UNIVERSITY of HAWAI'I® MĀNOA

Physical Chemistry Seminar

Thursday, February 9 2017, 4:30 pm

Department of Chemistry, Bilger 242

Carbonic Acid – An Intricate Plot

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Carbonic acid, H_2CO_3, plays an important role in many fields of chemistry and physics including astrophysics, biology and geochemical systems containing carbonates. Carbonic acid easily decomposes into carbon dioxide and water under ambient conditions and even more so in the presence of water. However, at the temperature of many extraterrestrial environments, its decomposition is hindered and thus it is expected to occur on comets, in interstellar grains, at the surface of Mars, or on the Jupiter's icy satellites Europa, Ganymede, and Callisto.

In 1993 Hage, Hallbrucker and Mayer developed a cryo-technique with acid-base chemistry resulting into two distinct polymorphs of carbonic acid, which were either synthesized in methanol or water as solvent and were called alpha- or beta-phase respectively. The beta-H_2CO_3 is also formed under conditions similar to those in space, i.e. when a 1:1 mixture of CO_2 and H_2O ice is irradiated by protons, electrons or UV radiation. In the absence of water, solid CO_2 can also be bombarded with protons or CO can react with OH radicals.

We prepared both polymorphs in sufficient amounts and to isolate the vapor above each solid sample into inert gas matrices (Argon and Neon). By this procedure we could show that carbonic acid is stable enough to survive a way of about 100 mm of travel through the gas phase at room temperature under vacuum conditions ($<10^{-4}$ mbar) lasting a few milliseconds. Interestingly, the isolated molecules from both phases were not identical, which inspired Bernard to cast doubts on the result. In his PhD thesis he suggested that the alpha-phase is in fact the monomethyl ester of carbonic acid, while beta carbonic acid is the only crystalline phase of H_2CO_3 at normal pressure. A few months later Reisenauer et al. published a comparison between our matrix isolation spectra of carbonic acid and their isolation spectrum of the monomethyl ester, which they generated by the decomposition of tert-butyl methyl carbonate. They came to the same conclusion as Dr. Bernard.