PHOTODISSOCIATION OF DIBORANE ISOLATED IN SOLID PARAHYDROGEN: EVIDENCE OF SLOW DIFFUSION-CONTROLLED RECOMBINATION

AARON I. STROM, ANH H. M. NGUYEN, IBRAHIM MUDDASSER, DAVID T. ANDERSON, Department of Chemistry, University of Wyoming, Laramie, WY, USA.

Our group is interested in characterizing the diffusion of chemical impurities in quantum solids such as solid parahydrogen (pH₂). In this work we report FTIR studies of the 193 nm photodissociation of diborane (B₂H₆) isolated in solid pH₂ in the 1.5 K to 4.3 K temperature range. In the gas phase, diborane photodissociation at 193 nm has been shown to produce BH₃ with a quantum yield of 2.00(25). In our studies, we deposit B₂H₆ in solid pH₂ and fully resolve vibrational peaks for the ¹¹B₂H₆, ¹³B¹⁰BH₆, and ¹⁰B₂H₆ isotopologs of diborane in natural abundance. We then photolyze the B₂H₆/pH₂ sample for a short period of time (30 min, 100 mW/cm²) and observe the B₂H₆ peaks decrease in intensity as new peaks grow in. We suspect that we are producing BH₃ upon photolysis which forms a complex with the pH₂ host to form BH₃·pH₂. What we found surprising is that after we stop the 193 nm laser, we observe regrowth of the diborane peaks indicating that the photoproducts can readily diffuse through solid pH₂ even at the lowest temperatures studied (T = 1.52 K). We can track the regrowth in the concentration of each diborane isotopolog separately, which means we can extract rate constants for the kinetics of recombination for each isotopolog. Assuming the recombination process is diffusion-controlled, we can use the fitted rate constants to look for kinetic isotope effects in the recombination reaction. We use these measurements to distinguish between two potential diffusion mechanisms, activated thermal hopping and quantum tunneling. This project is still ongoing, and the most recent results and analysis will be presented.

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