

OPTICAL CONSTANTS OF KEROGEN FROM 0.15 TO 40 μm : COMPARISON WITH METEORITIC ORGANICS; B. N. Khare,¹ W. R. Thompson,¹ C. Sagan,¹ E. T. Arakawa,² C. Meisse,² and I. Gilmour³

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Kerogens are dark, complex organic materials produced on the Earth primarily by geological processing of biologically derived material, but kerogens have chemical and spectral similarities to some classes of highly processed abiological extraterrestrial organic materials. Kerogen-like solids have been proposed as constituents of the very dark reddish surfaces of some asteroids [1] and are also spectrally similar to some carbonaceous organic residues and the Iapetus dark material [2]. The optical constants of kerogen can be used to investigate the effects of particle size, void space and mixing of bright and dark components in models of scattering by dark asteroidal, cometary, and satellite surfaces.

We have measured the optical constants of both Type II kerogen and of a macromolecular organic residue from the Murchison carbonaceous chondrite via transmission and reflection measurements on thin films. These films, of thickness 0.2-1.3 μm , are produced by vacuum deposition of kerogen powder heated to 550-750°C onto sapphire, CaF_2 , and CsI substrates. IR spectra of the thin films show that the spectral features of the kerogen powder are retained (Fig. 1).

Apparently no substantial change in optical constants occurs upon vacuum deposition, except for the desirable loss of silicate contaminants which can be seen in the spectra of the powder at $\sim 1100 \text{ cm}^{-1}$.

The infrared spectra of complex organic solids such as kerogens generally show a limited number of absorption bands which are due to well-defined chemical groups [3,4] (Table 1).

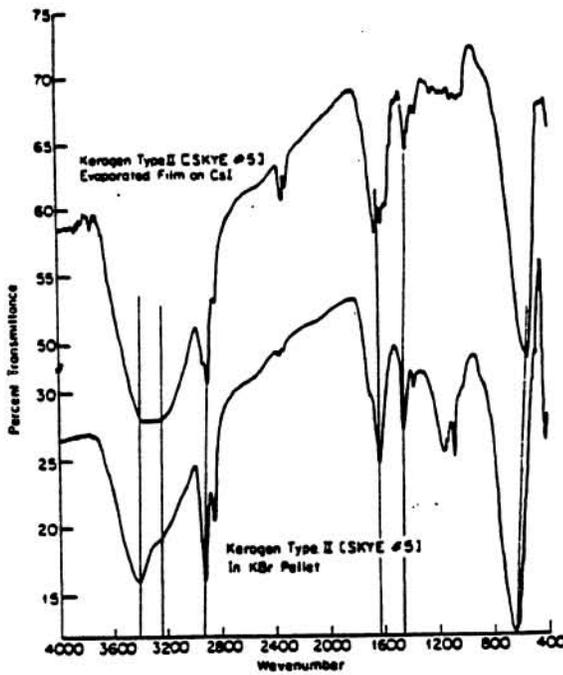


Fig. 1. Vertical lines indicate similarities between the evaporated film of kerogen and the original kerogen in KBr matrix, demonstrating that major spectral features are preserved.

Table 1. Assignments of absorption features in FTIR spectra

<u>Structural Unit</u>	<u>Wavenumber (cm^{-1})</u>
OH stretching	3400
Alkyl CH stretching	2900/2850
C=O stretching	1710 (shoulder)
C=C aromatic and polyaromatic rings	1630
aromatic CH deformation absorptions	870/820/750
out of plane deformation of aromatic CH	650

The band at 2326 cm^{-1} is due to atmospheric CO_2 in the spectrometer.

The real part of the refractive index, n , of Type II kerogen is determined by variable incidence-angle reflectance to be 1.60 ± 0.05 from $0.4\text{--}2.0\ \mu\text{m}$ wavelength. Work extending the measurement of n to longer wavelengths is in progress. The imaginary part of the refractive index, k , shows substantial structure from 0.15 to $40\ \mu\text{m}$ (Fig. 2). The values are accurate to $\pm 20\%$ in the UV and IR regions and to $\pm 30\%$ in the visible. We have also measured k values of organic residues from the Murchison meteorite. Figure 3 compares the k values obtained for the evaporated kerogen film with the k values of the evaporated Murchison organic residue. The Murchison sample, like the kerogen, shows considerable structure, and as expected, does not show any feature associated with aliphatic functional groups. Comparison of the kerogen and Murchison data reveals that between 0.15 and $40\ \mu\text{m}$, Murchison has a similar structure but no bands as sharp as in kerogen, and that the k values for Murchison are significantly higher than those of kerogen.

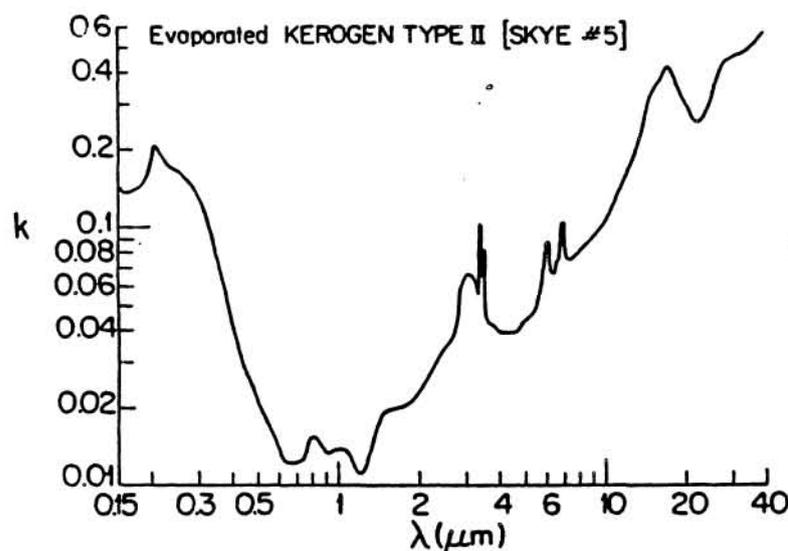


Fig. 2

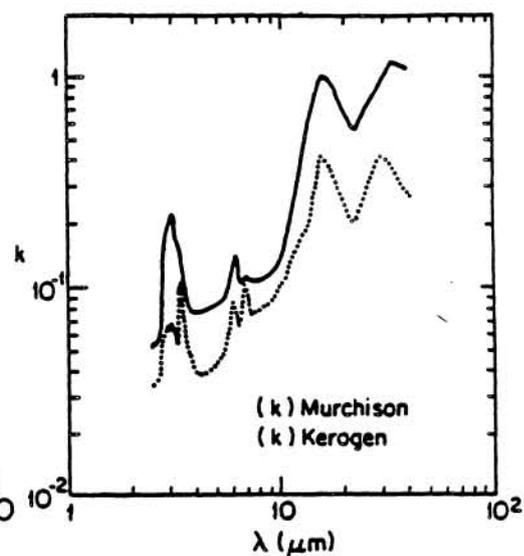


Fig. 3

Brooke et al. [5] detect strong 3.4 and $2.8\ \mu\text{m}$ emission features in comet P/Brorsen-Metcalf and find that the positions and widths of these features coincide with those observed in comets P/Halley, Wilson (1987 VII), and Bradfield (1987 XXIX). Comets and carbonaceous chondrites probably both accreted from low temperature condensates in the solar nebula [6,7], but the organic residues of comets can derive from pre- and post-accretion irradiation of hydrocarbon-containing ices, a somewhat different origin than that generally envisioned for meteoritic organics [8,9]. The $3.4\ \mu\text{m}$ CH and $2.8\ \mu\text{m}$ OH features in the above comets well match spectral features found in organic residues of $\text{H}_2\text{O-CH}_4$ and $\text{H}_2\text{O-C}_2\text{H}_6$ ice irradiation [10,11,12]. Similar spectral features in the kerogen suggest not its presence in comets, but simply some basic spectral similarities due to commonality of functional groups in these materials.

References

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