NOBLE GASES IN THE AMORPHOUS CARBON SYNTHESIZED BY GLOW-DISCHARGE CVD
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To account for the trapping mechanism of noble gases in meteorites, some laboratory experiments synthesizing carbon matter have been made. The synthesized carbonaceous materials, such as propane soot, electron-discharge kerogen (1), vapor-growth carbyne (2) and diamond (3,4) have been reported to be efficient trappers of noble gases.

We have synthesized carbon materials used by glow-discharge CVD, and analyzed the elemental and the isotopic composition of noble gases in the synthesized carbon material. A schematic drawing of the synthesizing apparatus is shown in Figure 1. The reactant gas mixture which was composed of 95% H2, 5% CH4, and 1-2% noble gases (1% He, 1% Ne, 96% Ar, 1% Kr, 1% Xe; atmospheric isotopic composition for each gas) were led to the discharge quartz tube through gas flow meter by being evacuated with a rotary pump. Total gas pressures measured with oil-manometer were about 2 torr. An electric furnace was used to heat the discharge tube at 800°C. A glow-discharge was obtained by applying a low frequency electric potential of between 1.1kV and 4.6kV to the electrode. After discharge had been maintained for 20 hours, a black matter was deposited on the silicon substrate patched on the electrode. As it had no lines by X-ray diffraction, it was identified to be amorphous carbon.

The noble gas contents of the materials were measured by mass spectrometer using stepwise heating technique. Our amorphous carbon were extremely enriched in noble gases, especially heavy noble gases. For example, the sample KS-97 was synthesized under the condition of 2.0% partial pressure of noble gases mixture, of which 132Xe concentration was 1.2×10^{-3} cm^3STP/g. The stepwise heating analysis showed that the trapped noble gases were mainly released at 800-1200°C. This release temperature was apparently different from that of adsorbed component and from that for diamonds (3,4).

The elemental abundance patterns are shown in Figure 2. The patterns were characterized by large enrichment of 3He, 20Ne, 84Kr, and 132Xe relative to 36Ar when compared to the original gas compositions. A fractionation factor F(132), being defined by (132Xe/36Ar)sample/(132Xe/36Ar)ambient atmosphere, was as large as about 10^4 in our material. The heavy noble gas pattern was similar to the trend of calculated ion abundance in plasma condition by Jokipii(5). The trend of the amorphous carbon was very close to the ion abundance pattern at the electron temperature of 5000-7000K. The fractionation of light noble gases, however, could not be explained by the plasma process. This result suggested that there was a different mechanism which gave strong effect on trapping light noble gases. Although strong elementary fractionation was found on the amorphous carbon, no significant isotopic fractionation of noble gases was detected.

Concerning heavy noble gases, the distribution coefficients
in the meteoritic acid residues were some four orders of magnitude larger than those inferred for our experiments. The amorphous carbon in our plasma process, however, is the best noble gas trapper of all carbon materials which have been reported, except for one sample by Dziczkaniec et al. (2). Moreover, our samples had strong retentivity for noble gases and showed a characteristic elemental abundance patterns. There seems to be some similarity between our amorphous carbon and meteoritic acid residues.

References

Figure 1.
Schematic diagram of the apparatus.

Figure 2.
Noble gas abundance patterns in the amorphous carbon:
Fractional rates of the noble gas mixture are 1.1%, 1.3%, 2.0%, and 2.1% for KS-85, 91, 97, and KS-109, respectively. The discharge voltage is 3.5kV, except for KS-109(2.1kV).