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FT-IR and μ-IR analysis of Carbonaceous Chondrite meteorites characterization as possible analogue of next sample returned materials

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Abstract

In this work, the Fourier Transform Infrared Spectroscopy (FT-IR) and Infrared μ-spectroscopy (μ-IR) techniques have been applied on four Carbonaceous Chondrites (CC) meteorites, as possible analogues of the Hayabusa2 and Osiris-REx space missions asteroid targets. The analysed CC meteorites belong to CV, CI and CM classes. Chondrules, CAIs, and mineral inclusions, have been identified and analysed in detail in the spectral region 8-14 μm (μ-IR analysis). CC packed powders have been analysed using a FT-IR spectrometer in the spectral range of 2-14 μm. The absorption bands, Christiansen and Reststrahlen features, of the main minerals have been identified. We plan to compare the FT-IR spectral results with C-type asteroids data collected by in-flight spectrometers (e.g. 1Ceres, 10Hygeia etc.).

1. Introduction

Different types of analysis were performed to characterise returned asteroidal and cometary samples, and meteorites [1,2,3]. The mineralogy and composition of an extraterrestrial body is the key to know its geological evolution. For this purpose, remote-sensing infrared spectroscopes are mounted onboard space probes [4]. To support space data interpretation is fundamental their comparison with spectra acquired on extraterrestrial samples that can be considered analogs of the space mission targets. Waiting for the best analogs, i.e. samples that will be returned from primitive asteroids targets by Hayabusa 2 and Osiris Rex missions [5,6], we applied FT-IR and μ-IR techniques to four CC meteorites, as possible analogues of 101955 Bennu (B-type) and 162173 Ryugu (C-type).

2. Samples and Analysis

We analysed four CC samples: 1) Murchinson (CM2 group) and 2) NWA8267 (CM2 group), characterized by small chondrules and refractory inclusions [7]; 3) NWA2086 (CV3 group) with considerable amount of large mm-size chondrules and Calcium Aluminum Inclusions (CAIs), many surrounded by igneous rims [8], 4) Orgueil (CI1 group) characterized by the absence of chondrules and refractory inclusions and with a high degree of hydration [9]. A preliminary analysis was performed on CC samples using a Stereo Microscope (Leica M205c) equipped with a digital camera in order to select the sample regions characterized by a significant mineralogical heterogeneity. Spectra have been acquired with μ-IR Microscope (mod. Bruker Hyperion 3000) and analysed in the spectral range of interest: 8-14 μm on the selected regions (Fig.1). The Christiansen features and Reststrahlen bands of the main minerals have been identified and summarized in Table 1.

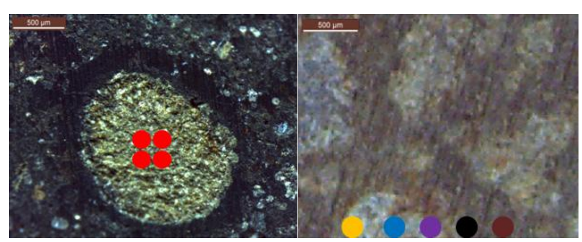

Figure 1. Examples of selected regions analysed with the μ-IR technique. *Left*: NWA8267 (CM2). *Right*: NWA2086 (CV3).

To support the identification of minerals detected in selected features by μ-IR analysis, packed powders of meteorite samples were analyzed by FT-IR spectroscopy. FT-IR analysis was performed using a Bruker Vertex 80 Spectrometer with a MCT-detector (which is liquid nitrogen cooled) obtaining the bi-directional reflectance in the spectral range 2-14 μm.

The measurement configuration for data acquisition was with incidence (*i*) and emission angle (*e*) of 30°. The acquired spectra are shown in Fig. 2.

Table 1: Bands identified by means of μ-IR technique.

Meteorite	NWA2086	Murchison	NWA8267	Orgueil
Type and class	CV3	CM2	CM2	CI
Analysed region	Chondrule, Matrix	Inclusions	Chondrule, Matrix	Matrix
Christiansen feature (μm)	8.2	8.4, 9.2	8.5	8.9
Main spectral bands (μm)	9.1, 10.5, 11.2, 12	9,10, 10.4, 10.5 11, 11.5, 12.2	9.1,10.5, 11.6	9.5,10,10, 11.3, 11.9

3. Results and future perspectives

The data acquired with μ-IR technique (Fig. 2, on *Left*) on CCs matrix, chondrules and CAIs inclusions indicate that the spectral bands:

- in Murchison can be ascribed to the Fe-rich olivine, to a pyroxene mixture and phyllosilicates [7];
- in NWA8267 can be assigned to a mixture of pyroxene with the predominance of the Ca-rich member [10];
- in NWA2086 can be ascribed to olivine, Ca-rich plagioclase and pyroxene [8];
- in Orgueil can be ascribed to serpentine, saponite, and Fe-rich olivine [9].

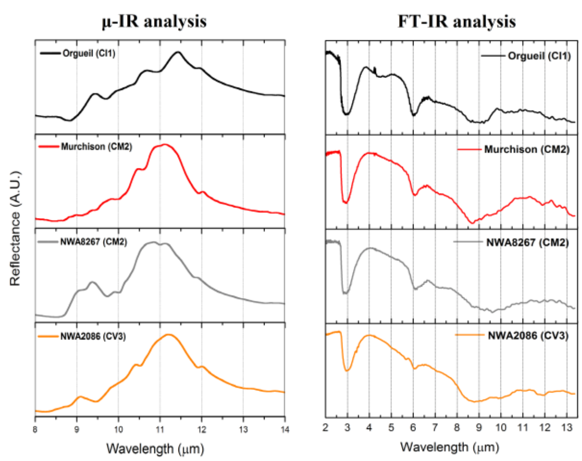

Figure 2. The spectra obtained by μ-IR (*left*) and FT-IR (*right*) spectroscopy on the four CC meteorites.

The spectral data acquired with FT-IR analysis on CC powders show a distinct absorption band between 2.8 and 3 μm which is attributed to the OH stretching band and a weak absorption band at 3.4 μm which can be attributed to the presence of organics [11]. These features are weaker in CM and CI than in CV3 sample for which clear absorption bands can be observed between 3.3 and 3.5 μm.

We plan to compare, in the near future, the CCs spectral data obtained between 2 and 4.2 μm with C-type asteroids spectra, e.g. 1Ceres, 10Hygeia, to find similar spectral features. In addition, Field Emission-Scanning Electron Microscope with Energy Dispersive Spectroscopy (FE-SEM/EDS) measurements will provide chemical information of meteorite samples and high resolution images of the inclusions morphology. This technique, combined with μ-IR and FT-IR analysis will provide a comprehensive mineralogical framework for the CC meteorite selected samples, which will help the returned samples characterization of next sample return missions.

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