Degradation of methylene blue in aqueous solution via plasma exposure through gas/liquid interface

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Medical and biological applications of plasma recently have shown remarkable progress with worldwide attentions [1]. High-pressure non-equilibrium plasma including atmospheric pressure is attractive in the field of plasma medicine because thermal damage to cells is negligible with appropriate tuning of the plasma parameters and experimental setup. Particularly, in plasma medical application, it is important to understand plasma interactions with organic materials through plasma/liquid interface because the active species from plasma interact with biomolecules including cells through water in many cases. In this study, plasma interactions with organic materials through plasma/liquid interface as a basis of fundamental processes in plasma medicine have been investigated by degradation of organic molecules due to irradiation of atmospheric-pressure plasma. The Optical emission spectrum of atmospheric-pressure He plasma shows considerable emissions of He lines and the emission of O and OH radicals attributed to dissociation of water (H₂O) has been confirmed in atmospheric-pressure He plasma. Transmittance of the methylene blue aqueous solution treated with the atmospheric-pressure He plasma has been measured by UV-Vis spectroscopy. With increasing plasma treatment time, decrease in absorption peak intensity, which reflects concentration of methylene blue molecules in the aqueous solution, has been confirmed. Variation in molecular structure of methylene blue (MB) in aqueous solution treated with the plasma has been observed via FT-IR and XPS. The results obtained from XPS and FT-IR analyses exhibit that the atmospheric-pressure He plasma exposure has made it possible to degrade organic materials in solution due to oxidation by irradiated radicals from plasma through plasma/liquid interface.