Multielectron redox reactions in the electrical double layer at the air/plasma/water interphase

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Cold atmospheric-pressure plasma (CAPP) is a partly ionized gas operated at atmospheric pressures, consisting of charged particles (electrons, ions), radicals, and neutral particles (atoms, molecules) as well as photons. CAPPs typically have low gas temperatures around 300 K, but high electron temperatures or energies of several electron-volts. CAPPs produce various atomic or molecular species if interacting with water and molecular gases such as air. For example, CAPP in air can produce reactive oxygen and nitrogen species (RONS) including biologically active compounds NO_x, H_2O_2, NO_3^-, NO_2^- and O_3. These CAPP products lead to the activation of surface modifying processes in bio-tissue. There are three major multi-electron reactions in nature: nitrogen fixation by bacteria, water oxidation in photosynthesis, and oxygen reduction during respiration. Here we found that a cold atmospheric pressure He-plasma jet (CAPPJ) can oxidize N_2 to HNO_3 with impurities of HNO_2 and H_2O_2 at low temperature and atmospheric pressure at the plasma/water interface. The multielectron mechanisms of the interfacial reactions in the electrical double layer at the plasma-air/water interphase is discussed and evaluated. Analysis of the images which displayed the presence of pH indicators and redox indicators in the aqueous phase showed that redox reactions occur at the plasma/water interface and the products of electrochemical reactions slowly diffuse into the bulk of the aqueous solution. Acidification of an aqueous solution during the CAPPJ treatment correlates with an increase in HNOx concentration in the aqueous phase. The multielectron mechanisms of the interfacial reactions in the electrical double layer at the plasma-air/water interphase is discussed and evaluated. Studies of the mechanisms of plasma-induced processes in biological tissues and surfaces can help to neutralize and prevent side effects in medicine, agriculture, and food disinfection.