

SPECTROSCOPY AND DYNAMICS OF QUANTUM STATE CONTROLLED SiO^+

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New tools for cooling and internal state control of molecules emerged in the past decade that allowed fast progress in the field of ultracold molecules. In this work, control of the rotational state of trapped ultracold SiO^+ was utilized to study its spectroscopy and reaction dynamics. SiO^+ was prepared by laser ablation of SiO followed by 1+1 REMPI. The ions were trapped in an RF Paul trap and sympathetically cooled by co-trapped ultracold atomic Ba^+ ions. Rotational states of SiO^+ were cooled and controlled by means of optical pumping with a spectrally pulse-shaped broadband light source. The pumping via the $\text{B}^2\Sigma\text{-X}^2\Sigma$ electronic transition on rotational lines with selected N and ΔN was used to cool SiO^+ molecules to the ground rotational state and to create a narrow distribution of occupied rotational states centered on a targeted level. Populations centered at different rotational states ranging from $N=3$ to $N=65$ were created. SiO^+ quantum states were probed with photodissociation spectroscopy via the $\text{C}^2\Pi\text{-X}^2\Sigma$ electronic transition. The $\text{C}^2\Pi$ state was experimentally characterized for the first time. Rotational state control was used to facilitate line assignment and to probe high rotational levels of the $\text{X}^2\Sigma$ state unpopulated at room temperature. Reaction of trapped SiO^+ with H_2 was studied. The reaction rate of rotationally “thermal” SiO^+ was found to be in good agreement with the literature value. The reaction rates of thermal H_2 with ultracold rotational state controlled SiO^+ were measured. Reaction of H_2 with SiO^+ “super rotor” states in which rotational energy is of the same order as bond dissociation energy and rotational period approaches time of collision was studied.