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Article / Book Information

Title	Study on Bactericidal Effect of Plasma Irradiation and Influence of Reactive Species on Sterilization
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Study on Bactericidal Effect of Plasma Irradiation and Influence of Reactive Species on Sterilization

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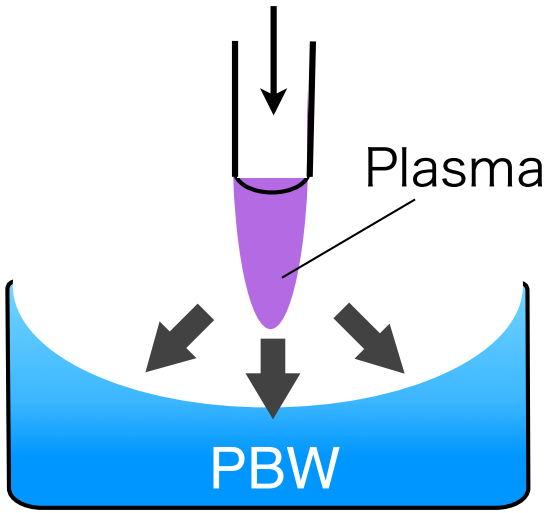
Plasma Bubbled-up Water (PBW)

Plasma is irradiated to the liquid surface and
active species are introduced/generated in the water

▶ Capable of producing liquid with bactericidal effect

- Capable of treating objects with complex shape
- No heat or discharge damage
- Can be stored and used for a certain period of time



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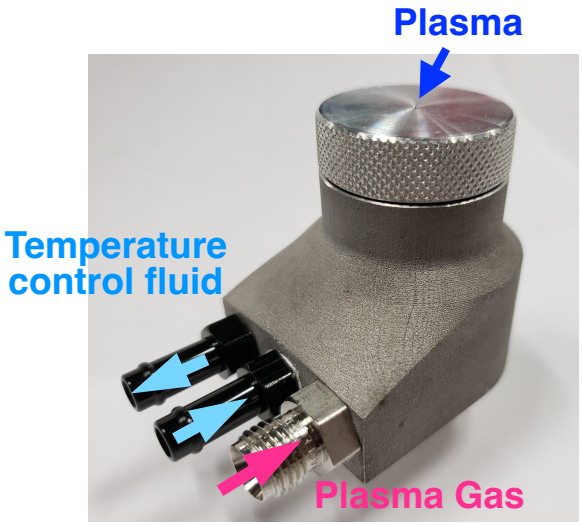
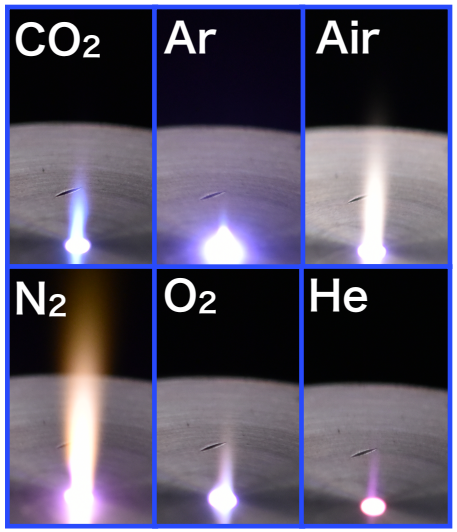
Applications in the medical and agricultural fields

Purpose of this study





The disinfection effect of Plasma Bubbling Water is affected by

- **Gas types**[1]
- **Gas temperature**[2]

[1] T. Takamatsu *et al*., "Microbial inactivation in the liquid phase induced by multi-gas plasma jet", *PLoS One*, 10, 7, 0132381, 2015

[2] H. Kawano *et al*., "Influence of gas temperature in atmospheric non-equilibrium plasma on bactericidal effect", *Biocontrol Sci*., 23, 4, pp. 167–175, 2018

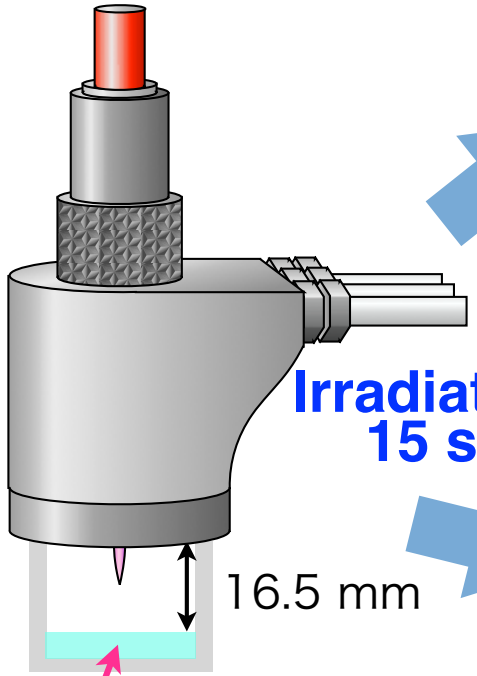
The type and amount of reactive species produced depend on the gas types and gas temperature of the plasma

In this study

The relationship between reactive species produced from plasma of various gas types and temperatures and the disinfection effect was investigated.

Quantification method of reactive species

Temperature controlled
multi-gas plasma system



Spin trapping agent / Indicator
200 μL

Irradiate for 15 sec

ESR: Electron Spin Resonance

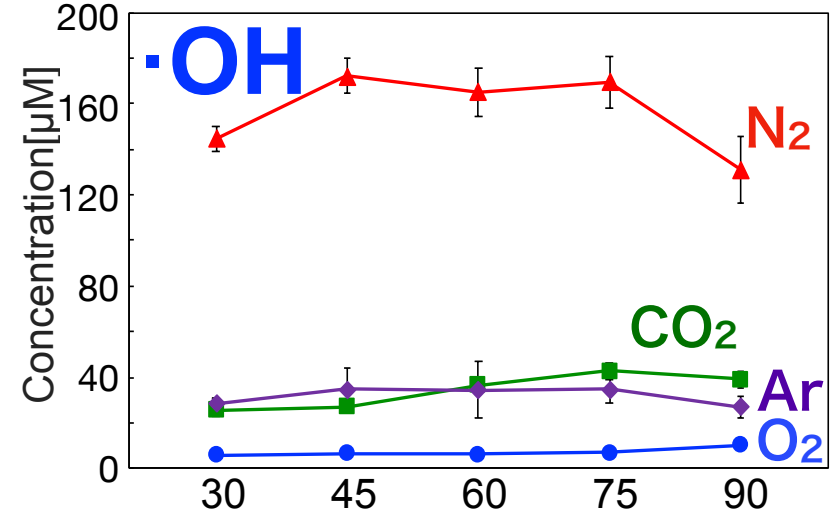
Reactive species	Spin trapping agent
HO·	**DMPO** 5,5-Dimethyl-1-Pyrroline-N-Oxide
$^1O_2$	**TPC** 2,2,5,5-Tetramethyl-3-pyrroline-3-carboxamide

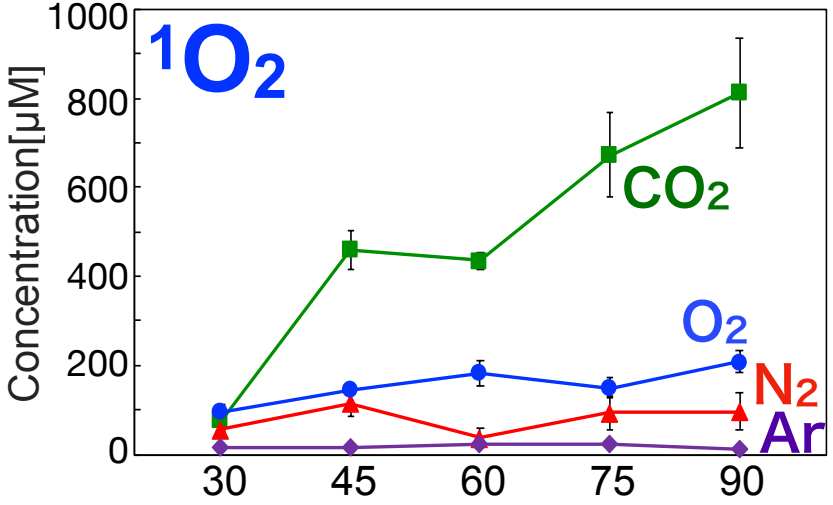
Absorption spectrophotometry

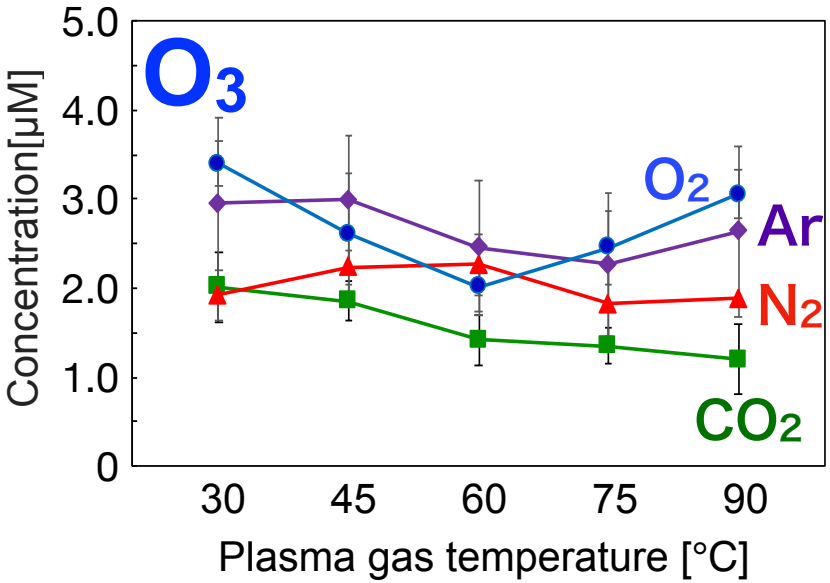
Reactive species	Indicator
O_3	**Indigo**
H_2O_2	**Xylenol Orange + Ammonium iron(II) sulfate**

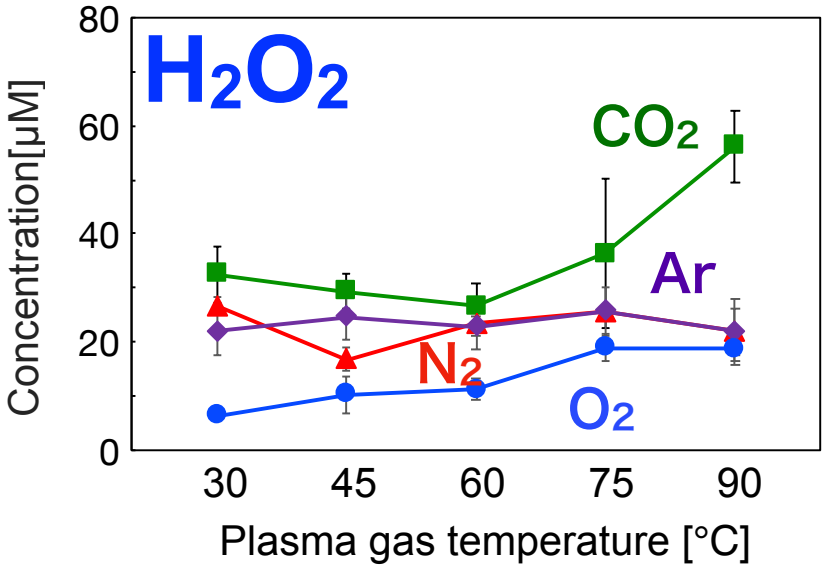
Gas species: O_2, N_2, CO_2, Ar
Gas flow: 3 L/min, Gas Temperature: 30, 45, 60, 75, 90 ℃

Dependence of reactive species on gas species and temperature



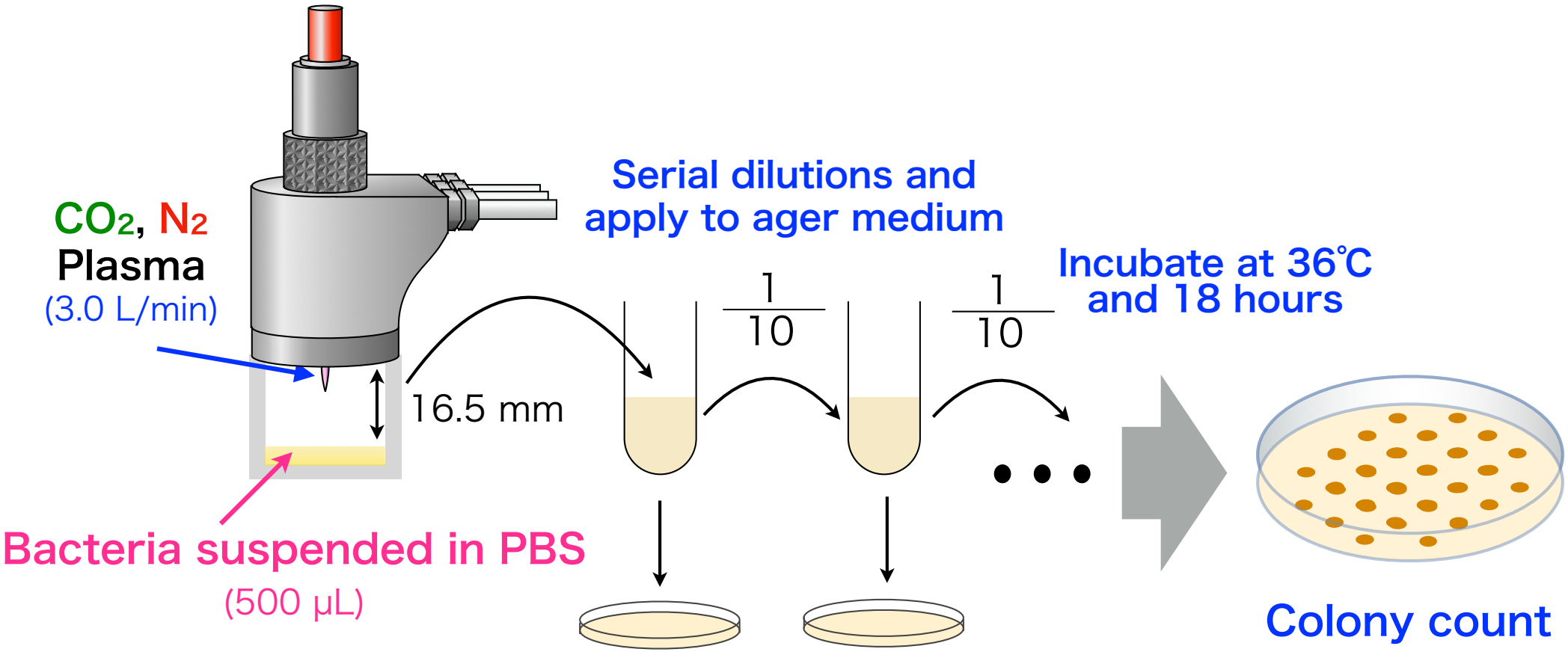






☑ Reactive species produced in the plasma showed dependence of gas species and temperature.

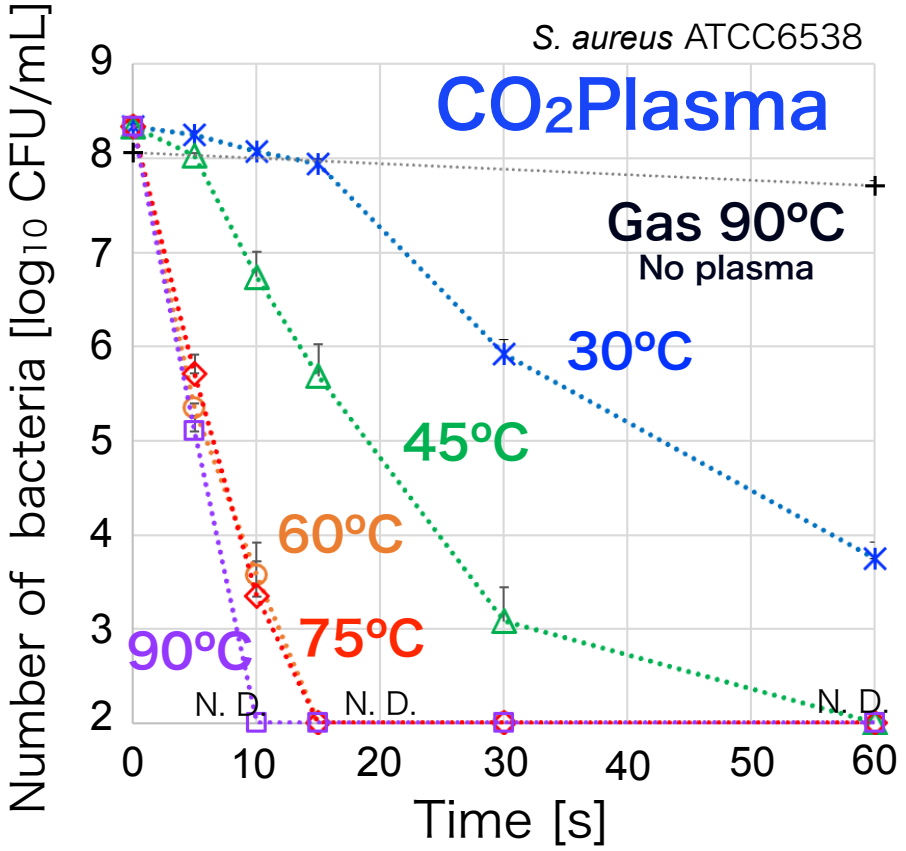
Experimental method of disinfection

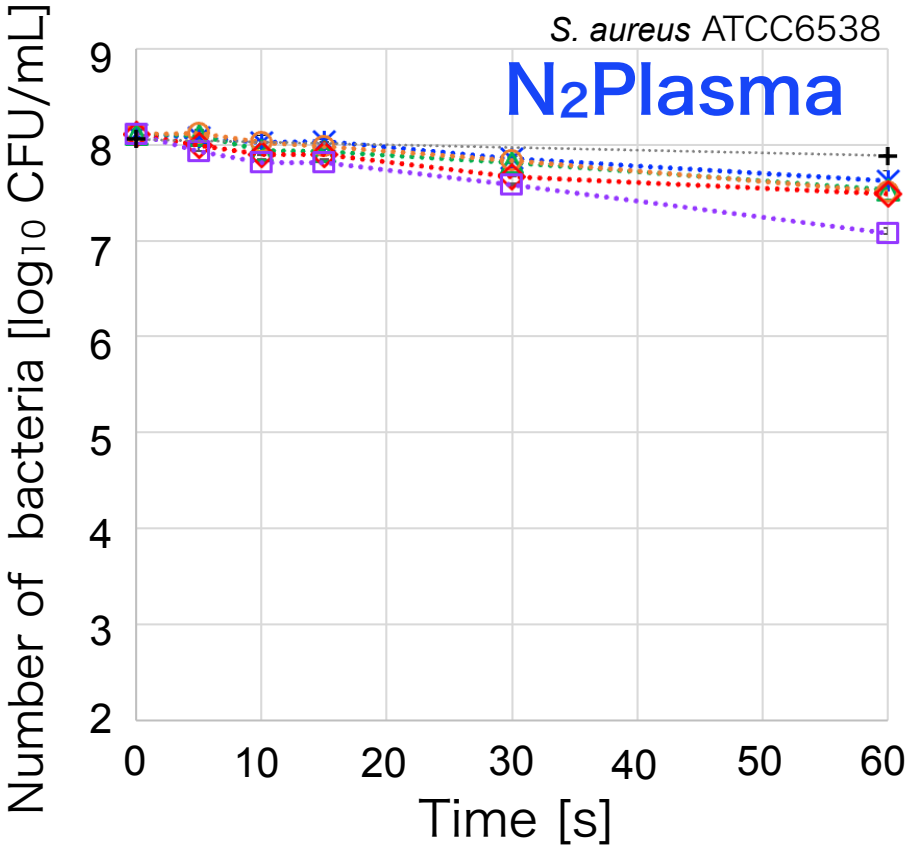


Plasma gas temperature: 30, 45, 60, 75, 90 ℃

Bacteria type: *S. aureus* ATCC6538

Dependence of disinfection effect on plasma gas temperature





- CO_2 plasma reduced the number of bacteria by more than **6** orders of magnitude in 10 seconds at 90℃
- N_2 plasma reduced the number of bacteria by maximum of 1 order of magnitude.

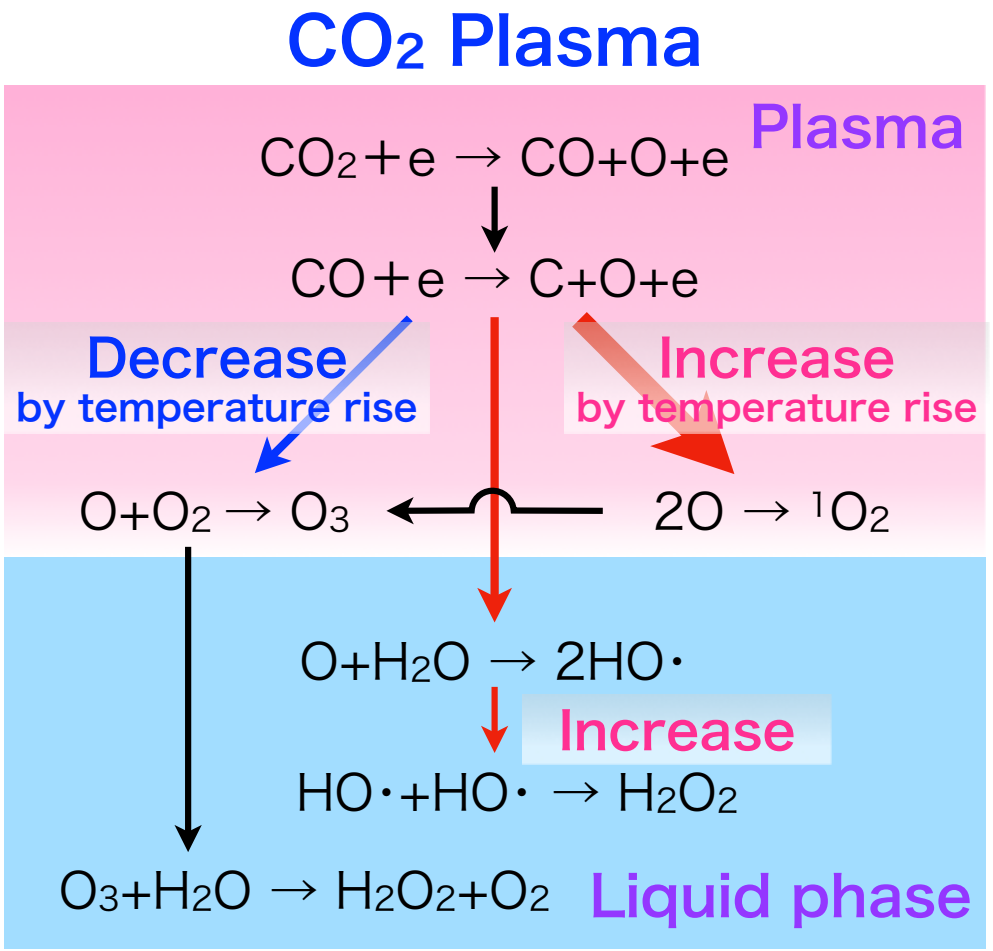
Disinfection effect was improved
by rising the plasma gas temperature.

Reactive species that contribute to disinfection

By temperature rise . . .

- Increased $^1O_2$, H_2O_2 production
- Improved the disinfection effect

☑ $^1O_2$, H_2O_2 are thought to contribute to disinfection effect.



Takamatsu T, Uehara K, Sasaki Y, et al (2014) Investigation of reactive species using various gas plasmas. RSC Adv 4:39901–39905.

Future plan

☐ Measurement of the change in the amount of reactive species before and after disinfection.