Characterization of 6 electrode microwave plasma torch for decontamination

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An atmospheric low gas temperature plasma torch using microwave has been developed and applied to in-vivo sterilization. Research in atmospheric plasma sources has been quite active, because they combine many advantages, such as low cost, simple design and easy handling. In addition, with atmospheric plasma it is possible to treat substances which are not resistant to vacuum, such as living organisms. A contact-free treatment can be achieved without any heating and painful sensation.

Our plasma torch consists of 6 stainless steel electrodes placed inside an aluminum cylinder of 135 mm in length. The centers of the 6 electrodes, whose surfaces are serrated, are distributed equally at a distance of 6 mm from the inner surface of the cylinder. The size of the torch's opening is 35 mm in diameter. Ar of 2.2 slm is applied from the base of the electrodes through a shower plate which regulates gas flow around the electrodes. Microwave power at 2.45 GHz is applied to the electrodes through coaxial cables via a 2 stub tuner. The input power is 80 W. Six plasmas are produced between each of the electrode's tips and the inner surface of the cylinder.

To examine medical compatibility of our plasma, the gas temperature and the UV light intensity are measured. In the vicinity of the torch, the gas temperature is relatively high (over 500 K). However, around 8 mm away from the torch, the gas temperature decreases drastically. As the distance from the torch increases further, the temperature decreases more gradually. At the position of 17 mm away from the torch, the temperature is 301 K, low enough for 'in-vivo' application. There are charged particles at this position because the floating potential of a probe is not 0. The UV light intensity is measured by a UV power meter which has sensitivity between 160 and 380 nm. From the plasma, the UV power density is 90 $\mu W/cm^2$ which is not much because this light intensity is in the same order of that from the sun. Of course, we need more discussion because the plasma spectrum has many peaks while the sun light has a continuous spectrum.

When an *Escherichia coli* (and other) culture is placed at a position 17 mm below the torch, where the gas temperature is sufficiently cool (301 K), for 2 minutes, the bacteria are almost completely killed in a 40 mm diameter circle. We consider that this technique could be used for different medical application, in particular wound healing and, have started a clinical study for the therapy of chronic foot and leg ulcers.