Laboratory studies on the formation of PAH clusters: I. UV and plasma effects on anthracene clusters.

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The unidentified infrared (UIR) bands are characterized by main features at 3.3, 6.2, 7.7, 8.6 and 11.2 microns. The UIR bands are observed from wide variety of objects in the Galaxy and in extragalactic regions. Therefore, the carriers of the UIR bands should be stable materials. Furthermore, it was expected those carriers are ubiquitous in the space. Therefore the carriers could be the clue to understand physical environments and chemical evolutions of various objects.

Polycyclic aromatic hydrocarbons (PAHs) have been considered most plausible candidates of the UIR bands. PAHs are consisting of carbon atoms arranged in benzene rings decorated at the edges by hydrogen atoms. They have C-C and C-H bonds which show the vibration modes at mid-IR region corresponding to the main features of UIR bands. In addition, PAHs are starting molecules of organic evolution. They have been thought to be materials of organic matter which will become the origin of life. Therefore, not only a laboratory studies on the spectra of PAH molecules but the evolution to the PAH clusters and further alteration with UV and plasma are necessary.

Experiments on the formation of anthracene clusters were carried out in our laboratory. Anthracene, which is one of PAHs, has a molecular structure consisting of three benzene rings in straight. It has two solo C-H bonds, which do not have neighbor hydrogen atoms in the benzene ring, and two quartet C-H bonds, which have four C-H bonds in a benzene ring. Anthracene clusters were produced by evaporation of commercial powder in He gas atmosphere of 30, 80 and 150 Torr. The produced clusters were white. As the result of transmission electron microscope observation, the sizes of the produced clusters are distributed from 50 to 150 nm. These clusters showed characteristic features at 11.3 and 13.7 micron bands, which are attributed to the vibration mode of solo and quartet C-H bond, respectively. In addition, 12 micron band was newly appeared from the clusters produced in higher gas pressure. This band corresponds to 12-14 micron plateau, which has been widely observed with UIR bands. The anthracene clusters produced in He gas of 80 Torr were irradiated by UV at 254 and 365 nm for 15, 40 and 60 hours. In the case of irradiation at 365 nm, peaks at 8.7, 10.0, 11.3, 13.7, 21.1 and 21.5 microns were immediately disappeared. In contrast, peaks at 8.2, 9.7, 10.6, 12.3, 13.1 and 14.7 microns were newly appeared. Furthermore, a peak at 16.6 micron was shifted to 16.7 micron and got to strong. In the case of irradiation at 254 nm, those peaks were similarly changed as 365 nm. However, this change was very slowly in comparison with 365 nm. This result implies that the alteration of anthracene clusters with UV irradiation depends on wavelength. On the other hand, the clusters with yellow were produced by evaporation of commercial powder in the plasma field in He gas. Produced clusters were spherical with the size of 120 nm. These clusters were not shown sharp peaks at 11.3 and 13.7 micron bands, but shown broad peaks at 11 and 13 micron bands. This result suggested that PAH clusters are easily altered by plasma.