

# Design of a Carbon Silicon Electrode for Iontophoresis Treatment towards Alopecia

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**Abstract**—This study presents design of a carbon silicon electrode for iontophoresis treatment towards alopecia. The alopecia is a medical description means loss of hair from the body. For solving this problem, the drug need to be delivered into the scalp, therefore, the iontophoresis was chosen to use in this treatment. However, almost common electrodes of iontophoresis device are made with metal material, the electrodes could give patients hurt when they using it, and it is hard to avoid the hair for attaching the hair. For this reason, an electrode is made with silicon material to decrease the hurt from the electrodes, and the carbon material is mixed in it for increasing conductance. The several cones with stainless material on the electrode make the electrode is able to void hair to attach the affected part. According to the results of a vivo-experiment, the carbon silicon electrode showed a good performance and in treatment comfortably.

**Keywords**—Carbon silicon, drug delivery system, iontophoresis

## I. INTRODUCTION

LOSS of hair from the head and body is called alopecia in the medical description, sometimes to the extent of baldness. When hair loss occurs in only one section, it is known as alopecia areata. This is the most form of the disease and is consistent with a sudden loss of hair, causing patches to appear on either the scalp or other bodily areas. If untreated, or if the disease does not respond to treatment, complete baldness can result in the affected area, known as alopecia totalis. Many facts could cause the alopecia happened such as over processing or frequent use of chemical relaxer, chronic exposure to traction on hair and etc. Lately, in current modern world, alopecia is more and more popular. Using iontophoresis method to treat alopecia is a very convenience and effect way. The iontophoresis provide a mechanism to enhance the penetration of hydrophilic and charged molecules across the scalp [1].

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However, almost common electrodes of iontophoresis device are made with metal material, the electrodes could give patients hurt when they using it on their scalp. In addition, common electrodes are hard to attach the scalp of patients completely, because almost patients they have some hair that cover on the scalp. In this paper, a carbon silicon electrode for iontophoresis treatment towards alopecia is presented. An electrode is made with silicon material to decrease the hurt from the electrodes, and the carbon material is mixed in it for increasing conductance. Several cones are set on the electrode, and top of the cones are covered with stainless to attach the affected part for approaching the iontophoresis effect. According to the results of performance test and a vivo-experiment, the carbon silicon electrode showed a good performance.

## II. METHODS

### A. Basic idea of using the carbon silicon electrodes

Iontophoresis is a technique using a small electric charge to deliver a drug through the skin [2]. The alopecia treatment chosen iontophoresis by it is basically an injection without the needles. The medication is most widely applied to treat the alopecia. Therefore, the patients could daub the liquid medicine to their affected part themselves, and doctor can put the electrodes of the iontophoresis device to the affected part of patient's scalp easily. And patients can feel well when they are receiving the treatment. But, almost electrodes for iontophoresis treatment are made with material that could hurt the patient when they receive the treatment. In addition, common electrodes are hard to touch the affected part. Therefore, using carbon silicon electrodes are proposed. The electrode is made with silicon material to decrease the hurt from the electrodes, and the carbon is able to increase the conductance of the electrode.

### B. Electrodes design

For approaching the iontophoresis effect and easy to be used, the electrode is designed as a comb. The tops of electrode are able to keep away from hair for touching the scalp completely. Body of the electrode is made with silicon material to decrease the hurt from the electrodes when the patients use it. And the carbon material is mixed in it for increasing conductance. The stainless material is covered on the tops of the electrode and connected with the electrical wire from the iontophoresis machine. The electrical wires are set in the carbon silicon electrode. The basic idea of the carbon silicon electrodes for iontophoresis to treat the alopecia is shown in figure 1.

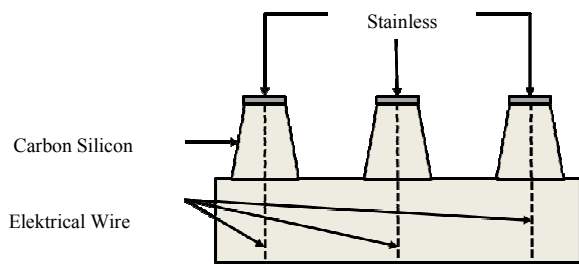


Fig. 1 The basic idea of the carbon silicon electrodes for iontophoresis to treat the alopecia

III. EXPERIMENTS

A. Manufactured carbon silicon electrode

The electrode was made as a circular that diameter was 30.30 mm and height is 5 mm, and 7 small cones were made on it. The carbon silicon electrode was composed of 58.43% carbon, 4.97% hydrogen and 36.6% silicon. The tops of the small cones were cut for placing the stainless material. The stainless material (Stainless SUS316L, The Nilaco Corporation) was cut as several foursquare blocks and placed on small cone by epoxy. The electrical wire from the iontophoresis device was through the carbon silicon electrode to connect with the stainless blocks each other. Figure 2 shows the manufactured carbon silicon electrode for iontophoresis treatment towards alopecia.

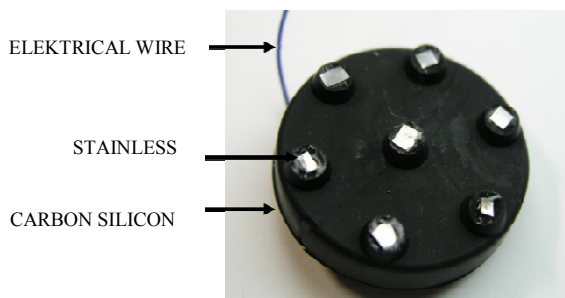


Fig. 2 The manufactured carbon silicon electrode for iontophoresis treatment towards alopecia

B. Experiment

1. Electrodes performance test

For testing performance of the carbon silicon electrode, a LCR meter was used in this test. The LCR meter (Precision LCR Meter 1061A, Chroma) is microprocessor-controlled, automatic and programmable LCR measuring instrument that provides high accuracy, speed and reliability. The original carbon silicon electrode which was not rebuilt is connected with the LCR meter. The frequency was changed from 100 Hz to 100 kHz with 4 stages. Also, a same size electrode only made with silicon was tested by LCR meter in same condition for comparing with the carbon silicon electrode.

2. In-vivo experiment using carbon silicon electrode for iontophoresis treatment

An adult (6 weeks) normal female rat anesthetized by using Zoletil. After the rat slept, the hair of back and abdomen from rat was removed by a razor. Rat's back skin was applied with 0.004 M 400 ml A2p-Mg Water-soluble vitamin for checking the effects of the electrodes. The proposed carbon silicon electrode and common silicon electrode were putted on back of rat to touch the skin and fixed with tape individually. And positive electrode from the iontophoresis device was attached to the abdomen of the rat with electrode gel. The stimulation has been carried through during 20 minutes by iontophoresis device. After the stimulation process, the rat with its skin was stabilized by 10 minutes. The parts of electrodes attached skin were sampled and frozen with liquid nitrogen after they were grinded. The frozen skin samples were putted in test tubes individually, and 5 ml PBS solution was filled in each test tube. The centrifugal machine was used to cause the deposition of solids in these solutions. The processed samples were analyzed using High performance liquid chromatography. Figure 4 shows the vivo experiment using carbon silicon electrode for iontophoresis treatment.

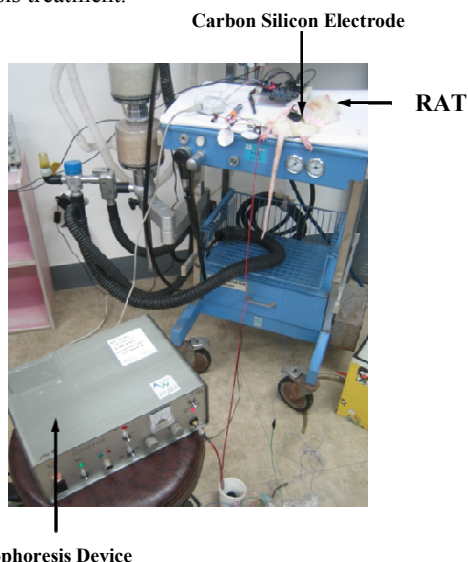


Fig. 3 shows using carbon silicon electrode for iontophoresis treatment in the vivo experiment

IV. RESULTS

The impedance values of the carbon silicon electrode and normal silicon electrode were shown in table 1. The impedance values of the carbon silicon electrode changed from 47.1 to 60.5 ohm via the frequency was changed from 100 Hz to 100 kHz. The silicon electrode's impedance value changed from 0.64M to 439.06M ohm via the same frequency changing with the carbon silicon electrode test.

TABLE I  
COMPARING THE COMMON SILICON ELECTRODE AND CARBON SILICON  
ELECTRODE

Frequency	Silicon Electrode		Carbon Silicon Electrode	
	IZI ( $\Omega$ )	Current (mA)	IZI ( $\Omega$ )	Current (mA)
100 Hz	0.64M	0	47.1	15.4
1 kHz	10.67M	0	52.3	15.8
10 kHz	130.41M	0	47.6	15.8
100 kHz	439.06M	0	60.5	15.8

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Figure 4 has shown the result of the in-vivo experiment using carbon silicon electrode to enhance the iontophoresis treatment effect. Through the same stimulation process by iontophoresis device, the percentage of 0.04 AP-Mg that penetrate to the skin with carbon silicon electrode and normal silicon electrode were 0.96% and 0.44% each other. The result value in using the carbon silicon electrode is bigger than silicon electrode 2 times.

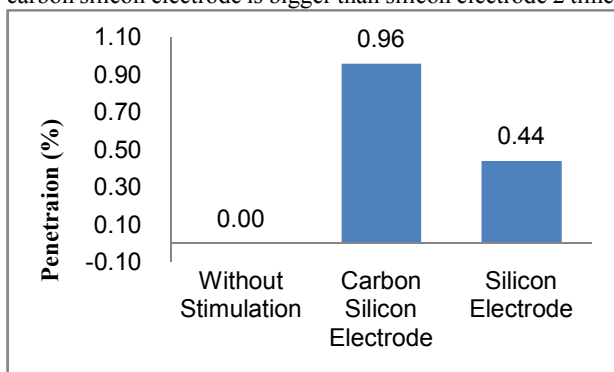


Fig. 4 The sampled solution's percentages of 0.04 AP-Mg that penetrate to the skin with different electrode by iontophoresis stimulation

#### V. CONCLUSION

As the results of the experiments, the carbon silicon electrode for iontophoresis treatment towards alopecia has shown a good performance. By the carbon silicon mixture material, the impedance of the presented carbon silicon electrode is much smaller than the normal silicon electrode. Also, the small cone shape part is able to let the stainless blocks avoid the hair to touch with the affected part of the patient's scalp completely. In the future work, the conductance of the carbon electrode will be increased. Also for the comfortable, improving the flexibility of the electrode will be arranged in the future schedule, too.

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