EPSC Abstracts
Vol. 13, EPSC-DPS2019-339-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Differential ablation of organic-coated micrometeoroids observed in the laboratory

Michael DeLuca (1,2), Zoltan Sternovsky (1,2), Mihály Horányi (1,3), Tobin Munsat (3), Juan Diego Carillo-Sánchez (4), John M. C. Plane (4), Diego Janches (5)
(1) Laboratory for Atmospheric and Space Physics, University of Colorado, Boulder, CO, USA, (2) Aerospace Engineering Sciences Department, University of Colorado, Boulder, CO, USA, (3) Physics Department, University of Colorado, Boulder, CO, USA, (4) School of Chemistry, University of Leeds, Leeds, UK, (5) NASA Goddard Space Flight Center, Greenbelt, MD, USA (michael.deluca@colorado.edu)

Abstract

Earth's atmosphere is constantly bombarded by micrometeoroids that inject material into the upper atmosphere. To study how micrometeoroids ablate in the atmosphere, we shot organic-coated olivine particles into an air target at 10-20 km/s. Our studies confirmed that the organic coating ablates differentially from the rest of the particle, and indicated that large molecules may survive the ablation.

1. Introduction

Studying how micrometeoroids ablate in free molecular flow is essential in order to understand how exogenous material is delivered to Earth and the atmospheres of other planets by micrometeoroids. For instance, micrometeoroids may have delivered exogenous organic molecules to the early Earth that played a role in the origin of life [1], if the organics could survive the ablation process. Ablation studies are also important for interpreting ground-based observations of meteors, in which differential ablation [2], the process by which more-volatile species in a meteoroid will ablate before the less-volatile species, may affect the detectability of meteors.

2. Experimental Method

To study the physical processes involved in meteoric entry, we create simulated meteors in the laboratory using the 3 MV electrostatic dust accelerator at the University of Colorado. Using the accelerator, we shot olivine particles coated in polypyrrole (PPy) at speeds of 10-20 km/s into a gas target [3] containing air. The gas target contains a series of 16 charge collectors to collect the ions produced by the particles as they travel through the gas, heat up, and ablate under free molecular flow conditions. The charge collectors provide spatially-resolved observations of each particle's charge production, and an impact detector at the end of the target chamber detects whether or not a particle has fully ablated. In the experiment, the particles were observed to ablate their PPy coating first, followed by impact signals that showed the olivine cores of the particles did not ablate.

3. Results

These observations provide an independent laboratory confirmation of differential ablation of meteors. The experimental ablation profiles were also compared to a simple meteor ablation model which takes into account the heating of the particle and the breakdown of PPy. Combined with the model, the products of the PPy ablation can be constrained using the ionization data. The ionization efficiency of the PPy ablation products was calculated, which may play a role in the detectability of meteoric organics by radar. Carbon atoms will not produce ions in air at the velocities most of the particles were shot into the gas target, indicating that larger organic molecules might be responsible for the observed ionization. The experimental results show that organics can differentially ablate from the surface of a micrometeoroid, and indicates that large molecules can survive that ablation, potentially providing a pathway for the delivery of organic material from micrometeoroids into the atmosphere of a planet.

References

[1] Anders, E.: Pre-biotic organic matter from comets and asteroids, Nature, Vol. 342, pp. 255-257, 1989.

[2] McNeil, W.J., Lai, S.T., and Murad, E.: Differential ablation of cosmic dust and implications for the relative abundances of atmospheric metals, Journal of Geophysical Research, Vol. 103, pp. 10899-10912, 1998.

[3] Thomas, E., Simolka, J., DeLuca, M., Horányi, M., Janches, D., Marshall, R.A., Munsat, T., Plane, J.M.C., and Sternovsky, Z.: Experimental setup for the laboratory investigation of micrometeoroid ablation using a dust accelerator, Review of Scientific Instruments, Vol. 88, pp. 034501, 2017.