



Thermal degradation of N-rich organic laboratory analogues: new insight on the cosmomaterials organic precursor composition

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1. Introduction

The observed organic matter in the different objects, carbonaceous chondrites and IDPs, accessible to laboratory analyses is the result of a complex history. This history is divided into several phases the first of which take place into the presolar nebula and is followed by post accretional processes on the parent bodies [1, 2]. In the carbonaceous chondrites organic matter (both soluble and insoluble), nitrogen is a very minor constituent about 2wt%, but in micrometer scale localized zone of some IDPs the nitrogen content can reach values as high as 20wt% [1, 3]. Additionally, the Insoluble Organic Matter (IOM) polyaromatic structure suggests a formation through thermal processes of the organic precursor(s). In this IOM N-bearing cycles have been identified but not chemical functions like amino groups. The precursor(s) of all the organic matter observed in IOM and IDPs could then be nitrogen rich. To test this scenario, N-rich laboratory analogues, (polymeric solids) were thermally degraded at four different temperatures to simulate short time thermal processes in the solar nebula.

2. Experiment

The laboratory analogues selected to test the N-rich precursor scenario were tholins (SA90 type), initially produced to simulate Titan atmosphere organic aerosols, and HCN polymers [6]. Both of these analogues are N-rich, 15 at% for tholins and 32.2 at% for HCN polymers. They were heated at four different temperatures 300, 500, 700 and 1000°C under an inert argon atmosphere to avoid combustion and oxidation processes. The residues of these heating were the subsequently analysed by various technique to follow and characterized the nitrogen

content by elemental analysis, the chemical diversity and particularly the nitrogen speciation by infrared spectroscopy and the evolution of the degree of organization of the heated material skeleton by Raman spectroscopy.

3. Results

The nitrogen content of the residue decreases with temperature. However, even at 500°C the N/C ratio (Table 1) and the amines content (Figure 1) in the material are still large compared to chondritic material. At this temperature very common chemical functions in IOM have been completely removed from the residues, the methyl band is no more detectable in the infrared spectra. Those two results let us assumed that it is not possible to produced an IOM like organic material from a initially N-rich precursor like tholins and HCN polymers and that

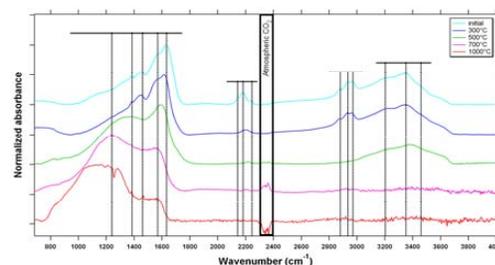


Figure 1: infrared spectra of the intial and heated tholins. The nitrogenated amino groups are still present while methyls have been destroyed.

Table 1: evolution of the elemental composition of heated tholins.

	Intinal tholins	300°C	500°C
C at%	35.42	40.55	57.9
H at%	49.76	45.51	27.4
N at%	14.75	13.92	14.67
N/C	0.42	0.34	0.25
H/C	1.40	1.12	0.47

the organic matter precursor was probably not N-rich.

The Raman spectra of these residues with 514 nm excitation laser, exhibit the two first order carbon bands, the D band around 1350 cm^{-1} and the G band around 1550 cm^{-1} typical of disordered carbonaceous material.

The G band was found to be very sensitive to the degradation temperature. The width of this band (FWHM-G) decreases dramatically when the peak temperature increases, and its position increase toward higher Raman shift (Figure 2).

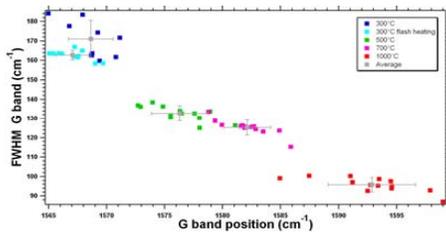


Figure 2: evolution of the Raman G band parameters with increasing heating temperatures. A clear linear correlation is observed between the position and the FWHM of the G band.

Both parameters present a linear correlation, and this evolution demonstrates structural changes during the heating process. Those changes are probably an aromatization and a growth of the polyaromatic units. This linear correlation between the G band position and FWHM, is also observed in organic matter from Antarctic micrometeorites [7]

The Raman spectra, at 514 and 244 nm excitation wavelength, of thermally degraded tholins are very similar to the spectra of some organic matter from IDPs. So the presence of thermal degradation product, comparable to degraded tholins, in IDPs cannot be ruled out. To go deeper into this kind of comparison a better characterization and comprehension of nitrogen in IDP's organic matter is mandatory.

References

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