AOGS 2006
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Laboratory Production of Fullerenes and a Possible New Formation Route for Carbonaceous Materials in Carbon-Rich AGB Stars

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Most of the carbon in the outflow of carbon-rich asymptotic giant branch (AGB) stars is in the form of CO and C2H2 (Latter 1991). Carbonaceous materials such as polycyclic aromatic hydrocarbons and fullerenes are believed to form from C2H2 and its derivatives because CO is a very stable molecule (Allamandola et. al., 1987; 1989). Therefore, all of the theoretical calculations were carried out based on C2H2 gas abundances, i.e., no one has ever considered CO gas as a carbon source. If carbonaceous materials are formed not only from C2H2 molecules but also from CO gas, then most predicted formation constraints such as gas outflow velocity, stellar mass loss rate, total gas pressure, temperature and C/O abundance ratio will require reconsideration. We produced carbon particles by resistive heating of a carbon rod at a total pressure of 200 Torr in a gas mixture of He and CO in the laboratory. As a result of high-resolution transmission electron microscope (TEM) observations, we observed many large cages, which appear to be short nanotubes or large fullerenes. We concluded that the large cages are single shell structures, i.e., fullerenes of many sizes, but most are larger than C70. This was determined by TEM observations including electron diffraction patterns, by observation of sublimation of carbon grains at temperatures as high as 800°C and by measurement of their infrared spectra. Moreover, we found a significant 19-micron feature during a synthesis experiment of core-mantle grains, which corresponds to a 19-micron feature seen in carbon-rich AGB stars that also exhibit a 21-micron feature. This may be the first evidence of the presence of fullerenes around carbon-rich AGB stars. Future observations to verify a correlation between the 19- and 21-micron features could prove to be very valuable. Latter W. B. (1991) ApJ, 377, 187-191. Allamandola L. J., Sandford S. A., & Wopenka B. (1987) Science, 237, 56-59. Allamandola L. J., Tielens A. G. G. M., & Barker J. R. (1989) ApJS, 71, 733-775.