Development of a Battery-operated Plasma Device Using Dielectric Barrier Discharge Plasma in Ambient Air

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ABSTRACT

Dielectric barrier discharge (DBD) plasma in air, a kind of non-thermal plasma, can disinfect the surface of a wound and enhance blood clotting without tissue damage. The purpose of this study was to design a prototype of a new, easily portable, DBD plasma device for first aid. In our prototype, the plasma discharge could be adjusted by changing frequency and using the pulse width modulation (PWM) function from a microcontroller. An electrode, coupled with the surface micro discharge (SMD) technique, reduced current leakage passing through the body. While the Lissajous standard method was utilized to measure the energy consumption per cycle, the optical emission spectroscopy approach analyzed the elements of plasma generation in ambient air. The prototype was convenient to carry and the amount of plasma discharge (containing the activated species O, OH, O_2-, O_3, N_2, N_2+) was easily varied to affect microorganisms and tissue.

Keywords: Battery-operated plasma device, Dielectric barrier discharge, Non-thermal plasma, Plasma discharge in air

INTRODUCTION

High voltage in the gap between two plane-parallel metal electrodes, in which at least one of them is covered by a dielectric layer, produces DBD plasma (Figure 1) (Priyadarshini, 2013). The dielectric barrier is made of a material of low dielectric loss and high dielectric strength: such as glass, quartz, or ceramics (Fridman and Friedman, 2013). To ignite plasma between the electrodes, the electric field across the two electrodes must be high enough to cause dielectric breakdown of the gases in ambient air. The minimum breakdown voltage calculated from the Townsend avalanche and the Paschen curve is about 3 kV/mm (Lieberman and Lichtenberg, 2015). DBD plasma is a relatively novel technology, environmentally friendly, and safe for humans. Previous studies have shown that it could be used directly on human tissue without damage or pain (Fridman et al., 2006). DBD plasma in air has been shown to effectively reduce wound healing time through many factors, including clotting, decontamination, anti-inflammatory, and healing processes (Fridman and Friedman, 2013).