Carbon onions in meteorites

SIR — Ugarte reported that soot, when annealed by intense electron radiation, naturally transforms itself into giant nested shells ('onions') of carbon¹. Kroto² in News and Views pointed out that these carbon onions could be related to fullerenes3 and 'nanotubes'⁴. The carbon onions are formed by irradiation-stimulated graphitization, which is different from the accretion mechanism originally considered in laser ablation³ and arc-discharge processes⁴ used for fullerene synthesis.

Some years ago, Smith and Buseck⁵ observed well-ordered graphitic particles in the Allende meteorite which were concentric circular or polygonal structures, about 100-500 Å in diameter. These particles were found in residue samples that had been etched in fuming HNO₃ within the matrix of the meteorite, which is predominantly amorphous carbon. These concentric structures observed in the meteorite are remarkably similar in size and appearance to carbon onions¹ and nanotubes⁴.

Ugarte¹ describes a transition of irradiated soot in a 300-kV high-resolution electron microscope, originally composed of nanometric needles and tubular particles, which slowly becomes more spherical with prolonged exposure to the beam. These spheroidal graphite shells are similar to the nanotube structures described by Iijima⁴, produced by an arc-discharge evaporation method similar to that used for fullerene synthesis. Detailed examination of the newly formed graphite onions created in the electron beam shows that they consist of an assembly of concentric graphitic cages, with the distance between layers similar to that for bulk graphite (3.4 Å). Electron micrographs of the nanotubes also correspond to the lattice images of graphite (3.4 Å). This is consistent with the observations of Smith and Buseck⁵ that the lattice fringe spacing of the particles identified in Allende is 3.4 Å, corresponding to partially graphitized carbon. In the light of these structural similarities, we propose that the structures identified by Smith and Buseck in Allende are related to the carbon onions and nanotubes, and perhaps fullerenes³. If this is the case, then the presence of these onion-like structures in Allende is the first observation of fullerene-related carbon clusters in an extraterrestrial sample.

A question that remains, however, is how could these carbon onions form in a meteorite such as Allende? We cannot exclude the possibility that the amorphous carbon in Allende was transformed during examination by the highresolution microscope. But a natural

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mechanism that could be responsible for the formation of concentric structures in carbon-rich meteorites is shock synthesis. Yamada et al.6 simulated shock conditions in the laboratory using acetylene polymer samples and examined the shocked products using the high-resolution electron microscope. Spherical particles, composed of graphitic layers with lattice fringe spacings and ring patterns corresponding to a graphitic reflection, were observed. In these experiments impact energies were of the order of 10^{12} erg cm⁻³. Impacts delivering energies of this magnitude would exceed the mechanical strengths of planetesimals⁷ and lead to catastrophic fragmentation. Shock phenomena in the interstellar medium, particularly on grains containing organic molecules, could also drive synthesis of concentric carbon structures⁸. Lower-energy impacts may be sufficient to drive synthesis of concentric carbon clusters, but this has yet to be demonstrated experimentally.

L. Becker

G. D. McDonald

J. L. Bada

Scripps Institution of Oceanography, University of California at San Diego, La Jolla.

California 92093-0212. USA

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Forensic evidence by DNA sequencing

SIR — We wish to report on a rape case in which direct genomic sequencing was used to compare HIV-1 pol gene sequences from the male defendant and the female victim. We believe that this was the first time that evidence produced by DNA sequencing has been used in court.

The male was a Swedish intravenous drug abuser who was found to be HIV-1

to frozen peripheral blood mononuclear cells (PBMC) from the woman obtained 17 months earlier (5 weeks after the suspected transmission). Unrelated HIV-1 infected individuals (10 intravenous drug abusers and 20 homosexual men) from the same geographical area (Stockholm) served as controls. A region of the pol gene corresponding to amino acids 8-222 of the reverse transcriptase was

	160	170	180	190	200	210	220
Consensus	GWKGSPAIFQSSM	TKILEPFRKQ	NPDIVIYQYMI	DDLYVGSDLE	GQHRTKIEE	RQHLLRWGF	TTPDKKHQ
Male		4	2		К	31	
Female		4	2		5-K	6	
	1						

Amino-acid sequences of the HIV-1 reverse transcriptase of the virus populations in uncultured PBMC from the male and the female aligned to a consensus of published HIV-1 sequences (Los Alamos database). Dash, identity with the consensus sequence; letter, amino-acid change; numbers, positions with genetic polymorphism within the virus population in the sample according to the code: 1 = K, N, R and S, 2 = I and M, 3 = Q and E, 4 = Dand E, 5 = I and V, 6 = R and S. A nucleotide was scored as polymorphic only if at least 20% of the virus population was reproducibly estimated to be mutant.

positive in 1986. Before the present analysis was conducted, he had been convicted for rape and deliberate transmission of HIV-1 in the Stockholm district court. The evidence for this conviction did not include any forensic analysis because the woman involved did not file a report until a year after the alleged rape. However, she had been shown to seroconvert for HIV-1 antibodies within a few weeks of the rape. For this reason, a genetic analysis of the HIV-1 strains carried by both parties was performed before the case was tried in the court of appeal.

Two samples of whole blood were obtained on separate days from both subjects. In addition, we had access directly sequenced from uncultured PBMC from the male, the female and the controls using a solid-phase sequencing method¹⁻³

The direct DNA sequence analysis showed that the virus populations harboured by the male and the female were highly homologous (see figure). It was possible to identify a unique Arg 49, Arg 83, Asp 169, Met 178, Lys 204 and Lys/Ser 211 signature pattern which was shared between the male and female sequences. No other sequences from the intravenous drug abusers and homosexual men from the same geographical region fitted more than two out of these six amino acids. Phylogenetic tree analysis also showed that the sequences from