

## **Abstract**

The Interstellar Medium (ISM) is an extreme environment that requires a wide range of experimental techniques to investigate its many shades. This thesis presents a collection of studies in Laboratory Astrochemistry aimed at providing new experimental data for astrochemical modeling and probing the fundamental chemistry underlying the phenomena investigated. The core of this thesis is the study of the reactivity in the gas phase of ions related to the third-period elements  $\text{Si}^+$ ,  $\text{P}^+$ , and  $\text{H}_2\text{CS}^+$ , for which the ion-neutral chemistry is still poorly understood. Investigation of the chemistry of the molecules containing these elements will also be useful to reveal ionic reaction pathways producing relevant prebiotic species. The reactivity of these ions has been studied by means of the Guided Ion Beam technique, with apparatuses available both at the University of Trento and the SOLEIL synchrotron (France), at the DESIRS beamline. In Trento, the ions are generated by electron impact ionization on neutral precursors, while at SOLEIL, they are produced by dissociative photoionization of neutral species, allowing for experiments at a higher energy resolution compared to electron impact. The reactivity has been studied with a range of saturated and unsaturated nitriles and hydrocarbons, amines, and other targets detected in the ISM. Besides reactivity, a second project regarding the acquisition of the gas-phase infrared spectrum of the astrochemically relevant  $\text{HCCS}^+$  ion has been performed at the FELIX Laboratory (the Netherlands), with the aim of providing new data for future observations. Data were collected by IR-action spectroscopy, using the 22-pole cryogenic ion trap FELion. Next projects regard the investigation of the gas-phase reactivity of  $\text{HCCS}^+$ . Reactivity occurs not only in the gas phase, but also on solid icy grains of interstellar dust and debris. Although the dusty material accounts for only 1% of the total mass of the ISM, they behave like micro-submicro chemical reactors, exhibiting a rich chemistry, which is often triggered upon interaction with ionizing radiation. In these grains, part of the so-called "missing sulfur" is believed to be locked up in various forms (e.g., iron sulfides like troilite,  $\text{FeS}$ ), and it might be possible that sulfur contained in interstellar minerals is transferred to the icy mantles upon cosmic ray bombardment. As part of this thesis, the development and commissioning of a new setup for the study of energetic processing of simulated interstellar ices by  $\text{He}^+$  ions (used as a proxy for cosmic rays) is discussed. The activity has been carried out at TRIUMF, Canada's Particle Accelerator Centre (Vancouver, British Columbia, Canada) and at the University of British Columbia (UBC, Vancouver, Canada). Preliminary results are also presented as the outcome of the first two beamtimes spent with the system in the current configuration.