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THE 2.5-5.0 μM SPECTRA OF IO: EVIDENCE FOR H_2S AND H_2O FROZEN IN SO_2

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The techniques of low temperature spectroscopy are applied here to identify the constituents of the ices covering the surface of Io, a satellite of Jupiter.

Infrared spectra of Io in the 4000-2000 cm^{-1} region, including new observational data, are analyzed using laboratory studies of plausible surface ices.

Besides the well-known absorption bands attributable to sulfur dioxide frosts, four unidentified infrared spectral features of Io are pointed out. Two are at 2597 cm^{-1} and 2558 cm^{-1} and the second pair fall at 3367 cm^{-1} and 3175 cm^{-1}. These absorptions fall close to the fundamental X-H stretching modes in H_2S and H_2O respectively. The infrared absorption spectra of mixed molecular ices ranging from pure materials, to binary mixtures of H_2S and SO_2 (either mixed at different concentrations or layered), to $H_2O/H_2S/SO_2$ mixtures are discussed. The effects of ultraviolet irradiation (120 and 160 nm) and temperature variation (from 9 K to 130 K) on the infrared spectra of the ices are also examined. The comparative study shows that: (1) Io most likely contains H_2S and H_2O mixed with SO_2. The 2597 cm^{-1} and 2558 cm^{-1} bands in the Io spectra can be accounted for by the absorption of the S-H stretching vibration (ν_1) in H_2S aggregates and isolated molecules in an SO_2 matrix. The weak 3367 cm^{-1} and 3175 cm^{-1} bands which vary spatially and temporally in the Io spectra coincide with the ν_3 and ν_1 O-H stretching vibrations of clusters of H_2O complexed with SO_2. (2) The observations are well matched by SO_2.matrices containing about 3% H_2S and 0.1% H_2O and which have been formed by the condensation of a mixture of the gases onto a 100 K surface. (3) In the comparison of the spectra using the mixed molecular ice samples versus the layered ice samples only the former can explain the shifts and splitting of the absorption bands in the Io spectrum and account for the fact that solid H_2S is observed in the surface material of Io at temperatures and pressures above the sublimation point of pure H_2S. In addition to pointing out the presence of H_2S and H_2O on Io, the originality of this study comes from the fact that it is the first to consider mixed solids in carrying out laboratory simulations of planetary surfaces providing a realistic simulation of the "dirty" ices covering the surfaces of many satellites.

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