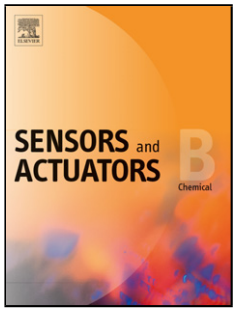

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Ex Vivo Identification of Thyroid Cancer Tissue using Electrical Impedance Spectroscopy on a Needle

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Highlights

- Introduced of biopsy needle with bipolar interdigitated electrodes on tip.
- Evaluated discrimination capability using various solution conductivity levels.
- Estimated conductivity of human thyroid tissue for general use in other EIS sensors.
- Obtained high sensitivity and specificity between normal and cancerous tissues.

Abstract

To improve the detection accuracy of cancerous thyroid tissues during biopsy and surgery, a hypodermic needle that incorporates an electrical impedance spectroscopy (EIS) sensor was previously developed and was named EoN (EIS on a needle). Prior to the *ex vivo* experiment using human thyroid tissues, the discrimination capability of the EoN was evaluated using various conductivity levels of solutions. The discrimination capability was rigorously verified based on experimental results, as well as an electrical equivalent circuit and curve fitting. Then, the electrical impedances of 13 patients' thyroid samples were analyzed in the sweeping frequency range from 1 Hz to 1 MHz. The optimal frequency exhibiting the best discrimination results between the normal and cancerous tissues was obtained based on a proposed discrimination index. The discrimination index was evaluated for each patient to verify whether it can discriminate between normal and cancerous tissues. In addition, the resistances of the tissues were extracted through curve fitting, and the conductivity was estimated for its general use. The results indicated that the conductivity can be used for distinction between normal and cancerous tissues in EIS sensors regardless of their shapes and dimensions. To align the impedance level data of the patients, a normalized impedance was employed by dividing the measured impedances of each normal and cancerous tissues into that of