Gas Phase Ion Chemistry: From the Laboratory to the Stars

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Gas phase ion chemistry is important in many environments including atmospheric, interstellar, and combustion chemistry; moreover, these processes provide insight into solution chemistry and serve as a benchmark for theory. The flowing afterglow technique,[1] developed about 50 years ago at the NOAA labs in Boulder, provides a powerful and versatile approach to the study of a wide array of ionic reactions.

This presentation will briefly review the history of the flowing afterglow technique, and the many developments that have expanded and refined the experimental capabilities. This talk will then describe how kinetics provides chemical insight into mechanisms, thermodynamics, and ionic structures for classical physical organic reactions as well as for atmospheric and interstellar chemistry.

In particular, the use of isotopes allows us to distinguish isomeric ions, reveal hidden processes, and explore reaction barriers that dictate the branching between competitive mechanisms.[2] Moreover, our gas phase studies allow an examination of the "alpha-effect," an enhanced reactivity of nucleophiles with lone electron pairs adjacent to the reactive center;[3] these studies probe whether the effect, first observed in 1962, is an intrinsic property of the nucleophile or a result of solvation.[4]

The interstellar medium is a dynamic chemical laboratory, and more than 170 neutral and ionic molecules have been detected in molecular clouds,[5] despite the harsh conditions. Our experimental studies are directed at understanding the formation and interaction of these species. Reactions of both positive and negative ions with atomic and neutral reactants will be described, and chemical networks of molecular syntheses will be presented.[6]

Future directions and instrumental developments, including Laser Induced Acoustic Desorption and Electrospray Ionization, will be discussed.

References

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