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EVALUATING OBJECT AND REGION OF CONCENTRIC ELECTRODE IN BIO-ELECTRICAL IMPEDANCE MEASUREMENT

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Abstract-Concentric electrode is easy to use and used widely for measuring bio-electrical impedance. But, its evaluating region was not investigated in detail. Then, the characteristics of concentric electrode were studied from various points of view. In case of use without electrode paste, impedance is determined with the contacting condition between electrode and skin surface over all frequency range. In case of use with electrode paste, impedance is composed of stratum corneum in the frequency range of 20Hz-1kHz and is mainly composed of subcutaneous tissue in the range of 200kHz-1MHz. In the high frequency range, evaluating region of concentric electrode is the area less than the radius or the gap of center electrode.

Keywords -Bio-electrical impedance, skin impedance, concentric electrode, evaluating region

I. INTRODUCTION

The method measuring bio-electrical impedance using concentric electrode in local part non-invasively is widely applied. Although detecting bio-impedance varies by electrode size, frequency, and types of electrode paste, the detail results have not been cleared yet. Then these points were investigated through some experiments such as adhesive tape stripping. This paper shows some concrete yardsticks as evaluating object and region based on the results.

II. METHOD AND MATERIALS

Gold concentric electrode as shown in Fig.1 which is used for admittance skin moisturization meter[1][2] was investigated about evaluating region toward depth. Measurements were carried to capacitance C_p at frequency 1MHz with various depth d of tank filled with distilled water. The results are shown in Fig.2 as the ratio to C_0 for large value of d . The electrode gaps were $g_1=2.5\text{mm}$, $g_2=6\text{mm}$ and $g_3=30\text{mm}$. Next, skin admittance of forearm under various conditions were measured at frequency from 10Hz to 3.5MHz, whose results shown in Fig.3. Finally, vector impedances of forearm with cream electrode paste were measured from 20Hz to 1MHz in normal skin and 15 times stripping skin with adhesive tape. Gap length was 10mm. The results are shown in Fig.4.

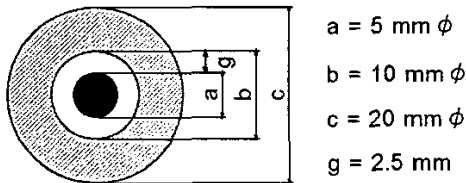


Fig.1 The construction of concentric electrode.

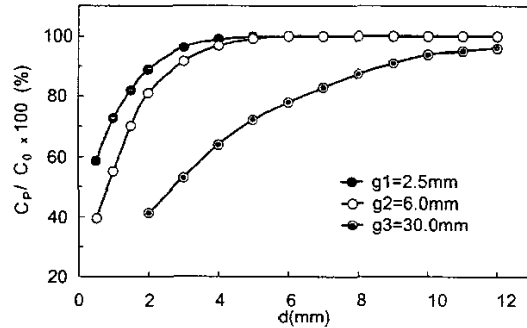


Fig.2 Influences of test material thickness.

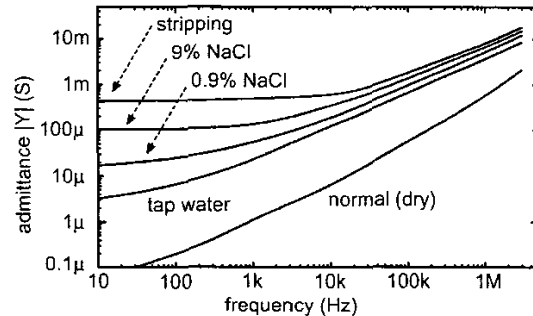


Fig.3 Frequency characteristics of skin impedance.

III. RESULTS AND DISCUSSIONS

In the case of standard electrode as shown in Fig.1, capacitance was 8.92pF for enough size of depth and the capacitance for limited size water field was decreased shown in Fig.2. But, the change of capacitance depend on different gap are small. In case of 3mm of material thickness, the decrease of capacitance is about 4%. Then, the evaluation region of homogeneous material is about 3mm depth. The depth of current pass become deeper with larger gap length. However, the contribution of wide spreading current area to total impedance is not so large. In the high frequency range, evaluating region of concentric electrode is the area less than the radius or the gap of center electrode.

From the skin impedances of normal condition and 15 times stripping the ratio of contribution of stratum corneum to total skin impedance were evaluated in every frequency point as shown in Fig.5. From 20Hz to 1kHz stratum corneum impedance is dominant. At higher frequency the contribution of subcutaneous tissue increases and at over 200kHz subcutaneous tissue impedance is almost whole. It depends that the subcutaneous tissue impedance is almost same level over all frequency band and stratum corneum impedance decreases largely with the

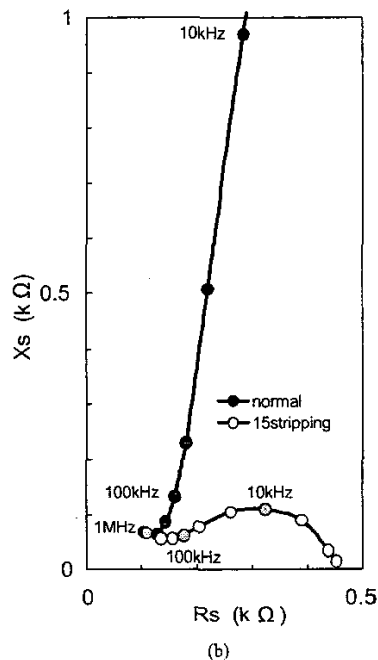
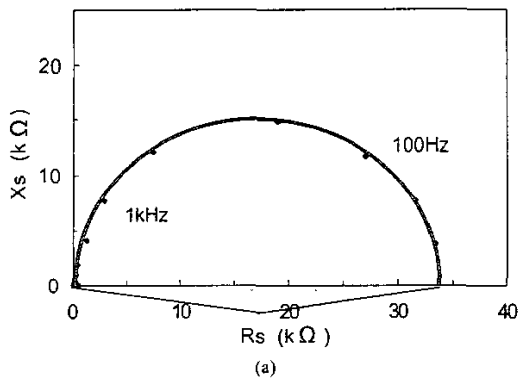


Fig.4 Vector impedance loci of normal skin impedance and 15 times stripping .

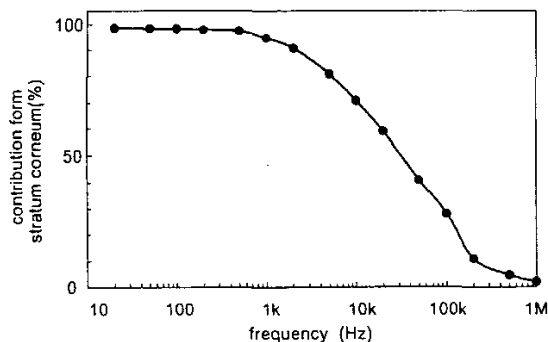


Fig.5 Contribution from stratum corneum impedance for total skin impedance.

In skin moisturization meter measuring the admittance without paste, the impedance in low frequency band should be used on theory. However, the impedance in high frequency band is used paradoxically because of the influence of ion in low frequency band. In low frequency band, the ion influences not only to the resistance but also to the capacitance by the reason of α dispersion[6]. Then, it shows in incorrect moisturization data. The principle of skin moisturization measurement is application of not electrical properties but mechanical properties of skin where skin moisturization varies the contactness between electrode and skin surface. For the measurement of stratum corneum impedance low frequency 20Hz-1kHz is desired. And at high frequency band, it needs rejection of subcutaneous tissue impedance.

In the measurement of the characteristics of subcutaneous tissue, the electrode must be contact perfectly to skin, and the two electrode system needs the frequency band of 200kHz-1MHz. Further, the stripping of stratum corneum is very effective for precision measurement.

IV. CONCLUSION

Concentric electrode is easy to use and is used widely for measuring bio-electrical impedance.

(1) From 20Hz to 1kHz stratum corneum impedance is the majority in the skin. At higher frequency the contribution of subcutaneous tissue increases and at over 200kHz subcutaneous tissue impedance is almost whole.

(2) In skin moisturization meter measuring the admittance without paste, the impedance in low frequency band should be used in theory. However, the impedance in high frequency band is used paradoxically because of the influence of ion in low frequency band.

(3) For the measurement of stratum corneum impedance low frequency 20Hz-1kHz is desired. And at high frequency band, it needs rejection of subcutaneous tissue impedance.

(4) In the measurement of the characteristics of subcutaneous tissue, the electrode must be contact perfectly to skin, and the two electrode system needs the frequency band of 200kHz-1MHz. The evaluating region of concentric electrode is the area less than the radius or the gap of center electrode.

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increasing frequency[3][4]. Almost same result was reported as the result of finite elemental method[5].