Abstract

Atmospheric air plasmas in contact with water produce "plasma-activated water" (PAW), which contains various solvated reactive oxygen and nitrogen species (RONS) after subsequent gas-liquid interactions. This thesis presents experimental investigations of the transport mechanisms of the typical air plasma long-lived species: hydrogen peroxide (H_2O_2), ozone (O_3), nitric oxide (NO), nitrogen dioxide (NO_2), and nitrous acid (HNO_2) into the water in two experimental procedures. First, the single-species transport study, where the transport of the gaseous species generated by external sources, is investigated separately in the water through a bulk reactor which has a fixed surface area of water, and aerosol reactor which produces charged or non-charged of water microdroplets with a larger surface-area-to-volume ratio. Second, the plasma–water interaction is investigated through the atmospheric air plasma of the streamer corona discharge type in contact with water aerosols produced by the electrospray of charged microdroplets or by the nebulized mist of non-charged microdroplets. The solvated aqueous RONS produced during the single-species or plasma–water interaction study, in contact with water, are compared in terms of two main parameters: the role of the gas/plasma–water interface surface area and the role of the charge given by the electrosprayed water microdroplets. An *in situ* optical diagnostic technique of the High-Speed camera imaging method is used for determining the sizes and surface areas of the electrosprayed water microdroplets including their visualization when studying gas/plasma–water interactions.

The solvation of the gaseous species HNO_2 and NO_2 in water is enhanced dominantly by an effect of the charged microdroplets, while the gas/plasma–water interface area parameter plays a dominant role in the enhanced solvation for O_3, NO, and HNO_3. The solvation of H_2O_2 in water is slightly enhanced by the increasing gas–water interface area of the microdroplets with respect to the bulk water. This study contributes to a deeper understanding of the transport mechanism of the gaseous plasma RONS into the water in terms of charged microdroplets and gas/plasma–water interface area. That will lead to design optimization of the plasma–liquid interaction systems to produce PAW containing selected aqueous species with a specific composition that is important in many research fields, such as medicine and biology, as well as food and agriculture.

Key words: plasma–liquid interactions, plasma-activated water, reactive oxygen and nitrogen species, Henry's law solubility, hydrogen peroxide, ozone, nitric oxide, nitrogen dioxide, nitrous acid, water electrospray, aerosol microdroplets, bulk water