Do Titan's Dunes Glow in the Dark? Ralph D. Lorenz[1], Sarah M. Hörst[2] , Chao He[2]
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Introduction: Titan's vast fields of organic sand dunes likely contain compounds which may fluoresce. The absence or presence, and possibly color, of fluorescent emission, may make a useful classification technique for Titan surface material.

Composition: While Titan's dunes [1] cover a substantial fraction of its surface, the composition of Titan's sand is not known, but (as reviewed in [2]) seems likely to be principally organic. It is optically dark, and has a low dielectric constant [3]. A near-infrared signature [4] associated with aromatic compounds correlates with the dunes, although is very non-specific. Since photochemical products from which the sand is presumably derived include nitriles and other N-bearing species, it is likely incorrect to refer to the sand as just 'hydrocarbons' – the incorporation of nitrogen into laboratory tholins is well-documented. Mass spectra of the upper atmosphere taken during Casssini flybys [5] show a broad peak consistent with polycyclic aromatic hydrocarbons (PAHs), likely also including N-substituted PAHs ("PAN-Hs").

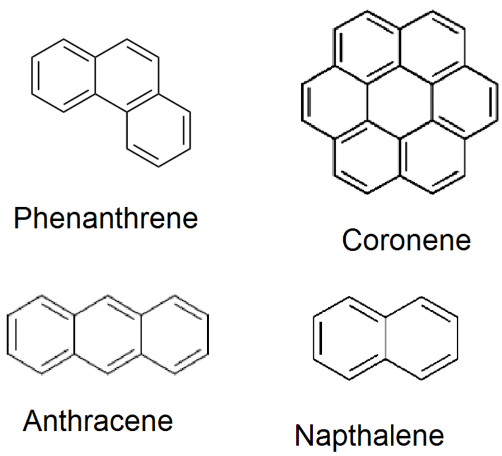

Figure 1. Structures of some simple PAHs : Phenanthrene and Coronene are seen in figures 2,3 ; Anthracene and Napthalene have been tentatively identified in Cassini flyby data [5]

Fluorescence: Many aromatic organics, and especially PAHs, exhibit fluorescence. Even when stimulated by near-UV light such as that from an inexpensive light-emitting diode (LED) 'black light' (typically these emit at 390nm), prominent fluorescent emission can be seen without special photodetectors (figures 2 & 3).

In fact, fluorescence is used to detect PAHs (typically from petroleum contamination) seawater. Time-gated laser methods are used to enhance sensitivity and specificity – crude oil dilution to 10 parts per billion can be detected via pyrene fluorescence [6]. Prototype Mars instruments have reliably detected PAHs in Atacama soils at 10s of ppb levels [7].

Figure 2. Samples (clockwise from top left) - Terrestrial silicate sand (Erg Chebbi, Morocco), Tonic water (contains quinine), ACS Coronene 97%, "Tide" powder detergent (contains an 'optical brightening agent'), ACS Phenanthrene 95% at bottom left. Samples are in white plastic trays.

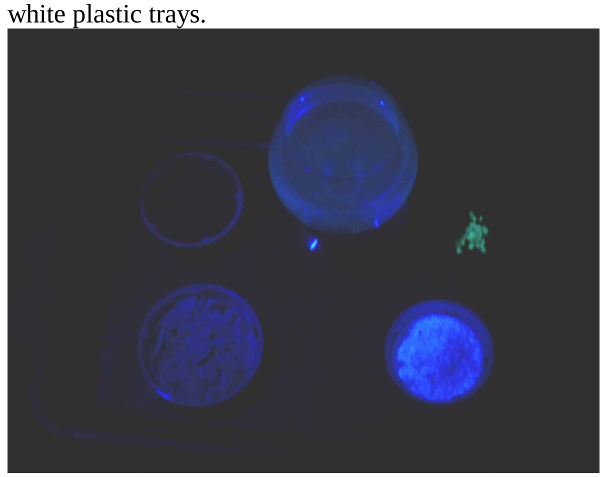

Figure 3. Same samples as figure 1, seen with a standard digital camera (Casio EX-RZ10) in darkness, with samples illuminated with a near-UV LED flashlight (390nm). The sand is totally dark ; some faint fluorescence is seen from the quinine solution and the phenanthrene, and strong yellow fluorescence from coronene.

The relevance for fluorescence at Titan was noted by Hodyss et al. [8] They measured fluorescence of tholins and aqueously-altered tholin materials, which are of particular interest astrobiologically since hydrolysis of laboratory tholins can yield amino acids [9] and other important prebiotic molecules. Hodyss et al. [8] noted that tholins were most responsive to excitation at 410nm, and unaltered (in acetonitrile solution) emitted most strongly at 471nm (blue). However, aqueously-altered tholin in ice had a fluorescent emission peaking around 550nm (green). Spectroscopy or even color imaging could discriminate these emissions : we have ourselves noted with the naked eye that tholin hydrolysis products fluoresce prominently, whereas at least some unaltered tholin samples showed no glow under 390nm illumination.

Application to Future Missions: The strong absorption of blue and UV light by Titan's haze (which is what gives Titan its orange color) means no solar UV reaches Titan's surface. Haze absorption, and strong Rayleigh scattering by the thick nitrogen atmosphere likely make long-range (km) remote sensing challenging at UV wavelengths, but the immediate vicinity of a lander could be lit with a UV floodlight, and/or the close-in workspace of a robotic arm/hand lens camera could be equipped with UV LED illuminators, as on MAHLI on MSL (which has 2 LEDs emitting at 365nm [10] and has been used to search for fluorescent minerals [11]).

Imaging at night on Titan with UV LED illumination could detect fluorescence easily, and there seems a rather higher a priori likelihood of finding fluorescent materials on Titan than on Mars. The Dragonfly relocatable lander concept [12] could make such measurements in a number of locations, sampling both dune sand and aqueously-altered materials of astrobiological interest [13]. By identifying compositional gradients (with mass spectrometric analysis [14] of sands, and bulk elemental analysis by gamma-ray methods [15]) in a dunefield, such a mission may inform the sand source material and transport processes at work on Titan [16,17].

Speculations: A topic of future study is to assess whether likely Titan sand material might exhibit triboluminescence (either direct mechanical stimulation of light emission, or via triboelectric charging [2] and glow discharge effects). A landed mission should take long-exposure night-time images, especially if it is windy, just in case.

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