ELECTRIC CONDUCTIVITY OF VEINS APPLIED IN CABG OPERATIONS

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The first time electric conductivity – temperature relationship (σ-T) has been studied in biological materials on bone, by Behari, Liboff and Shamos.

Since then, the method has been used in studies on elastin, keratin, collagen, nucleic acids and other, more complex biological materials. The method makes it possible to observe phase processes, such as thermal denaturation, water release and thermal decomposition, occurring in heated biological materials.

The most important features in the electric conductivity-temperature relation of vein walls derive from the major molecular constituents of tissue that is collagen and elastin. Therefore, during analysis of the obtained results electric properties of collagen and elastin become the focus of attention. Solid-state proteins are characterized by relatively high temperature of denaturation and their physical properties are deeply affected by the water content. Electric conductivity increases with increasing water content and the activation energy of charge conduction process is reduced.

Usually denaturation of collagen is observed in the temperature range of 450–520K. The range of denaturation temperatures is an outcome of the degree of collagen crystallity, water content and presence of other substances. Changes in the thermal stability of collagen can be shown either by an increase or a decrease in the temperature of denaturation. In turn, water associated with proteins is divided into three SUB-types: structural, bound and free water released subsequently during heating. The structural water, about 0–0.07 g/g, is incorporated in the collagen structure. Its liberation is possible when collagen undergoes thermal denaturation. The term bound water, 0.07–0.25 g/g, refers to water molecules tightly bound to specific sites in collagen chains filling in the spaces between molecules. The bound water-protein interaction is not as strong as in that of structural water. The term free water refers to the water content higher than 0.45 g/g. According to Nomura, in the range 0.25–0.45 g/g both, free and bound water is absorbed. The release of both free and bound water occurs after denaturation.

Usually a DC voltage is applied to a sample and the current flowing through the sample is measured. Measurements of σ-T can be carried out also during monotonic temperature changes. The method is applied in studies on polymers and complexes. Monotonic heating of sample induces changes in its dimensions. Thus, the measured current is a sum of both conduction and displacement current. Also, the latter is caused by a change in capacitance of the sample.

The aim of this work was to study the effect of temperature on electric conductivity of the vein wall. On the basis of the recorded thermograms, temperatures of the phase transitions and enthalpy of the charge conduction process were determined.

Vein samples were taken from patients 50–60 years old during CABG operations. The σ-T relationship was measured for the vein samples studied in the temperature range of 295–520K. The DC voltage was applied to the sample and the electric field strength was within the range of voltage-current linearity where Ohm's law is obeyed. Current was measured by an electrometer (W7–30 or Keithley 6514). Prior to measurement of electric conductivity, each sample was maintained at 380K for a period of one hour. At the same time the release of free water took place. Then, the sample was cooled down to room temperature and heated again from 295K to 530K. All experiments were performed at the heating rate of 1K/min with samples exposed to air. In order to show the effect of water release at 380K, measurements were also carried out for non-dried samples in the range of 295–380K.

The values of electric conductivity σ were calculated on the basis of current and voltage applied and the geometrical size of sample. The peak temperature of the σ-T curve along with the temperature of kink of the σ-T curve, show the temperature of phase transition of proteins constituting the vein wall. The enthalpy of the charge conduction process was determined using the Arrhenius plot. The calculations were performed at the intervals of the linear dependence of $\ln \sigma = f(T^{-1})$ ($r \geq 0.999$).

Currently, correlation between biomedical parameters and determined electric parameters of vein walls is studied.