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Organic and Bio material Surface Modification via Corona Discharge induced Atmospheric-Cold Plasma

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Abstract

This paper is to elucidate on the cold plasma-mediated surface modification of organic cells and biomaterials. We demonstrate that the non-aggressive cold plasma can apply on organic materials without causing thermal and electrical damages. The atmospheric pressure cold plasma was generated by utilizing the combination of corona discharge-induced plasma on a tip edge, and the dielectric barrier discharge (DBD). Specifically, this work presents the transformation of the hydrophobic to the hydrophilic surface of sunflower seeds. Therefore, our cold plasma becomes an alternative method of surface treatment for the organic- and bio- materials.

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Keywords: Atmospheric Cold Plasma; Corona Discharge; Dielectric Barrier Discharge; Ozone, High Voltage

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The nature of corona discharge plasma involves with high electric field localized at the edge of associated electrodes. Corona induced plasmas are usually classified according to its gas temperature, non-thermal (cold) plasma, and thermal plasma. There are extensive studies on the applications of utilizing high electric fields in bio, solid and liquid organic materials [1-4]. In environmental applications, for example, the high-voltage electrical discharge has been employed in water cleaning and wastewater treatment [2]. In agriculture applications, many researches have been focused on modifying and improving seed germination characteristics. For enhancing the germination process, oxygen may be provided to seeds by using the chemical based water to improve the germination rate [3]. However, such traditional processes leave the chemical residual causing pollution to the environment. In contrast, the cold plasma is an environmentally friendly, and does not leave any contaminated aqueous waste. In this paper, we propose a cold plasma generated by employing the benefit of fringe field inducing corona discharge on tips' edges in conjunction with the dielectric barrier discharge (DBD) for seed surface modification. Our objectives are (1) to determine if organic materials, such as sunflower seed, used in this work, can survive under atmospheric cold plasma surface treatment without thermal damage, (2) to obtain better hydrophilic properties, leading to better water absorption and enhancing the rate of seed germination acceleration. The water droplet process and contact angle measurement were performed before and after treatment to substantiate the effectiveness of the surface activation. [5-7].

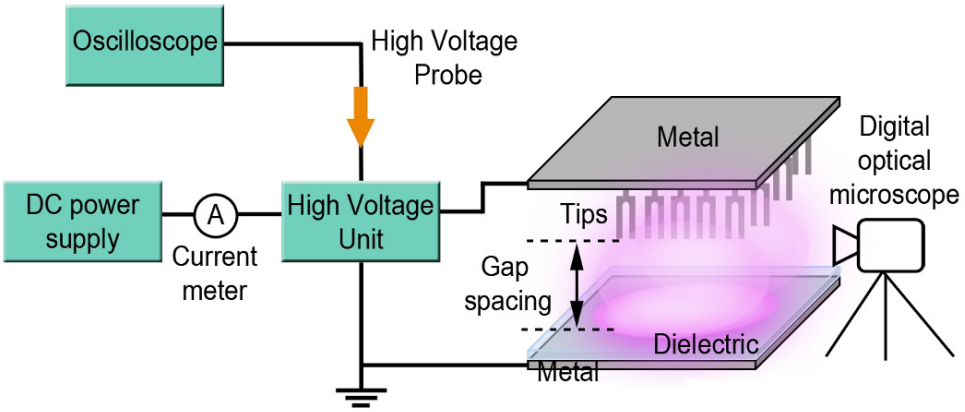

Fig. 1. Schematic Schematic diagram of the plasma device and the experimental setup

Fig. 1 demonstrates the schematic diagram of the cold plasma system utilized in this work. The DC power supply (OMRON DC 24V, 2.1 A) was connected to High Voltage Power Supply Generator. Under plasma operation, the average power consumption was ~5 W. The tips which are stainless steel tip with ~4 cm long and a pair of cut sharp edge, serve as the powered electrode, and a dielectric layer is placed covering a grounded metal plane electrode in order to prevent the transition from corona to arc, causing the thermal damage to bio-materials, and also to stabilize the atmospheric corona gas discharge plasma. Air is the main feed gas of the plasma generation. The argon (Ar) gas may, however, partially introduce to form a mixture of Ar/air.

During such treatment, active species such as charged particles, radicals and UV photons generated in plasma will react only with the surface of a material, leaving the bulk material unchanged. Therefore, to substantiate that our corona discharged-induced plasma is non-equilibrium plasma, the rice grain was exposed to glow discharge plasma. Thermal Imager (Fluke-Ti100) and Thermopoint (AGEMA Infrared Systems) were utilized to measure the real time temperature of operated sample (Fig. 2). During plasma operation, the surface temperature of the specimen increases less than 1°C, whereas high voltage pulse induced plasma in DBD structure shows ~6-13°C temperature increasing after ~1 min treatment [6]. Therefore, this method allows a gentle seed treatment due to the negligible increase in