

FUNDAMENTAL AND APPLIED STUDIES OF THE STRUCTURES
AND REACTION DYNAMICS OF BIOMOLECULES USING MASS
SPECTROMETRY AND ION MOBILITY SPECTROMETRY

Thesis by

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To my parents, grandmother, and big brother.

Especially to my wife.

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I thank Isik, Luther, Paul, and God.

And special thanks to Jack.

Abstract

Chapter 1 reviews studies of non-covalently bound metal complexes related to the structures and reactions of biomolecules in the gas phase, chapter 2 introduces the Route 66 method for identifying disulfide linkages in peptides using mass spectrometry. Collisional activation of singly charged cationic alkali and alkaline earth metal complexes of peptides with disulfide linkages results in highly selective elimination of hydrogen disulfide (H_2S_2). Further activation of the product yields amino acid sequence information in the region previously short-circuited by the disulfide bond. In chapter 3, we demonstrate applications of this methodology by identifying three disulfide linkages in insulin with a peptic digest using the Route 66 method. In chapters 4 and 5, gas phase reactions triggered by the bimolecular collision of a water molecule with collisionally activated anionic and cationic sodiated dicarboxylic acid clusters are examined. The water molecule serves as a proton donor for a dicarboxylate anion in the cluster and introduces energetically favorable dissociation pathways, such as the decomposition of the malonate ion, to yield an acetate ion and CO_2 .

To further explore the utility of IMS in the identification of organic compounds on other planetary bodies, pursuant to NASA objectives, ion mobilities are investigated for different classes of biomolecules. Chapters 6 and 7 report the reduced ion

mobilities of protonated amino acid cations and deprotonated carboxylate anions, respectively, determined in both N_2 and CO_2 drift gases. A 12-4 potential model for the ion-neutral interaction is used to investigate the high correlation observed between masses and mobilities of the ions. Computational analysis employing a 12-4 model supports ring conformations for multicarboxylate anions consistent with higher ion mobility values than calculated for extended structures. In Chapter 8, the ion mobilities of tertiary and quaternary ammonium cations in N_2 are reported along with their high mass-mobility correlation. We also detail the sensitivity of the collision cross sections of molecular ions to the ion-neutral interactions using the classical ion-neutral collision model and the computational trajectory method. The shape asymmetry of the ammonium cations plays an important role in determining the observed correlation between mass and mobility.

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