-based electrochemical sensor for accurate cabotegravir determination in pharmaceutical and biological samples

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Abstract

A highly sensitive electrochemical sensor is reported that employs a modified electrode for the precise measurement of cabotegravir, a potent anti-HIV drug. Cyclic voltammetry (CV), differential pulse voltammetry (DPV), and electrochemical impedance spectroscopy (EIS) were utilized for this purpose. Electrode modification involved the immobilization of Cr_2AlC MAX phase/g-C_3N_4 onto a glassy carbon electrode (GCE) to enhance its electrocatalytic activity and selectivity for cabotegravir detection. Under the optimal experimental conditions, the working potential (vs. Ag/AgCl) was to 0.93 V. The developed sensor exhibited a good linear relationship in the range 0.05 µM to 9.34 µM with a low limit of detection of 4.33 nM, signifying its exceptional sensitivity. Additionally, it demonstrated successful cabotegravir detection in pharmaceutical formulations and biological samples, achieving an RSD below 3.0%. The recoveries fell within the range 97.7 to 102%, confirming the sensor's potential for real-sample applications. This innovative electrochemical sensor represents a significant advancement, providing a simple, reliable, and sensitive tool for the accurate measurement of cabotegravir. Its potential applications include optimizing drug dosages, monitoring treatment responses, and supporting the development of cabotegravir-based pharmaceutical products, thereby contributing to advancements in HIV therapy and prevention strategies.

Keywords Cabotegravir · Cr_2AlC MAX phase · g-C_3N_4 · Electrochemical sensor · Modified glassy carbon electrode · Differential pulse voltammetry · Pharmaceutical products

Introduction

Cabotegravir (Fig. 1, CABO), a second-generation integrase inhibitor, has emerged as a promising option in the field of HIV treatment and pre-exposure prophylaxis [1]. Developed by ViiV Healthcare, Cabotegravir gained approval in 2020 from Health Canada and the European Medicines Agency, followed by the U.S. Food and Drug Administration in 2021, marking a landmark development in antiretroviral therapies for managing HIV [2]. Structurally similar to Dolutegravir, Cabotegravir targets the active site of HIV integrase, preventing the critical strand transfer of the viral genome into the host genome and effectively blocking viral replication [3]. Notably, it distinguishes itself with its extended duration of action and convenient dosing options. Available in both oral tablet and intramuscular suspension forms, Cabotegravir allows for daily oral administration or monthly intramuscular injections [4]. Given its significance in HIV therapy, precise determination of Cabotegravir concentrations is essential for optimizing treatment protocols and evaluating therapeutic outcomes.

Numerous analytical techniques have been reported for the determination of Cabotegravir alone or in combination with other antiretroviral drugs, including spectrophotometric [5], reversed-phase high-performance liquid chromatography (RP-HPLC) with UV detector [6], high-performance liquid chromatography method with mass spectrometry

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