

# Time-evolution of $\text{ONOO}^-$ concentration in the water treated with air plasma and its relationship to the production of OH radicals

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We measured time-evolution of the concentration of  $\text{ONOO}^-$  together with that of OH,  $\text{O}_2^-$ ,  $\text{NO}_2^-$ ,  $\text{NO}_3^-$ , and  $\text{H}_2\text{O}_2$  in the water treated with air plasma for 60 min. The concentration of  $\text{ONOO}^-$  was less than detection limit for the first 15 min and detected at 30 min or later, where the concentration increased from 6 to 9  $\mu\text{M}$ . The concentration of OH simultaneously increased at around 30 min. These characteristics indicate that OH is supplied not only directly from plasma but also indirectly through formation of  $\text{ONOO}^-$ , which suggests possibility of sustained release of OH in water treated with air plasma. Saturation in the concentration of  $\text{NO}_2^-$  and steep decrease in the concentration of  $\text{H}_2\text{O}_2$  and  $\text{O}_2^-$  at around 30 min suggest that these species may play some roles to produce  $\text{ONOO}^-$ .

## 1. Introduction

Air-plasma treatment generates various RONS which include OH,  $\text{O}_2^-$ ,  $\text{ONOO}^-$ ,  $\text{NO}_2^-$ ,  $\text{NO}_3^-$ , and  $\text{H}_2\text{O}_2$ . Among them,  $\text{ONOO}^-$  has a unique nature of relatively long lifetime of 1.9 s at physiological pH and release OH radicals during its decomposition reaction sequences [1]. This feature may be used to deliver short-lifetime ( $\sim \text{ns}$ ) OH radicals to remote locations from a plasma/liquid interface. Thus, we have measured  $\text{ONOO}^-$  together with the other RONS to discuss reaction mechanisms.

## 2. Experimental Setup

We treated deionized water using coaxial-type DBD, of which details have been reported elsewhere [2]. Treatment time was 60 min. We measured  $\text{ONOO}^-$  by means of fluorescence spectroscopy using nitrative stress sensing pyrromethene dye (NiSPY-3, Goryokayaku, Japan) [3].  $\text{O}_2^-$  and OH were measured using ESR.  $\text{NO}_2^-$  and  $\text{NO}_3^-$  were measured ion chromatography.

## 3. Results and discussion

Figure 1 show time-evolution in the concentration of measured RONS,  $\text{ONOO}^-$  was not detected for the first 15 min, and appeared at 30 min or later. Its concentration increased from 6 to 9  $\mu\text{M}$  for the last 30 min. OH radical appeared simultaneously at around 30 min. These characteristics clearly indicate that OH radicals can be supplied not only directly from plasma but also indirectly through formation of  $\text{ONOO}^-$ , which suggests possibility of sustained release of OH radicals in water treated with air plasma. Saturation in the concentration of  $\text{NO}_2^-$  and steep decrease in the concentration of  $\text{H}_2\text{O}_2$  and  $\text{O}_2^-$  suggest that these species may contribute to produce  $\text{ONOO}^-$ .

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## References

- [1] J. S. Beckman et al, PNAS **87**, 1620 (1990).
- [2] S. Imai et al, IEEE Trans. Plasma Sci. **43**, 2166 (2015).
- [3] T. Ueno et al, J. Am. Chem. Soc. **128**, 10640 (2006).

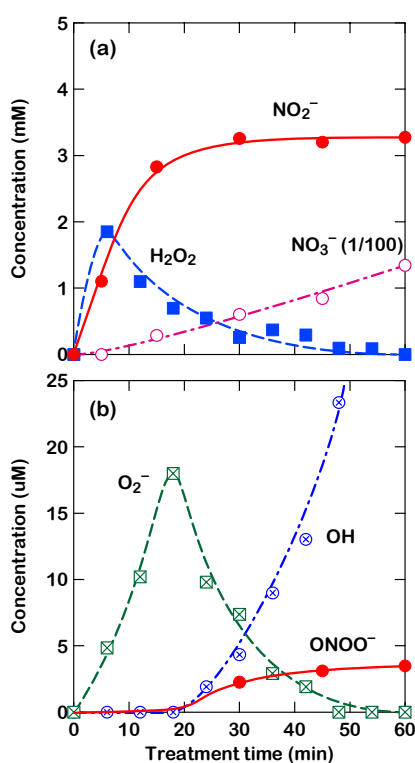


Fig. 1 Concentration of RONS in water measured as a function of air-plasma treatment time.