

Biomedical Application of Non-Thermal Atmospheric Pressure Plasma and Its Usefulness

Guest Editor: Tetsuo Adachi

Introduction to serial reviews: Biomedical application of non-thermal atmospheric pressure plasma and its usefulness

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Plasma is an ionized gas and is described as the fourth state of matter. Electrons, positive and negative ions, radicals, neutral and charged molecules, and photons have been identified in plasma. Plasma may be observed in daily life, e.g., as sun, lighting in thunderstorms, and the Northern lights, and has been applied to technology and industries, e.g., in low-energy light bulbs, surface treatment technologies, air purifiers, and flat panel displays.⁽¹⁾

The treatment of aqueous samples with plasma results in the generation of a large amount of reactive oxygen species (ROS) including hydrogen peroxide (H₂O₂), superoxide anion (O₂⁻), hydroxyl radical (OH), singlet oxygen (¹O₂), and other species that are generated from oxygen in atmospheric air or solution.⁽²⁻⁴⁾ Reactive nitrogen species (RNS) such as nitric oxide (NO) have also been detected.^(5,6)

“Plasma medicine” is a leading and innovative field combining life science and clinical medicine, and its potential has been demonstrated in various applications such as wound healing,⁽⁷⁾

blood coagulation,⁽⁸⁾ sterilization,⁽⁹⁾ dental cavity treatments,⁽¹⁰⁾ and cancer treatments.^(11,12) In these studies, a low dose of plasma was shown to induce the proliferation of cells, while a high dose induced apoptosis as well as necrosis in cells.⁽⁸⁾

ROS and RNS are regarded as the key substances in plasma that affect cell responses.⁽¹³⁻¹⁶⁾ Recent studies demonstrated that plasma exerts effects on cancer cells not only directly, but also by the indirect treatment of cells with previously prepared medium irradiated by plasma, termed plasma-activated medium (PAM).^(11,12,17-20) These findings suggest that the relatively short-lived ROS/RNS produced in media by plasma irradiation may be converted to other relatively long-lived species such as H₂O₂, nitrate/nitrite (NO_x), which endow PAM with high and sustainable reactivity.^(4,21)

In this serial review, basic research on plasma, its reactivity with cell membranes, and its application to the inactivation of bio-particles, blood coagulation, and cancer therapy will be discussed.

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