【Grant-in-Aid for Scientific Research (S)】

Quasi-Droplet Science: Chaos and Order Created by Transformation of Water

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Project Information	Project Number : 25H00405　　Project Period (FY) : 2025-2029 Keywords : Water, Quasi-droplet, Hydrogen bond, Collision, Cleaning & Sterilization

Purpose and Background of the Research

●Outline of the Research

Water-related issues have become critical in recent years due to water localization by climate change, increase of food demand, the expansion of the semiconductor industry, and changing lifestyles. Solving these challenges requires improving the functionality and efficiency of water usage. One innovative approach involves injecting pressurized air mixed with water vapor into the atmosphere, producing extremely tiny droplets about 1/10,000th of the thickness of a human hair. The collisions of droplets can achieve cleaning and sterilization at low temperatures with water saving and non-wetting. These droplets behave differently from normal water, likely due to their tiny size, but the exact mechanism behind their function is still unknown. These droplets include the transformation and coexistence of water vapor, liquid and quasi-solid states that have specific hydrogen bonds, involving complex energy conversions in a very short time. Therefore, we have defined these extremely tiny droplets, which exhibit properties different from those of normal water, as "quasi-droplet." In this study, we aim to unravel the mysteries of "quasi-droplet," which can be considered as a bridge in an unexplored scientific field that connects liquids and molecules, by approaching them from various perspectives, and to create "quasi-droplet science."

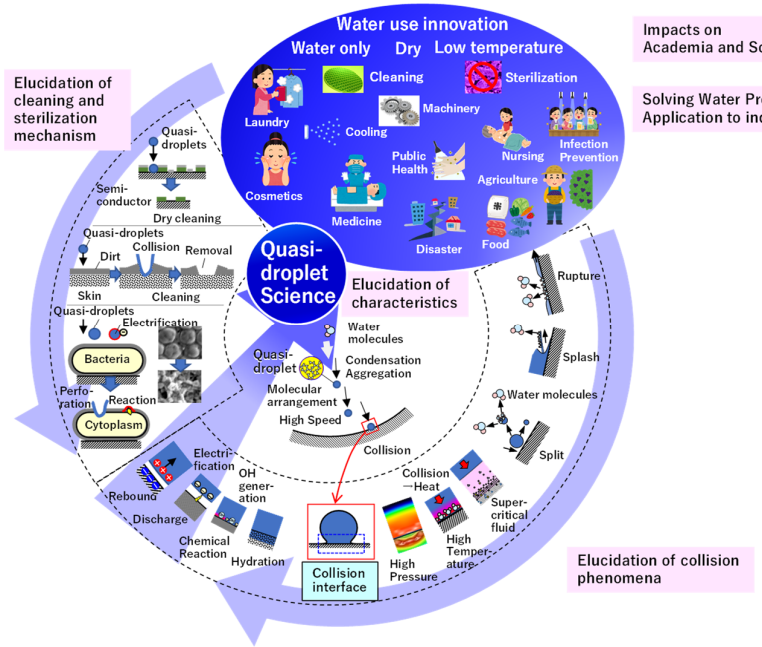

Figure 1. Image of Overall Research: Creating quasi-droplet science and impacts on academia and society.

Expected Research Achievements

● **Elucidation of the physical and chemical properties of quasi-droplets, phenomena at the collision interface, and the reasons for the appearance of specific functions to propose "Quasi-droplet science"**

(1) How do the physical and chemical properties of quasi-droplets differ from those of ordinary liquids? When the droplet becomes smaller, do the molecules inside and on the surface of the droplet line up differently and does the viscosity and pressure of the droplet differ from that of a normal droplet? How are quasi-droplets formed?
Experiment: Takehiko Sato, Siwei Liu (Tohoku Univ.), Hiroharu Yui (Tokyo Univ. of Science), Yoshihisa Harada (The Univ. of Tokyo), Minoru Tanigaki (Kyoto Univ.), Takashi Miyahara (Shizuoka Univ.)
Numerical Analysis: Kazumichi Kobayashi (Hokkaido Univ.), Yuka Iga, Siwei Liu (Tohoku Univ.)

(2) Why do unique features appear at the collision interface? How do the molecular arrangements, hydrogen bond, and mechanical, chemical, and electrical properties change at the moment of collision? How do the state of the cell wall and cell membrane change?
Experiment: Takehiko Sato, Siwei Liu (Tohoku Univ.), Hiroharu Yui (Tokyo Univ. of Science), Yoshihisa Harada (The Univ. of Tokyo), Shigeru Fujimura (Tohoku Medical and Pharmaceutical Univ.), Kosuke Tachibana (Oita Univ.)
Numerical Analysis: Kazumichi Kobayashi (Hokkaido Univ.), Yuka Iga (Tohoku Univ.), Kosuke Tachibana (Oita Univ.)

● **Promote the advancement of academia, the resolution of global water issues, and the application to various fields such as daily life, healthcare, and industry**

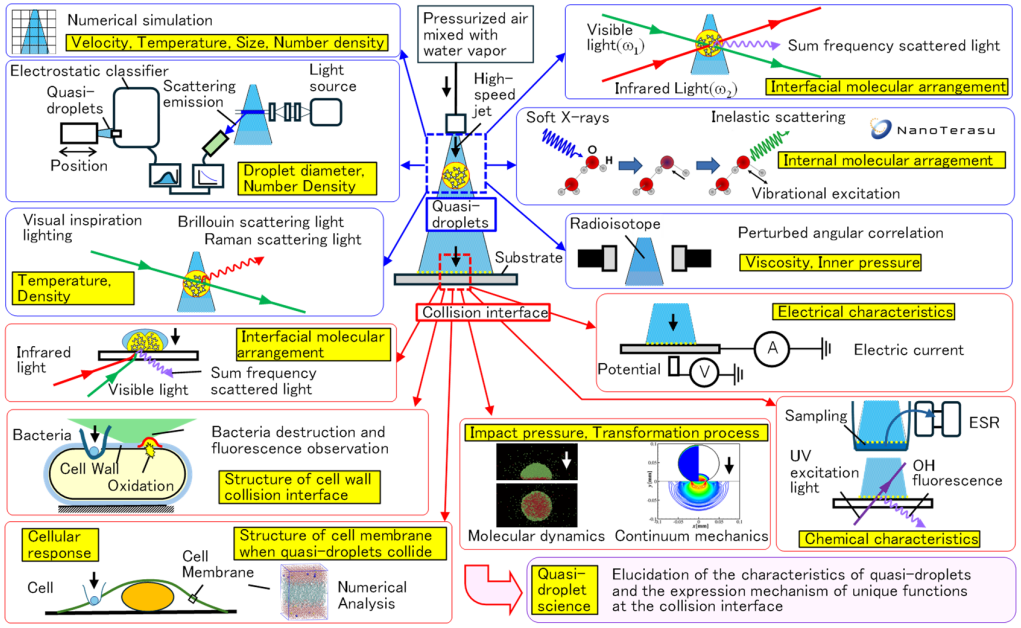

Figure 2. A set of measurement and analysis methods to elucidate the unique features of quasi-droplets.

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