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Reflectance spectra of solid organic acids and their mixtures with Fe-sulfide pyrrhotite: Insights into the surface composition of comet 67P/CG.

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Abstract

We present 0.3-17 μm reflectance spectra of different solid organic acids (including amino acids) and their fine-grained intimate mixtures with pyrrhotite ($Fe_{1-x}S$), a Fe-sulfide. These data provide a valuable basis for compositional interpretation of remote sensing spectra of the comet 67P/CG's surface. In particular, we investigate the ability of an opaque Fe-sulfide to suppress absorption bands of organic acids and to modify key spectral parameters such as contrasts, widths, shapes of absorption bands and continuum slopes. Finally, we compare our results to the VIRTIS/Rosetta spectra of comet 67P surface in order to assess the possible contribution of carboxylic O-H vibrations to the broad complex 3.2-μm absorption band in the comet spectra.

1. Introduction

The Visible and InfraRed Thermal Imaging Spectrometer (VIRTIS) onboard Rosetta orbiter revealed that the surface of comet 67P/CG is dark from the near-UV to the IR and enriched in organic and opaque components [1,2]. The VIRTIS spectra of the 67P nucleus show a broad complex absorption feature around 3.2 μm consistent with the ubiquitous presence of a variety of organic components [2]. The broadness of the observed band can be explained by the contribution from carboxylic functional groups [1,2]. Fine-grained opaque phases (in particular the Fe-sulfides pyrrhotite or troilite) are likely responsible for the low IR reflectance and low contrast of the 3.2-μm absorption band [1,2]. The work by Istiqomah et al. [3] provided the first important steps towards understanding the possible contribution of carboxylic acids to the VIRTIS spectra of the 67P surface. Reflectance spectra of organic acids are barely available. Diagnostic absorption features of carboxylic acids can be strongly modified in the presence of intimately admixed opaque components [e.g., 4,5]. Thus, the evidence of carboxylic acids on the surface of 67P requires dedicated laboratory studies of laboratory analogs including opaque components.

2. Samples and Methods

We acquired a set of 23 solid organic acids containing carboxylic groups (including 6 amino acids) at the Department of Chemistry of the Humboldt-Universität zu Berlin. The choice of acids was not based on their particular relevance to cometary organics, but rather on their compositional diversity. In this study we were focused only on organic acids which are stable in a solid state at room temperature. Two types of acid powders were spectrally characterized – coarse-grained non-sorted powders and fine-grained powders manually ground in an agate mortar. Several selected organic acids were mechanically mixed in different proportions with a well-characterized [5] fine-grained (<25 μm) natural pyrrhotite. The mixtures were prepared by manual grinding of the mixed end-member powders in an agate mortar. Biconical reflectance spectra (0.3-17 μm) of pure acid powders and acid-pyrrhotite mixtures were measured at the Planetary Spectroscopy Laboratory (DLR, Berlin) in vacuum at i=e=15° or i=13°; e=17° using a Bruker VERTEX 80v FTIR-spectrometer equipped with a Bruker variable angle reflectance accessory.

3. Results

The measured reflectance spectra were analyzed in terms of key spectral parameters (positions, depths, widths and overall shapes of major absorption bands, continuum slopes, reflectance values). Particular attention was dedicated to the position and shape of the short-wavelength flank of the broad complex

feature around ~3.3 µm associated with carboxylic O-H stretching vibrations. Gradual changes of spectral parameters as a function of pyrrhotite content in the mixtures were investigated, quantified and compared to the corresponding parameters of the average spectrum of the 67P surface [6]. The results of the analysis will be presented and their implications for compositional interpretation of VIRTIS/Rosetta spectra will be discussed.

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