Infrared Spectroscopy of Extraterrestrial Material: Comparison with Astronomical Spectra of Dust.

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Introduction: As part of our ongoing project to identify astronomical dust, we obtained infrared spectra of minerals and components from primitive meteorites. The aim is to produce a database of spectra for comparison with infrared spectra from dust in space, e.g. in circumstellar or protoplanetary disks. We think that minerals from primitive extraterrestrial material are well suited for this purpose, since these components formed in environments similar to that of the dust disks [1]. In addition, most of the dust observed is also not pristine, but has also been processed. So it is safe to assume that such materials are a good approximation of the dust observed [2].

Techniques: The infrared spectra of the specimens were obtained using a Perkin Elmer Auto Image infrared microscope. Usually, small grains (or already powdered material) were compressed after characterization to a very fine-grained, sub-micron powder using a diamond compression cell. In the following, the material was analysed under the infrared microscope. Of several measurements of the material, an average spectrum was calculated [1]. The astronomical spectra come from earth- and space-based observations, using the NASA Aerospace spectrograph at the NASA Infrared Telescope Facility (IRTF) for the circumstellar disk around β Pictoris [3], Aerospace Corp BASS (IRTF) for comet Hale Bopp [4], the ISOCAM at the Infrared Space Observatory (ISO) for zodiacal dust [5] and the United Kingdom Infrared Telescope (UKIRT) for the red supergiant PR Per [6].

Results: A selection of mid-infrared spectra of representative components from unequilibrated carbonaceous chondrites is compared with astronomical spectra in Fig.1. Matrix material is represented by olivine- and pyroxene-rich material from Allende and Vigarano. Interior material from Calcium-Aluminium-rich Inclusions (CAI) are from in Vigarano and Ornans, and a spectra of a Wark-Lovering rim from a Vigarano CAI.

These results are compared to spectra in the same wavelength range of a already evolved circumstellar disk, β Pictoris [3], a comet (Hale Bopp) [4], the zodiacal light [5] and dust around red supergiant, PR Per [6].

The zodiacal dust (Fig.1c) shows the greatest similarity to the matrix material from Allende and Vigarano, of which only a weak band has no match. Of the CAI materials, only the interior of the Vigarano sample shows good similarity between 9 and 11 microns, but a strong spinel (?) band at ~12 microns has no equivalent in the zodiacal light.

Comet Hale Bopp only shows similarity to the strong band at ~11.2. microns, occurring in the matrix spectra and the melilite/spinel rich interiors of the Vigarano and Ornans CAIs. However, there are no matches to the other strong band in the cometary spectra.

At the first glance, there are no matches for the spectra of the red supergiant PR Per (Fig.1b). However, with a slight shift of ~0.2 microns towards higher wavelengths, 4 of 5 strong bands in the spectra of the Ornans CAI provide a good match.

Allende matrix material and the interior of the Ornans CAI are similar to the composition of the circumstellar disk around β Pictoris Fig.1a).

Summary: Mid-infrared spectra of components from CV and CO chondrites show some similarity with astronomical spectra from several astronomical objects. However, in some cases small shifts in band positions are needed.

Since this comparison took place only in a narrow spectral range (8-13 microns), confirmation of these similarities is needed from spectra in the far-infrared (up to 100 microns). Also other factors which can influence the band positions, namely temperature, grain size and composition, have to be investigated in the future.

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References:

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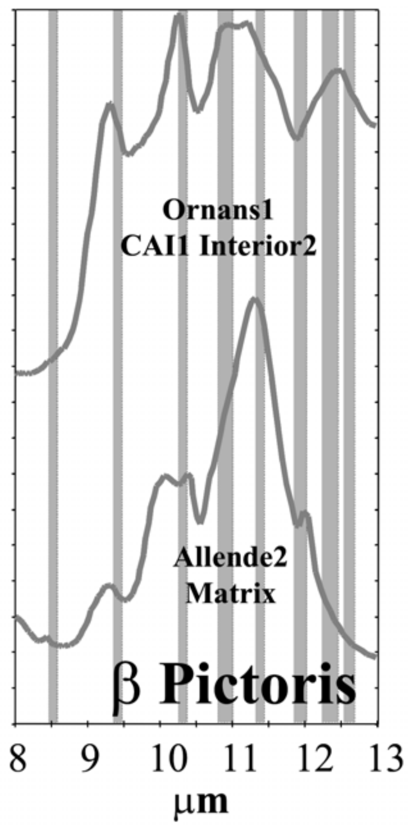

Fig1a

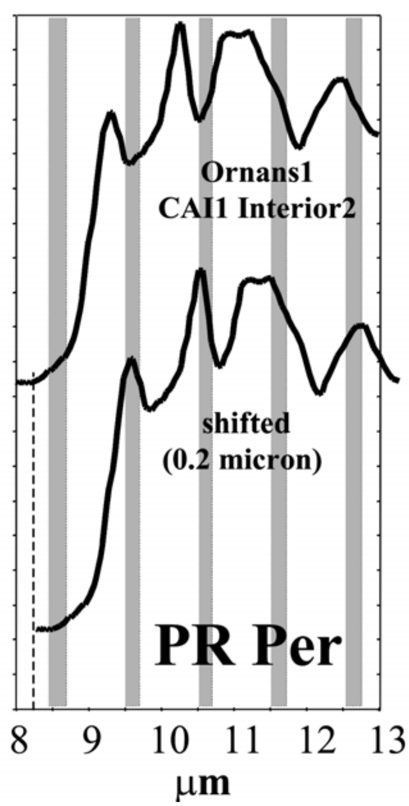

Fig.1b

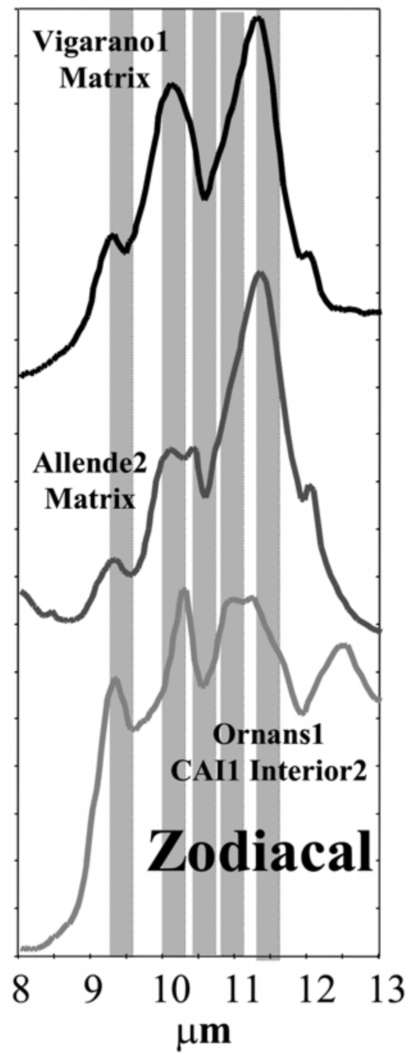

Fig.1c

Fig1a-c: (All spectra in relative absorbance) Comparison of laboratory spectra with the bands (grey bars) of astronomical spectra (a) matrix and CAI data with the spectra from the circumstellar disk around β Pictoris (b) with the AGB star PR Per. Here a small shift of 0.2 microns is necessary to achieve a fit for the bands. (c) compares the spectra with zodiacal dust in our Solar system.