

SOLUBLE ORGANIC SPECIES RELEASED FROM THE INSOLUBLE CARBONACEOUS MATERIAL OF A PRISTINE CR2 METEORITE. Sandra Pizzarello¹ and Lynda B. Williams², ¹Chemistry&Biochemistry, Arizona State University, Tempe AZ 85287-1604; pizzar@asu.edu. School of Earth and Space Exploration, Arizona State University, Tempe AZ 85287-1404; lynda.williams@asu.edu.

Introduction: Soluble organic compounds are known to be abundant in CM carbonaceous chondrites (CC), where they comprise a complex and diverse suite of both water-, and solvent-extractable molecular species [1]. The soluble organic composition of the Renazzo-type meteorites, known only recently through the studies of a few CR2 finds from Antarctica, was shown to differ from that of CMs in the overall preponderance of water- over solvent-soluble molecular species, N-containing amino acids and amines in particular [2]. According to a study by Cody and Alexander, the CR2 insoluble organic material (IOM) also shows substantial differences with other CC and appears to contain the largest alkyl component of all IOMs analyzed so far [3]. Given that Tagish Lake ranked at the other extreme of the measurements with the lowest alkyl portion in its IOM, the data appear to indicate that CR2 parent body processes may not have substantially altered its insoluble organics. We have undertaken a study of the soluble organic species released from the CR2 GRA95229 meteorite IOM upon hydrothermal treatment (HT) and compared the results with those obtained by similar studies of Murray IOM [4].

Method: Water and solvent extracted GRA95229 meteorite powders were further extracted with 6N HCl, CS₂, DCM and subsequently demineralized using 8N HF/3N HCl solution followed by acid washes, with the process repeated until reaching stable weight. Hydrothermal treatment employed 15mg of powders loaded with equal weight amount of degassed water in 5 x 300 mm Au tubes sealed under Ar flow and was conducted at 300°C and 100MPa for six days. After quenching, vials were opened and their interior rinsed with several water washes. Washes were dried and the residue derivatized with isopropanol 3N HCl and subsequently with TFAA. The powders were also collected, dried and extracted with DCM/MeOH (9:1, v:v) [4].

Results: *HT IOM solvent extracts* analyses showed that several hydrocarbons were released

by the treatment. Alkyl species, which had low abundance and distribution in whole powder extracts [2], were found present both as linear and branched species. Linear hydrocarbons start at C₁₀ (shorter chain molecules were likely lost by drying), their abundance peaks at heptadecane (~3nmole/g) and declines afterwards. The branched species are instead seen throughout the chromatogram up to the elution region of C₃₀ and their total abundance is higher than for any other group of compounds, possibly except the naphthalenes. Unsaturated and/or cyclic species may be present as well. The aromatic hydrocarbons in the extract make up a varied suite, which is listed in part in Table 1.

Table 1. Aromatic compounds identified in the GRA95229 IOM after hydrothermal treatment.

Compound	Whole	HT IOM
	powders	
	[n] nmol/g	[n] nmol/g
naphthalene	15.0	4.0
methylnaphthalene	[2] 10.0	[2] 4.0
dimethylnaphthalene	[10] 4.2	[11] 6.0
trimethylnaphthalene	[11] 1.0	[12] 4.0
naphthalene 1-phenyl	nd	≤1.0
phenanthrene	15.0	5.0
anthracene	1.5	1.0
methylphenanthrene/anthracene	[4] ≤1.0	[7] 2.0
di-,trimethyl “ “	nd	[22] 2.0
pyrene	15.0	2.4
fluoranthene	15.0	2.6
methylpyrene/fluoranthene	[8] ≤1.0	[9] 2.0
di-,trimethyl “ “	nd	[22] ≤1.0
biphenyl	5	2.0
terphenyl	1	≤1.0
benzothiophene	≤1.0	1.2
methylbenzothiophene	nf	[5] 4.8
di, tri, tetra-methyl “	nf	[37] 15.4
phenol	nf	0.5
methylphenols	nf	[2] 1.9
di, tri-,tetramethylphenols	nf	[12] 11.0

[n] number of isomers, when applicable; nd: not determined, nf: not found. Amounts are expressed according to the weight of the starting whole powder GRA95229 sample.

Here it can also be seen that more branched PAH homologs are found in the CR2 HT IOM than whole powder extracts. Figure 1 shows the many benzo[thiophene] homologs found in the HT IOM extracts, in this meteorite whole powders extract only benzo[thiophene] had been detected. Besides the table listings, some findings or lack of them were noticeable. Many peaks of methylated benzenes (up to five methyl, or equivalent, side chains) could be identified. Nitrogen containing polyaromatic hydrocarbons (PAHs) were searched for but not found and the phenols were the only O-containing molecules.

HT IOM water extracts analyses showed the presence of a series of linear dicarboxylic acid, as in the similarly treated Murray IOM, in the CR2 however, the C₄, C₇ and C₉ acids predominated with equal abundance (about 1nanomole/gram of meteorite).

The data presented here allow a few conclusions. As in the case of CM chondrites, the CR2 IOM

analyzed responded to the hydrothermolitic treatment with the released water- and solvent-soluble organic compounds. Overall, these molecules are found to be of smaller size, containing more alkyl chain branching and less diverse than those released by CM IOM under similar treatment. It is reasonable to suggest that the amounts of these molecular species may come to vary in the meteorite parent body depending on the length of the asteroidal alteration process; the presence of many-branched small PAHs in the CR2 IOM extracts appears also to indicate their peripheral position in the IOM through alkyl bridging. The total absence of N-containing molecules in this meteorite's HT IOM solvent extracts, when viewed *vis-à-vis* the preponderance of N-containing soluble species detected in whole powders water extracts [2], would seem to suggest that the overall elemental pool/precursor molecules that brought about the CR2 IOM differed in composition from those employed in water soluble compounds' formative processes.

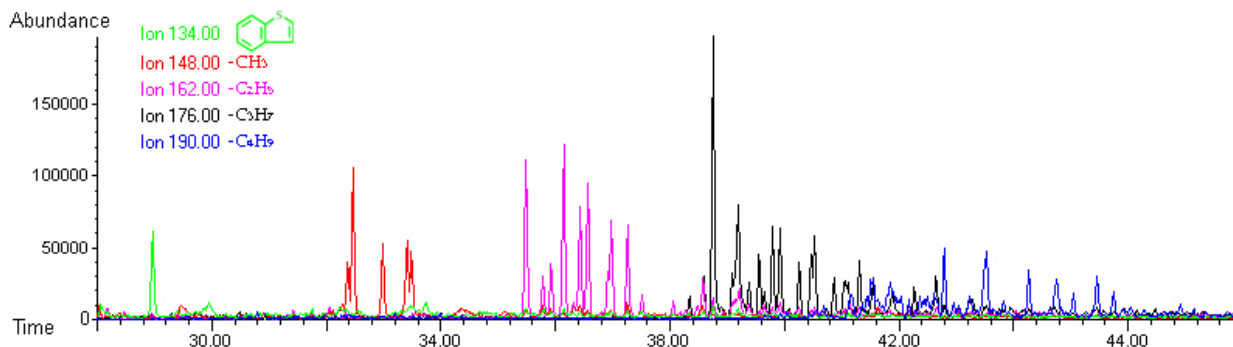


Figure 1. GC-MS chromatogram showing the elution of benzo[thiophene] and its C₁-C₄ higher homologs solvent-extracted from the hydrothermally treated IOM of the GRA95229 CR2 meteorite. On a J&W DB17 column, single ion traces.

References: [1] Pizzarello S. et al. (2006) in: *Meteorites and the Early Solar System II*, Eds. Lauretta and McSween, University of Arizona press, pp. 625-651. [2] Pizzarello S. et al. (2008) *PNAS* 105, 7300-04. [3] Cody G. and Alexander C. M. O'D (2005) *Geochim. Cosmochim. Acta* 69,1085-97. [4] Yabuta et al. (2007) *Meteorit. Planet. Sci.* 42, 37-48.