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Cometary analogues for GIADA calibration: micro-spectroscopy investigation

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Abstract

A suite of terrestrial materials has been selected as cometary analogues for GIADA calibration. These materials have been crushed, milled and sieved in order to produce grains with size ranging between 20 and 500 µm.
In this work, we will present a preliminary analysis of the cometary analogues by means of MIR and Vis-NIR micro-spectroscopy. We will investigate how the IR spectra of single micron-sized grains change by varying their sizes. The spectra of our analogues will be then compared with astronomical spectra of asteroids and with laboratory spectra of extraterrestrial samples collected by Stardust and Hayabusa probes.

1. Introduction

GIADA is part of the Rosetta payload and is able to measure the speed, the momentum, the mass, the optical cross section of single cometary grains ejected by the periodic comet 67P Churyumov-Gerasimenko [1]. For GIADA calibration, a statistically relevant number of grains acting as cometary dust analogues has been dropped or shot into the Proto Flight Model (PFM) operative in clean room in our laboratory. According to the results coming from the mineralogical analyses of Comet Wild 2 grains [2][3][4] and of Interplanetary Dust Particles [5], we selected a list of natural mineral as cometary dust analogues (Tab.1) for GIADA laboratory calibration. Therefore, for each material, we produced grains in four size classes: 20-50 µm; 50-100 µm, 100-250 µm and 250-500 µm. For a more realistic scenario, besides the pure monomineralic grains, we also produced grains coated (or partially coated) both with a layer of carbon and with a layer of sodium hexafluorosilicate (Na_2SiF_6), a material that the GIADA optical detectors (GDS) see as water ice: its optical properties are very similar to the water ice at the GDS operative wavelength range (900 nm).
All the micrometric grains used for GIADA calibration are analyzed by means of FE-SEM/EDS analyses, for a morphological and compositional characterization [6]. Complementary information on the same samples, i.e. mineralogy and chemistry are obtained by means of micro-spectroscopy investigation.
In this work, we focus on individual grains micro-infrared spectroscopy results. Our aim to compare these spectra with those acquired on cometary and asteroidal samples collected by Stardust and Hayabusa, respectively.

Table 1: List of the terrestrial materials used as cometary dust analogues during the calibrations activity performed on the GIADA [6].

Terrestrial Material
Forsterite
Fayalite
Melilite
Enstatite
Alkali-feldspar
Anorthite
Serpentine
Talc
Kaolinite
Pyrrhotite
Corundum

2. Experimental set-up

For the infrared micro-spectroscopy, we used a Fourier transform interferometer (Mod. Bruker Equinox-55) connected to a microscope, and located at the "Laboratorio di Fisica Cosmica e Planetologia", Naples (Italy). The IR beam is focused through a microscope objective on individual grains to collect their spectra. This set-up (working range 5000-600 cm^{-1}) is able to acquire spectra in transmission mode on single particles with dimensions ranging between 20 and 500 µm.

Visible-NIR (0.4-1.0 µm) diffuse reflectance micro-spectroscopy was performed at Orsay (France) using a VIS-NIR grating spectrometer coupled through infrared transparent fibers to an optical microscope, allowing illumination at angles higher than 35° and collection at fixed angle e=0°.

3. Discussion and Results

Infrared spectroscopy is a powerful and non-destructive analytical technique to investigate extraterrestrial grains.

Fig. 1 shows the transmission spectra of enstatite grains with different sizes: the two largest grains present similar features, while the smallest grain (Ø ~ 30 µm) displays a quite different spectrum. These spectral variations (such as the shape and the pick positions) can be qualitatively explained by the complex light scattering effects due to the different grain sizes [7].

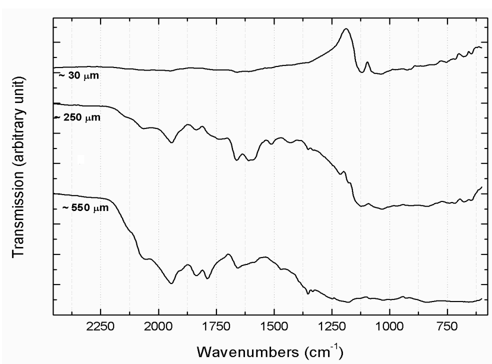

Figure 1: Transmission spectra of three enstatite grains with different dimension. As the grains are definitely not spherical, we report the length of the longest grain dimension.

In order to have more realistic cometary/asteroidal dust analogues, we have also produced and analysed mineral grains coated by an amorphous carbon layer. We have investigated the nonlinear effects of carbon coating on the silicate reflectance spectra.

In this work, we will show and discuss the preliminary results of our spectroscopic investigation, by comparing the spectra of cometary and asteroidal samples with those of our analogues.

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