INFRARED SPECTROSCOPY OF MICRO-ORGANISMS NEAR 3.4 μm IN RELATION TO GEOLOGY AND ASTRONOMY *

(Letter to the Editor)

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Abstract. Microorganisms sealed in KBr discs have an absorption spectrum over the 2.5–15 μm waveband that shows thermal stability as they are heated in an inert atmosphere to temperatures of about 400 °C. Microfossils tightly sealed within cavities in rocks could be endowed with similar properties of thermal stability. The observed absorption of interstellar material along the line of sight from the solar system to the galactic centre is remarkably similar to the spectrum of dry micro-organisms over the 3.15–3.7 μm waveband.

1. Introduction

We began this work, which will be reported in more detail elsewhere, from the controversial attack by Bridgwater *et al.* (1981) on the claim of Pflug and Jaeschke-Boyer (1979) to have found both chemical and morphological evidence of the presence of microfossils of an apparently eukaryotic character in sedimentary rocks of the Isua series. As we understand the situation, the minimum temperature set by geologists for the lowest metamorphic grade in this series is somewhat below 400 °C. The argument of the critics is that all evidence of biotic material would have been destroyed at such a temperature. Thus in a review of the controversy Nisbet and Pillinger (1981) wrote: 'In the oil industry it is well known that by 250 °C everything that can be cracked will be cracked to give methane and graphite end products.' The oil industry does not work with biomaterial tightly sealed inside small cavities, however, as Pflug (1980) reports to be the situation for the examples he has studied. And from thermochemical calculations one can see that strict enclosure conditions can make a substantial difference to the balance of the thermochemical reactions producing degradation to graphite. So instead of relying on cracking in the oil industry we sealed various microorganisms at a pressure of 6.8 tonnes cm^{-2} inside KBr discs. The cell containing such a disc was then placed in a furnace where an assigned temperature could be maintained for periods of hours, the furnace being flushed continuously by nitrogen gas at a pressure of 28 atm. The specimens were then examined for degradation by infrared spectroscopy using a Perkin Elmer 257 spectrometer over the wavelength range from 2.5–15 μm.

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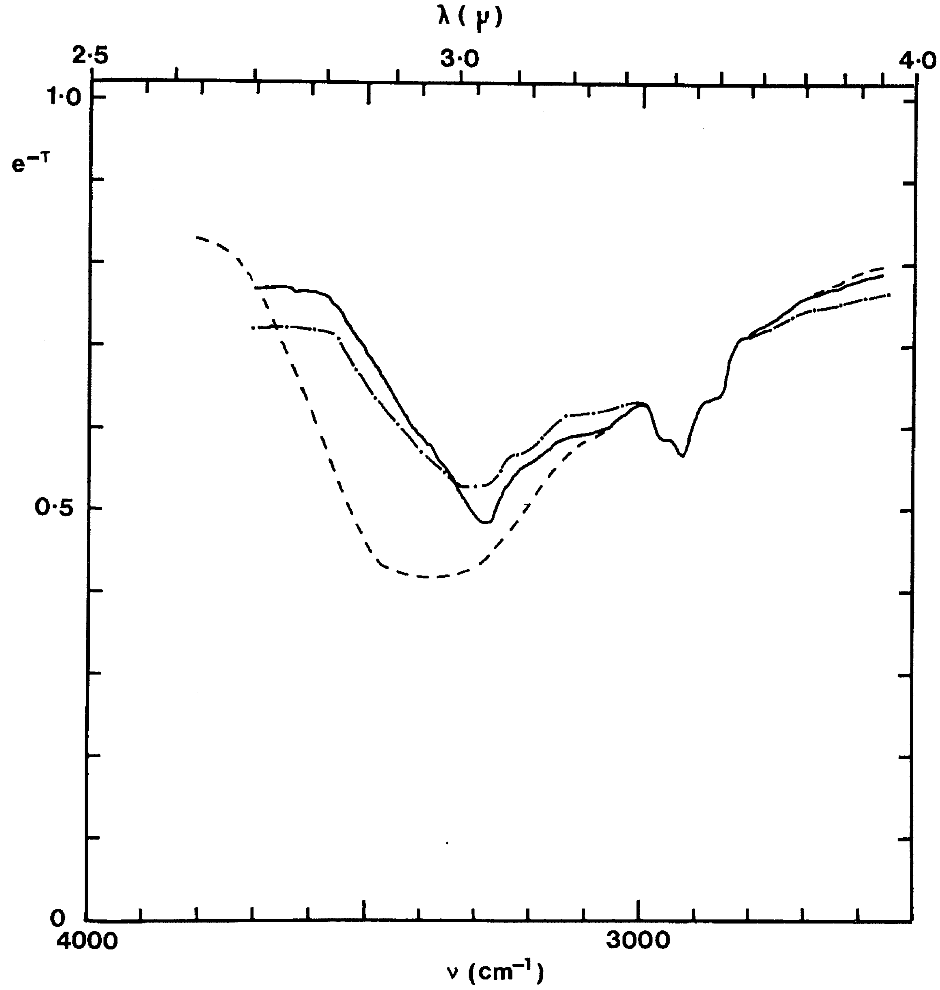

Figure 1. The measured transmittance curves for microorganisms. The solid curve is for *E. coli* at room temperature, the dot-dashed curve is for *E. coli* at 350 °C and the dashed curve is for dry yeast at room temperature. The dry mass of *E. coli* was 1.5 mg dispersed in a KBr disc of radius 0.65 cm. The transmittance data for yeast was normalised to agree with the *E. coli* curves at $\lambda = 3.406$ μm.

The results showed remarkable stability up to 380 °C after which, as the temperature rose significantly above 400 °C, there was degradation towards graphite. These values are likely to be on the conservative side, since it was hard to prevent the metal wall of the cell holding a KBr disc from becoming somewhat hotter than the recorded temperature which was measured by a thermocouple at the disc centre. Conduction tended to cause specimens to be heated above the recorded temperature, an effect shown in the highest temperature cases by an excess charring of the specimens towards the circumference of the KBr disc. In our estimate the

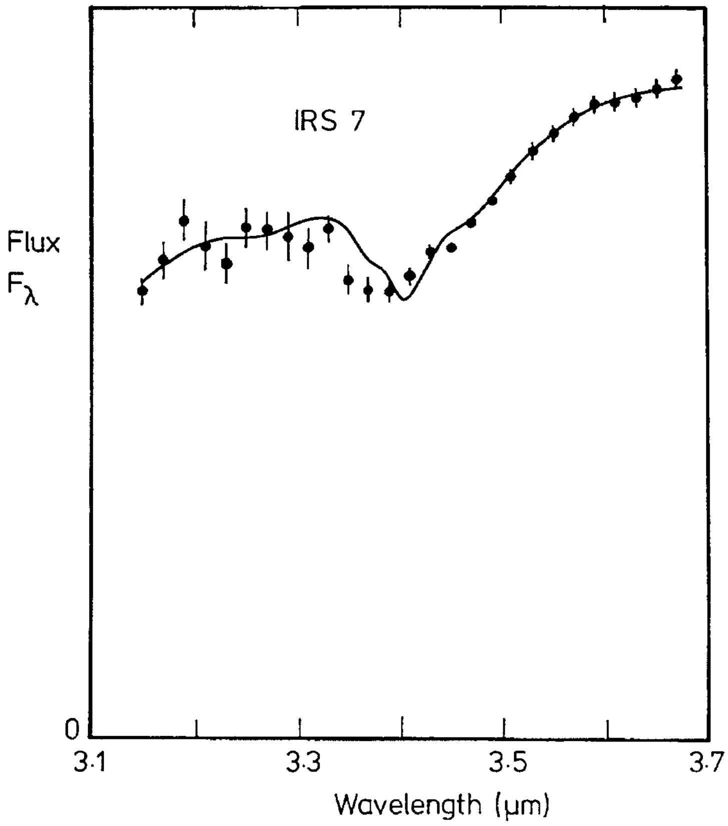

Figure 2. The astronomical observations for GC-IRS 7 (Wickramasinghe and Allen, 1980) compared with the calculated spectrum for bacteria heated to 350 °C. The calculation assumes a continuum with slope similar to that of a Planckian distribution at 800 K for the underlying source over the 3.15–3.7 μm waveband and an optical depth of 1.36 times the laboratory measurements shown in Figure 1.

temperature at the rim was about 25% higher than at the centre, giving a critical temperature for thermal stability of about 500 °C.

Figure 1 shows the measured transmittance curves of *E. coli* for recorded temperatures of 20 and 350 °C. While the curve is generally the same for the whole wavelength range shown in the figure, there is a striking invariance between 3.3 and 3.5 μm. Still more strikingly, the same invariance was shown to hold for eukaryotes, as the curve in Figure 1 for yeast cells shows. Judged by this invariance, and also the invariance of other absorptions further in the infrared, we conclude that the chemical integrity of biomaterial sealed in KBr matrices was preserved up to temperatures of at least 400 °C. If sealing in KBr is considered analogous to geochemical sealing as evidenced in the Isua material, the preservation of microfossils would be assured in rocks that had been metamorphosed to temperatures of 400 °C.

The laboratory measurements we have discussed here have a relevance to astronomy in relation to ideas recently discussed by two of the present authors (Hoyle and Wickramasinghe, 1981). Micro-organisms in a dry state that have been proposed as a model for interstellar dust would produce the invariant absorption effect at 3.4 μm shown in Figure 1. A suitable source for studying this absorption, IRS 7 at the galactic centre, has recently been observed by Wickramasinghe and Allen (1980) (points in Figure 2). The curve shows what the absorption effect would be for *E. coli* that has been dried out by heating to 350 °C. The curve is calculated from the data displayed in Figure 1 assuming a continuum slope similar to a Planck distribution of temperature 800 K for the underlying source, and for an opacity equal to 1.36 times the laboratory values for *E. coli*. The agreement over the entire waveband of Figure 2 is satisfactory. We note that the spectrum of microorganisms has shoulders within the 3.4 μm band at 3.36 and 3.478 μm, and that hints of such shoulders exist in the astronomical data. Another, slightly stronger absorption band is also to be expected centred on a wavelength in the range 2.9–3.05 μm. It remains to be seen whether future observations of IRS 7 bear out these predictions.

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