Chlorine Dioxide Is a Size-Selective Antimicrobial Agent

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Abstract

Background / Aims

ClO_2, the so-called “ideal biocide”, could also be applied as an antiseptic if it was understood why the solution killing microbes rapidly does not cause any harm to humans or to animals. Our aim was to find the source of that selectivity by studying its reaction-diffusion mechanism both theoretically and experimentally.

Methods

ClO_2 permeation measurements through protein membranes were performed and the time delay of ClO_2 transport due to reaction and diffusion was determined. To calculate ClO_2 penetration depths and estimate bacterial killing times, approximate solutions of the reaction-diffusion equation were derived. In these calculations evaporation rates of ClO_2 were also measured and taken into account.

Results

The rate law of the reaction-diffusion model predicts that the killing time is proportional to the square of the characteristic size (e.g. diameter) of a body, thus, small ones will be killed extremely fast. For example, the killing time for a bacterium is on the order of milliseconds in a 300 ppm ClO_2 solution. Thus, a few minutes of contact time (limited by the volatility of ClO_2) is quite enough to kill all bacteria, but short enough to keep ClO_2 penetration into the living tissues of a greater organism safely below 0.1 mm, minimizing cytotoxic effects when applying it as an antiseptic. Additional properties of ClO_2, advantageous for an antiseptic, are also discussed. Most importantly, that bacteria are not able to develop resistance against ClO_2 as it reacts with biological thiols which play a vital role in all living organisms.

Conclusion

Selectivity of ClO_2 between humans and bacteria is based not on their different biochemistry, but on their different size. We hope initiating clinical applications of this promising local antiseptic.