EFFECT OF VISCOSITY ON LOCAL IMPEDANCE OF BIOLOGICAL GEL: MEASUREMENT WITH MICRO-VIBRATING ELECTRODE

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INTRODUCTION

A biological body includes various electrolytes. Some studies tried to analyze the structure of organs with measurement of local electric impedance [1, 2]. To avoid the change of structure by movement of ions with a direct current, an alternating current is applied to measure electric impedance of electrolyte solutions. High impedance of a micro-electrode disturbs to distinguish signal of local impedance at specimen from that of the other part of the electric circuit. In the present study, a new methodology to measure local mechatronic property has been proposed, and measurement system has been designed with a micro-vibrating electrode. The effect of viscosity on local impedance of the biological gel was evaluated with the proposed system.

METHODS

The impedance between two electrodes soaked in an electrolyte solution varies with the distance between them. When the distance oscillates sinusoidally with a mechanically vibrating electrode, the impedance oscillates, too. The oscillation corresponds to the variation of impedance of the local space, where the electrode is vibrating. The variation was analyzed with spectrum and the amplitude at the corresponding frequency was measured. The electrode was made of a glass micro-capillary filled with a potassium chloride aqueous solution (3 mol/L). A platinum wire was inserted in the center of the capillary to decrease impedance of the electrode. The diameter of the tip of the capillary is 0.01 mm. One of the electrodes was vibrated with a piezoelectric actuator. The measurement system consists of an oscillator, an amplifier, a spectrum analyzer, a phase-contrast optical microscope, a charge-coupled device camera, and a monitor (Fig. 1).

The manufactured system was applied to measure electrolytes: the sodium chloride aqueous solution, the potassium chloride aqueous solution, a quail egg, and human blood. Variation was made in the viscosity of the solution with dextran. The viscosity was measured with a cone and plate viscometer. The measurement has been performed at 25 degrees centigrade.

RESULTS AND DISCUSSION

The experimental data show that impedance increases with the decrease in the concentration of sodium chloride in the solution from 9.0 to 0.1 percent, and with the increase in the amplitude of vibration of the electrode to 0.023 mm. The results also show that impedance depends on the variation of electrolytes and that the ratio of impedance between the potassium chloride (0.1 percent) and sodium chloride (0.1 percent) is 1.15, which can be approximated to 1.21 calculated from electric conductivity of chronological scientific tables. The experiment with a quail egg shows that the impedance is independently measured of that of the surroundings, when the electrode stuck into the yolk is vibrating: while the impedance varies with the concentration of electrolyte in the surroundings, when the electrode is not vibrating.

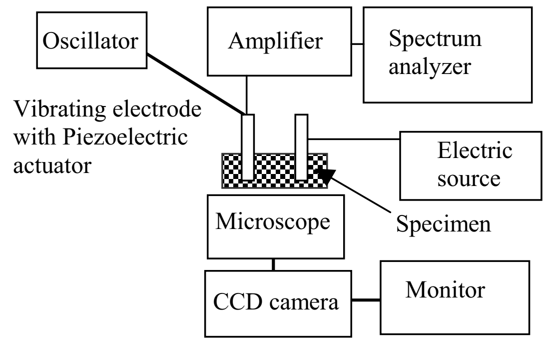

Figure 1: Measurement system.

The signal was also picked up as a function of viscosity, when the electrode was vibrated in the sodium chloride aqueous solution including dextran. The impedance increases with viscosity at higher frequency (>100 Hz), and with frequency at higher viscosity (>0.01 Pa s).

The result with human blood shows that impedance of the blood varies with coagulation process.

CONCLUSIONS

The experimental data show that the designed system is effective to detect the effect of viscosity on local impedance of biological gel.

REFERENCES

1. Tsai JZ, Cao H, *IEEE Transactions on Biomedical Engineering*, **47**, 41-47, 2000.
2. Wang Y, Haynor DR, Kim Y, *IEEE Transactions on Biomedical Engineering*, **48**, 1390-1401, 2001.
3. Grosse C, Tirado M, *IEEE Transactions on Instrumentation and Measurement*, **50**, 1329-1333, 2001.

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