

Structural Elucidation of a 220 nm Absorption Peak in Carbonaceous Candidates for the Interstellar 217.5 nm Absorption Using UV Raman Spectroscopy

Seiji Kimura

The University of Electro-Communications, Japan

Several carbonaceous materials have been proposed as candidates for the interstellar 217.5 nm absorption, but the carbon structure responsible for this absorption has not been elucidated. To identify the structure, Raman spectra were measured for three carbonaceous materials (anthracite coal, carbonaceous mesophase, and quenched carbonaceous composite [QCC]) using visible (532 nm) and UV (224.3 nm) excitation wavelengths. Raman spectroscopy, which measures the magnitudes and intensities of frequency shifts that occur due to inelastic light scattering from the material, is a powerful tool for investigating the structures of carbon materials because of its sensitivity to local differences in the carbon bonding state. In particular, overlap of the excitation and absorption energies greatly enhances the Raman scattering efficiency of the absorbing components, which is called the resonance Raman scattering effect. Therefore, by comparing the differences in two types of Raman spectra, the causal structure of the absorption close to the observation (hereinafter, the 220 nm absorption) can be identified.

The visible Raman spectrum of anthracite shows peak shoulders near 1260 cm^{-1} , 1163 cm^{-1} , and 1415 cm^{-1} , in addition to the 1584 cm^{-1} (G band) and 1336 cm^{-1} (D band) peaks measured on ordinary amorphous carbon materials. On the other hand, the UV Raman spectrum shows two strong Raman peaks at 1263 cm^{-1} and 1310 cm^{-1} , and two weak peaks in addition to the G band. The change in the UV Raman relative to the visible Raman appears in two peak intensities at 1263 cm^{-1} and 1310 cm^{-1} , suggesting that the local carbon structure associated with these two Raman peaks caused resonant Raman scattering. In contrast, for amorphous carbon particles that do not exhibit a 220 nm absorption peak, the UV Raman spectrum shows a prominent Raman peak only in the G band, which is clearly different from that of anthracite. These findings indicate that the carbon structure related to the Raman peaks outside of the G band is related to the 220 nm absorption, and that the G-band associated with electronic π - π^* transitions is related to the slope of the UV-visible absorption spectrum.

Similar to anthracite, the visible Raman spectra of carbonaceous mesophase and QCC show weak peaks other than those in the G and D bands. Furthermore, the absorption peak positions of heat-treated QCC are correlated with the disappearance of its weak Raman peaks. Thus, there is evidence that the carbon structure contributing to this weak Raman peak is related to the 220 nm absorption. In fact, conjugated double bonds have been proposed as a possible cause of the QCC absorption at 220 nm, and the weak peaks observed in the Raman spectra of the three samples are similar to the trend for the one-dimensional carbon structure. Considering that such similar local carbon structures are responsible for the absorption, it is a promising explanation for the similar absorption characteristics obtained in different candidate materials (anthracite, carbonaceous mesophase, and QCC). Mennella et al. noted the possibility that peculiar structural properties are required for the interpretation that there is a similar absorption peak in anthracite and hydrogenated amorphous carbon, but they did not confirm this experimentally. In this poster presentation, the local carbon structure will be discussed based on the results of Raman spectroscopy.