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Edible Sensor for Electric Impedance Spectroscopic Analysis of Bioactive Liquids Containing Silver Nanoparticles

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In recent years, nanotechnology has attracted a lot of attention in dentistry and biomedicine, with new methods for oral and general disease prevention and treatment emerging. Formulations of silver nanoparticles (AgNPs) with antimicrobial properties against a wide range of microorganisms are one of these methods [1]. Since ancient times, the antibacterial effect of silver on various microorganisms has been well documented. Silver is typically used to cause antimicrobial effects in the form of nitrates, but when silver nanoparticles (AgNPs) are used, the surface area available for microbe exposure is increased. Toxicity concerning AgNPs in laboratory studies has garnered different results, depending on particles' size, concentration, surface, and charge. Concerning oral and maxillofacial applications, their use is worth paying attention to, as it was not thoroughly investigated [2, 3]. Bioresorbable electronics, also known as green electronics, is a novel concept that involves electronic devices that can naturally degrade or dissolve into the environment. Electronic devices have the potential to provide promising solutions for continuous monitoring of physiological parameters in humans [4].

The aim of this study was to evaluate the possibility of detection and electrochemical characterization of two commercial solutions with 15 and 30 ppm silver nanoparticles using edible sensors with gold electrodes using electric impedance spectroscopy.For this research, sensors were made of edible materials (gold electrodes on protein base). The EIS measurements were performed by PalmSens4. The three-electrode design with counter (CE), reference (RE) and working (WE) electrode was used. The impedance was measured in the frequency range from 1 Hz to 200 kHz. Firstly, a dry platform (dry sensor) was applied without delivering any solution, followed by the application of deionized water, 15 ppm and 30 ppm solutions to detect differences in the modulus of impedance. A function of an impedance modulus and phase angle were measured. The results speak in favour of sensitivity, consistency and applicability within the experimental sensing system on the tested sensors. It was shown that characteristic EIS signals were observed in both tested liquids, with a pronounced characteristic decrease in the impedance value corresponding to the concentrations of silver nanoparticles. As a proof of concept, the proposed structure successfully differentiated two types of tested solutions by measuring the decrease in impedance compared to the dry edible sensor and deionized water. Increasing the concentration of AgNPs resulted in decreasing the measured modulus of impedance. The presented platform could be very useful for applications where edible electronics and nanoparticle-containing solutions should be combined, such as the controlled release of AgNPs for medical applications, as well as the measuring of the therapeutical concentrations.

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