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Electrohydrodynamic effect on physicochemical properties of plasma−water systems: experimental and numerical investigations

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As low-temperature plasma applications for biomedical, food, and agriculture have been increasingly given spatial attention, plasma apparatus has become more diversified and complex. Thus, the emerging issue is to make computational modeling of plasma−water systems, which is a fundamental problem of plasmas with water-containing substances, more realistic. However, so far, in plasma research with weakly-ionized collisional plasmas, including 1-atm plasmas, there is a large imbalance between experimental and numerical analyses. Unveiling this discrepancy is the very first step, but it can be the most challenging part of current modeling due to the complexity. In this context, we report that one of critical phenomena determining physicochemical properties of weakly-ionized plasmas is a collisional coupling between charged particles and neutral particles, resulting in electrohydrodynamic (EHD) flow. In reality, close to plasma electrodes, we can easily experience a weak gas flow. This weak flow significantly affects spatiotemporal distribution of gaseous and aqueous chemical species in plasma-water systems as well as plasma characteristics, and vice versa. As representatively shown in figure 1, there is a large difference between the total production rate of ozone in air and water regions. Finally, to clarify, we found out that taking this EHD flow, called ‘electric wind,’ effect into account in the numerical modeling of plasma-water systems shows a good consistency with experimental results.

References

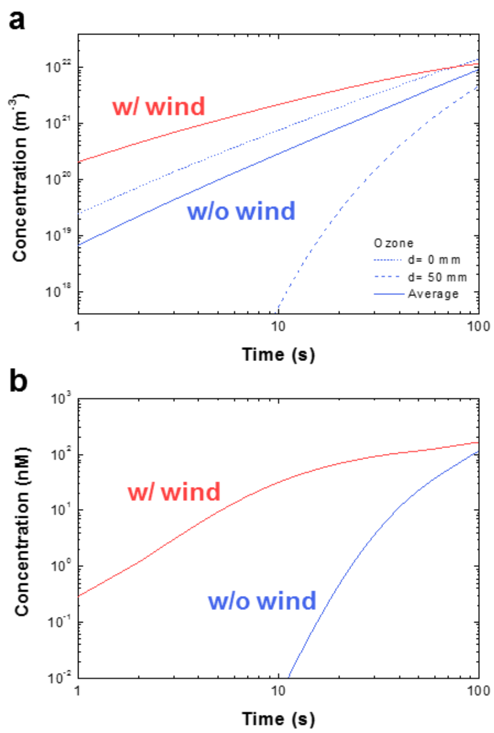

Figure 1. Time development of ozone concentration with and without the electric wind effect within 100 s of the plasma-on time in (a) gas and (b) liquid regions. In (a), dotted and dashed lines indicate the ozone concentration at a distance *d* of 0 and 50 mm from the plasma region, and the spatially-averaged concentration is denoted by a solid line.