

Iontophoretic Conditioning of the Electrode to Skin Contacts

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Abstract: By utilizing direct current (DC) iontophoretic treatment on electrodes with high impedance we show the effectiveness of iontophoresis as a driving force for permeation of ionic electrolyte into the skin barrier. After a 60 second DC treatment at 50 μ A or 100 μ A amplitudes on either saline, Nihon Kohden Elefix, or Agar based electrolytes we saw an immediate impedance drop ranging from 3-30%. The effects generally lasted several hours.

1 Introduction

In early electrophysiological recording, such as electroencephalography (EEG), low electrode-scalp impedance was necessary. In addition to using electrolyte to hydrate the skin, it was common to abrade the scalp to reduce impedance. Although with the advent of modern solid state amplifiers the necessity for low impedance in EEG has almost disappeared [1], transcranial electric stimulation (TES) and other applications like ECG, EMG and EIT still require low impedances to guarantee stable contact. Direct current iontophoresis, the physical process of driving ions through a medium with electrical current [2], is a promising technique for electrical contact conditioning. The goal of this study was to decrease the contact impedance by applying iontophoretic treatment at several amplitudes, with multiple electrolytes and study the short term and long term effects of the procedure.

2 Methods

2.1 Experimental Setup

We employed the multichannel NA 300 amplifier with a built-in Howland-type DC/AC constant current generator, isolated from the amplifier circuitry, Net Station v4.4.1a1 software, and Ag-Cl coated electrode head EEG net (Electrical Geodesics, Inc) to perform DC iontophoresis. A scanning protocol was used to select electrode pairs (one source, one sink) for treatment and either 50 μ A or 100 μ A of DC current was injected through the selected electrodes for a length of 60 seconds. 12-16 electrode pairs were selected for every subject, and were treated with the procedure while the rest of electrodes were left untreated. 2 subjects volunteered for the experiment, with a total of 5 sessions. All hardware complies with the International Electrical Safety Limits.

2.2 Impedance Measurements.

Table 1: Mean impedance drop at the source and sink electrodes immediately after the treatment for each session and electrolyte. Mean Untreated is the impedance change from the beginning of the session until the end of the session, hence showing the general impedance trend of the electrolyte.

	Saline 1	Saline 2	Elefix	Agar 1	Agar 2
Source, 50 μ A	-12.63%	-20.46%	-33.56%	-10.12%	-15.38%
Sink, 50 μ A	-9.93%	-3.41%	-9.86%	-9.03%	-24.06%
Source, 100 μ A	-18.60%	-23.13%			
Sink, 100 μ A	-15.82%	-8.40%			
Mean Untreated	0.48%	5.61%	-2.41%	-8.97%	-23.21%

Impedances were measured using the standard impedance checking methods in EGI's NA 300 system [1].

2.3 Electrolyte

Three electrolytes were used: saline electrolyte(1.5 liters of saline, 5ml of shampoo and 15 grams of sodium chloride (NaCl)); Nihon Kohden Elefix Paste (a propylene glycol based paste electrolyte that is FDA cleared and available commercially); Agar-saline based gelatinous electrolyte.

3 Results

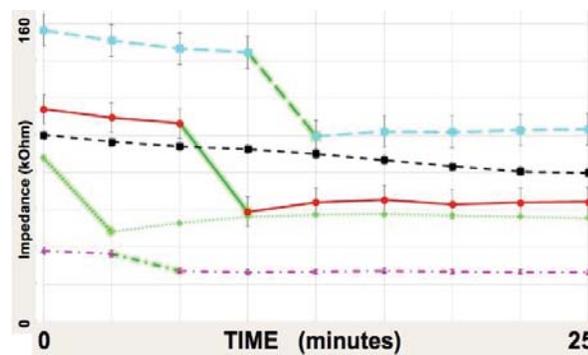


Figure 1: Impedance (kOhms) over time (minutes) of four treated source electrodes (in color) and the mean trend of untreated electrodes (black). The time segments with treatment are highlighted.

We have observed an average 19% impedance drop at the source and 11% impedance drop at the sink electrode immediately after injection with saline, and even larger effects with other electrolytes (Elefix, Fig.1).

Along with DC conditioning, AC treatment at 10KHz frequencies was shown to be effective in lowering impedance [3], suggesting possible future research direction.

References

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