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Search for Organics in 103P/Hartley 2 in the Near-IR with GNIRS

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Abstract

We report on the search in comet 103P/Hartley 2 for PAHs near 3.28 µm, for organic iso-nitriles near 4.9 µm, and for the 4.62 µm X-CN band with GNIRS instrument on Gemini-N. On 2010 Dec 5 UT, which was soon after GNIRS came on the telescope and near the peak of the light curve periodicity [1], spectra were obtained in the L-band (R~1700, high quality data) and M-band (R~4300, poor quality). The search for organics was motivated by *EPOXI Mission* encounter spectra of an organic feature in the near-IR [2] and anomalous CN emissions [3,4]. The data are being analyzed to derive flux limits on potential PAH emission bands with a focus on the relatively small species detected in *Stardust* Mission return samples from comet 81P/Wild 2 [5,6].

1. Introduction

Two mysteries imbue the study of cometary organics: Where are the PAHs that are so ubiquitous in the interstellar medium and in meteoritic organics [7]? What is the parent organic material of the short-lived species that decompose into CN in the coma of comet 103P/Hartley 2? Comet 103P/Hartley 2 was the target of the EPOXI (Deep Impact Extended) Mission encounter on 2010 Nov 04 UT [2]. In September 2010 there was an anomalous increase in CN [3] and in the few weeks leading up to the encounter it became clear that this comet is producing a strong CN feature that is due to a 'distributed' source of unidentified nature [4,8]. The carriers of such distributed sources are a long-standing mystery in cometary science [9].

By and large, comets are thought to be a population of small bodies in our solar system that are more primitive than the least-altered main belt asteroids. Unlike asteroids, comets do not contain the robust macromolecular carbon material or the large PAH domains. Rather, *Stardust* comet return samples show that comets contain small PAHs, as well as some aromatic molecules with some carbon (C) substituted by nitrogen (N) [5,6].

1.1 Focus on small PAHs in *Stardust*

Specifically, Stardust samples contain Naphthalene ($C_{10}H_8$) (as in moth balls), Acenaphthalene ($C_{12}H_8$), and Phenanthrene ($C_{14}H_{10}$) [5]. Smaller PAHs are expected to have longer lifetimes in comet comae [10]. At 1 AU, the UV radiation field of the Sun contains significantly less far-UV radiation compared to the ISM but is significantly more intense. The consecutive absorption of two UV photons can destroy a PAH. The decrease in stability arises because as the size of the fused ring PAH increases, the rate of UV adsorption becomes proportionally larger than the rate of radiative relaxation by fluorescence and phosphorescence [6]. Although Joblin et al. compute a lifetime of 10 sec for Anthracene ($C_{14}H_{10}$) at 1 AU, the lifetimes may be significantly longer according to recent laboratory measurements of small PAHs in an argon matrix [11]. Stardust collected samples from the coma of comet 81P/Wild 2 at a distance that corresponds to coma lifetime of 20 minutes to several hours, so the PAHs in Stardust samples will be the smaller ones with the longer coma lifetimes. We focused on looking for similarly small PAHs in comet 103P/Hartley 2.

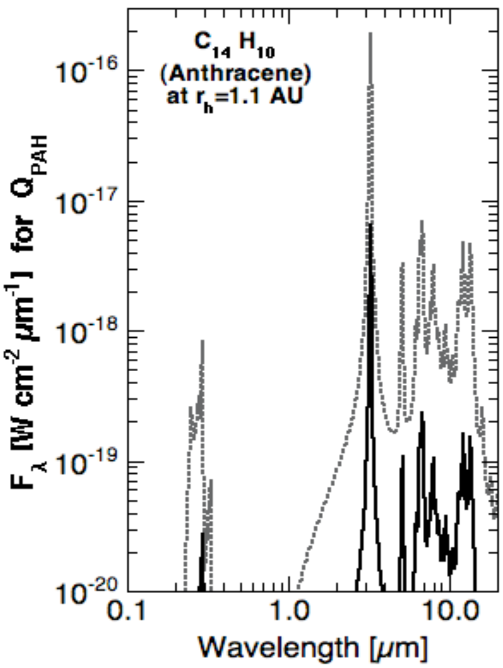

Figure 1: Fluorescence model for ($C_{14}H_{10}$), given Q_{PAH}=1.5E27 mol/s (*dotted line*, fitted to comet Halley [13]) and Q_{PAH}=5E25 mol/sec (*solid line,* GNIRS detection limit), for the distance of r_h=1.1 AU for comet 103P at ~2010 Dec 05 [7, 14].

1.2 Focus on nitriles in *Stardust* samples

Compared to meteorites, Stardust samples not only contain smaller PAHs but also are considerably more nitrogen-rich. The N predominantly occurs in the form of aromatic nitriles (R-C≡N) [6]. Many important biologic species on Earth incorporate C≡N bonds but without biology it is hard to break atmospheric N_2 (N≡N) and form C≡N bonds; the bottle neck in making organo-N compounds could be circumvented if aromatic nitriles were delivered to Earth by comets [5,6,11,12].

Aromatic nitriles (R-C≡N) or isonitriles (R-N≡C) might be the carriers for the distributed source of CN in comet 103P/Hartley 2. Many comets possess yet-to-be identified organic grain components that have finite lifetimes in the coma. Grains flying from the nucleus into the coma desorb or photo-dissociate after a few hours to less than a day and release simpler molecules that can include formaldehyde (H_2CO), cyanide (CN), or carbon monoxide (CO).

2. Implications

Characterizing cometary organics is a current challenge in cometary science because of the short lifetimes in comet comae or because the laboratory examination techniques applied to *Stardust* comet return samples appear to modify comet organics under even low energy doses such as in Raman spectroscopy or XANES (x-ray absorption near-edge spectroscopy) [6]. In *Stardust* samples PAHs often are associated with organics containing ISM enrichments in D and ^{15}N, so cometary PAHs probably trace the survival of some interstellar relic organics. PAHs have been mostly elusive to remote sensing efforts [7]; the sensitivity of GNIRS+Gemini improves the odds of detecting small PAHs in comets.

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