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Bubbles on Enceladus

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Abstract

Saturn's icy moon, Enceladus, ejects frozen particles consisting of water and salts indicative of a subsurface ocean. Believed to originate from hydrothermal reactions near the core, the subsequent pressure drop generates boiling liquids that erupt and expand out of the tiger stripes. The purpose of this research is to simulate the ongoing geyser activity of Enceladus in the lab and to explore the concentrations of biomass which could exist in geyser bubbles as compared to ejected particles. We tested variance of intensity of light absorbed from the bubbles at different heights of the simulated plume. An azo dye, Allura Red, is a complex organic that will act as a tracer molecule allowing for quantitative analysis of light absorption through a spectrophotometer. The azo dye in combination with water is ejected from a water chamber using compressed air to simulate bubbles forming and a jet erupting from a body of water. Samples were taken of the bubbles at varying heights of the simulated plume as analogs to the Enceladus geysers. This research will provide quantitative analog information on rising bubbles from the ocean of Enceladus which can be applied directly to the practical concern of measuring biomass in the plume.

Introduction

What we know about the interior ocean composition of the small icy moon, Enceladus, is based mostly on our data of the plume material being ejected into space. Something that would tell us more about the astrobiological possibilities on Enceladus would be to understand plausible organic concentrations in the plume bubbles based on known information of Enceladus plume composition and structure.

Why Bubbles?
Most of the plume mass is attributed to H_2O gas, with a smaller percentage of the plume mass attributed to the ice grains. How exactly bubbles fit into this framework is still not understood.
• There may be a contribution of organics to the total organic matter in the plume stored in bubbles forming near the geyser vents.
• Bubbles will give us a better understanding of processes taking place below the surface.
• Data such as expected bacterial concentrations can be determined.

A bubble is a thin film inflated with air or gas and it's formation is controlled by [1]

Operating Parameters:	System Properties:	Physiochemical Properties:
Gas flow through an orifice	Orifice Dimensions	Liquid Viscosity
Mode of Operation	Orifice Chamber	Liquid Density
Flow/static condition of a liquid	Volume	Nature of the Liquid (ex. polar or nonpolar)

By understanding the parameters that affect the bubble formation process, an experiment can be devised to simulate the bubbles forming in the Enceladus' subsurface vents.

Experiment

The Plume
To simulate a single Enceladus geyser (or jet), a compressed air tank was used to eject water and dye into the air. The air tank was created from a 4-inch diameter PVC pipe with endcaps. A hole was then drilled at the center of each end cap for the attachment of an air pump and pipe valve. A water hose functioned as a connection between the compressed air tank to the plastic bottle.

The Bubbles
A sonicator was used to generate bubbles in a solution containing dye, water and a surfactant. The surfactant, hexadecyltrimethylammonium bromide, allowed for the isolation of the bubble in the aqueous solution by forming a foam above the liquid [2]. The foam is then easily collected into a separate container to be condensed and analyzed.

Analysis

The samples collected are placed in a spectrophotometer passing light through the liquid to measure the intensity of light that is absorbed. Using Beer's Law, the amount of Allura Red present in each sample can be calculated and a calibration graph can then be produced relating the amount of concentration to absorbance.

These concentrations can thus be compared to correlate the concentration observed in the bulk liquid of the simulated geyser and the bubbles. This will provide the desired estimate for the biomass enhancement due to bubbles to that of the underlying liquid.

Conclusion

The ratio of the concentration of organics in a plume bubble to the concentration of organics in the bulk liquid will give us a better understanding of the biomass relationship between the bubbles and the plume.

- A difference in concentration in the plume to that of the bubble would indicate that there are processes that either inhibit or enhance the amount of organics captured within the drops ejected.
- A similar volume of organics in the plume with and without bubble considerations would be indicative that biomass enhancements from bubble processes are negligible.

References

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