Atmospheric pressure plasmas for surface and medical applications

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Non-thermal plasma jets at atmospheric pressure have attracted much attention in recent years due to their simplicity and low cost combined with a great variety of applications ranging from material processing to medicine. This work will give a brief overview of recent works focusing on the research and development performed at FEG, UNESP.

1. Introduction

The cold atmospheric pressure plasma jets (APPJs) were first reported in nineteen-nineties and since then they have been subject of intense research and development. For instance, over the last decade the number of publications on plasma jets in the literature has grown exponentially [1]. Also, various high impact journals published special issues and review papers dedicated on APPJs. A distinguishable feature of cold plasma jets is that they can be operated in air and provide enhanced chemistry via production of reactive species (radicals, photons and charged particles) while the gas temperature is maintained sufficiently low for processing of organic and biological components. Nowadays, plasma jets are routinely used in material processing for surface cleaning and deposition, etching, surface activation of polymers, decontamination of surfaces etc. [1]. Recently, application of non-thermal plasma jets in living tissues has been extensively studied giving the origin of so-called plasma medicine [1, 2].

2. Experimental

2.1. Plasma jet geometry

An important issue for the operation of a plasma jet is its geometry, which together with dielectric properties of the substrate, strongly influences the shape and the extension of generated plasma plume. Therefore, depending on the intended application many different plasma jet configurations have been investigated. Here, we report the effect of a horn-like jet nozzle, which allows extending plasma over larger area of the sample. This jet configuration was used for adhesion improvement of Al alloys and also for treatment of seeds.

2.2. Plasma polymerization

A three-electrode plasma jet configuration (one powered electrode and two grounded) was especially developed for deposition of polymer films at atmospheric pressure. Argon was employed as working gas for plasma generation. Mixtures of air with acetylene or hexamethyldisiloxane (HMDSO) were used as polymerizing agents. The films were deposited on glass substrates placed on an auxiliary grounded electrode and can be used as biocompatible coating or for corrosion protection.

2.3. Plasma jet at the end of long plastic tube

A crucial question in plasma medicine is how to deliver active plasma species to tissues or organs inside human body. Most commercially available plasma sources are too big and rigid for this purpose. Here, we report a method that allows generation of cold plasma jet at the end of long (up to few meters), flexible, plastic tube. The tube can be held with hand without risk of electric shock and the plasma jet can be easily handled and directed to a target. Here, we will describe the method and present some results of surface modification of polymers. Also, *in-vitro* experiments for microbial inactivation using APPJs at the end of plastic tube will be presented. Special attention will be given to plasma treatment of biofilms that represent major infection risk for medical gear in hospitals.

2.4. Microbial inactivation *in-vivo*

Finally, we will report some results of *in-vivo* tests performed on the tongues of laboratory rats that were experimentally infected with *C. albicans.*

3. References

[1] J. Winter, R. Brandenburg, and K.-D. Weltmann, Plasma Sources Sci. Technol. **24** (2015) 064001.

[2] H. Tanaka and M. Hori, J. Clin. Biochem. Nutr. **60** (2017) 29.