TRAPPING OF NOBLE GASES DURING FULLERENE SYNTHESIS U. Ott and S. Herrmann, Max-Planck-Institut für Chemie, Becherweg 27, D-55128 Mainz, Germany (ott@mpch-mainz.mpg.de).

Introduction: Ever since their original discovery, buckminsterfullerene C₆₀ and its siblings have raised much interest not only in material science, but also in astronomy [1]. Specifically it has been recognized early on that the cage structure offers the possibility for introduction of foreign atoms, even chemically inert ones such as the noble gases [2]. In meteoritics, it has been suggested that fullerenes may be an important carrier of trapped gases in primitive meteorites [3, 4]. Also, since experiments suggested incorporation of Xe to be much less efficient than that of the other noble gases [5], it was suggested that Earth’s “missing Xe” problem – and that of Mars, for that matter - may be due to the fact that fullerenes were a primary vehicle for bringing volatiles to the terrestrial planets [6, 4]. Since most likely trapping occurred during formation from the gas phase [7], we decided to study the efficiency of noble gas trapping from ambient gas during fullerene synthesis.

Experimental: Samples were prepared following standard methods for fullerene synthesis, including extraction of C₆₀/C₇₀ with benzene [8], in atmospheres of He, Ne, Ar, Kr and Xe, resp. at ambient pressures of 100 Torr (200 Torr in the case of Ne). Yields were highest for He, decreasing with mass. Noble gases were extracted by combustion at 300°C, 500°C and several steps at 600°C.

Results and Discussion: Clear-cut results were obtained for He and Ne, where concentrations of 5,850 and 2,930x10⁻⁸ cm³ STP/g were observed in our samples, corresponding to trapping efficiencies of ~45,000 and ~ 11,000x10⁻⁸ cm³/(g atm). Main release of He and Ne correlates with peak carbon combustion indicating that these gases are indeed trapped within the fullerene structure. The factor of four difference is intermediate between the order of magnitude difference observed for the incorporation efficiency into fullerenes heated to 600°C when exposed to 3 bar of ³He and Ne, resp. on one hand [2], and the about equal efficiency for He and Ne incorporation when exposed to >1000 bar pressure [5].

The case of the heavier noble gases is tricky. Among other things, they are strongly compromised by an adsorbed component. While this was mostly released at low temperature, there was significant tailing to the temperature where main combustion occurs. Subtracting adsorbed Ar based on the release of Ar adsorbed in similar quantities on the fullerenes synthesized in He and Ne, we estimate a trapping efficiency for Ar of ~3,000x10⁻⁸ cm³ STP/(g atm), i.e. another factor of 4 lower than that for Ne. The behavior of decreasing trapping efficiency with mass of noble gas is rather different from that of the meteoritic Q phase, for which orders of magnitude higher trapping efficiencies have been implied for the heavy noble gases (e.g., [9]). Trapping of noble gases by C₆₀/C₇₀ fullerenes during their formation seems an unlikely process by which planetary noble gases were acquired, therefore.

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