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A Renaissance Man in Ion Chemistry—A Tribute to Jesse (Jack) Beauchamp

We are pleased to join the many colleagues who contributed to this special issue of *The Journal of Physical Chemistry A* (and many who could not) in dedicating it to Professor J. L. Beauchamp upon the occasion of his 60th birthday. In his illustrious career, Jack has made major scientific contributions to the physical characterization of the chemical reactivity and properties of a wide array of interesting molecules and ions in the gas phase. Although categorizing Jack's copious contributions to physical chemistry is difficult, they can be loosely organized into three integrated phases that concern organic, inorganic, and biological chemistry, with an underlying theme of state-of-the-art physical techniques and concepts running through each.

Jack began his education as an undergraduate at the California Institute of Technology, graduating with honors in 1964. He then joined the group of Professor John D. Baldeschwieler as he began to develop ion cyclotron resonance (ICR) mass spectrometry into a useful chemical tool. Working primarily at Stanford University, Jack completed his thesis, "Ion Cyclotron Resonance Spectroscopy", receiving a Ph.D. from Harvard University. In 1967, he interviewed at his alma mater (where they generously helped generate a curriculum vitae for him) and has been a faculty member ever since of the Division of Chemistry and Chemical Engineering at Caltech, where he is presently the Charles and Mary Ferkel Professor of Chemistry.

Jack's early work concentrated on applications in *organic* chemistry. He was the first to demonstrate that ion cyclotron resonance (ICR) mass spectrometry could be used to study the acid—base properties of molecules and ions in the gas phase. These studies have evolved in numerous laboratories around the world and remain a major activity of many research groups. They provide intrinsic acid—base properties of isolated molecules, and thus insights into the role of solvation in modifying these properties in condensed phases. In addition, Jack's mass spectrometric investigations in the gas phase probe the mechanisms of a wide variety of chemical transformations, such as nucleophilic displacement and base-induced elimination reactions, which previously had been studied only in solution.

In related work, Jack was one of the first to examine the ionization energetics of organic free radicals by using photoelectron spectroscopy. This work includes spectra for about 40 organic radicals and focuses on carbonium ions as simple as

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methyl and as complex as the 1- and 2-adamantyl cations. Jack has shown that this experimental methodology is a sensitive and selective technique for identifying radical intermediates in a wide variety of phenomena, including the reactions of organic molecules with catalyst surfaces.

In 1971, Jack published his first paper on the reactivity of transition metal complexes, which presaged the second phase in his career, *organometallic* chemistry. To better understand the mechanisms and energetics of organometallic reactions, Jack's group developed the use of tandem ion beam mass spectrometry to measure metal−hydrogen and metal−carbon bond dissociation energies, one of the earliest applications of such sophisticated instrumentation to such complex chemical phenomena. This endeavor has evolved into a major database for organometallic fragments and coordinately saturated complexes. The availability of bond-strength data facilitates the interpretation of processes such as the rupture and formation of carbon−hydrogen and carbon−carbon bonds at transition metal centers, σ bond metathesis reactions, olefin metathesis, insertion of olefins into metal−hydrogen and metal−carbon bonds, and the decarbonylation of aldehydes and ketones.

In collaboration with Professor Michael T. Bowers at the University of California at Santa Barbara, Jack utilized yet another mass spectrometric tool to determine product kinetic energy release distributions (KERDs) for organometallic processes. These experiments probe the potential energy surface in the last stage of a reaction and provide additional insights into the reverse process, which often involves oxidative addition of a small molecule at a transition metal center. The development of theoretical models for analyzing these experiments has resulted in new and powerful methods for determining bond dissociation energies.

The most recent phase of Jack's career focuses on the development of novel mass spectrometric techniques in *biochemistry*. In particular, Fourier transform ion cyclotron resonance (FTICR) spectroscopy is being employed to investigate the properties, reactions, and structures of biologically significant molecules in the gas phase. In his characteristically methodical style, he focuses on fundamentals such as determination of acid−base properties of important functional groups in peptides and oligonucleotides. For example, the site specificity and energetics of protonation of small peptides has been related to their molecular electronic structure using photoelectron spectroscopy. He has provided the first detailed mechanisms and reaction energetics for processes involving hydrogen−deuterium exchange in protonated peptides. This work led to the discovery of the importance of salt bridge formation (formation of an ion pair induced by a charged functional group) as a determining factor in the reactions and structures of biopolymers in the gas phase. This salt bridge chemistry forms the basis of a practical and simple method for mapping aspartic acid residues in peptides. Most recently, Jack has focused on the solvation properties of complex ions in the gas phase, elucidating interesting phenomena such as magic numbers of solvent molecules, details of the desolvation process, and the formation of ions in electrospray ionization (ESI).

Although Jack's research typically focuses on novel chemistry, he has a clearly established ability to develop new applications of modern methods of chemical physics for problems of general chemical interest. Cases in point are his studies of multiphoton excitation of ions using infrared lasers. Jack recognized that the ion storage capability of an ICR mass spectrometer would permit a low-power, continuous-wave infrared laser to be employed in place of a high-power, pulsed laser. This insight allowed a series of studies in which the mechanism of multiphoton excitation could be investigated on a more manageable time scale without spatial and temporal inhomogeneities during irradiation. His group and others now routinely utilize this technique to activate stored ions and characterize potential energy surfaces for complex reactions involving organometallic and biologically important molecules.

Jack's career as a physical chemist is marked by an astute ability to examine interesting chemistry and chemical interactions using a variety of state-of-the-art mass spectrometers and related instrumentation. Although best known for his work with ion cyclotron resonance, his applications of photoelectron spectroscopy, ion beam mass spectrometry, infrared multiphoton dissociation, and near field scanning optical microscopy attest to his mastery of physical chemistry. Most telling, however, is his ability to sift through mountains of information and obtain the physical insight that allows others to progress in their own research.

In addition to his many scientific achievements, Jack has been a great educator, providing a ready colleague for collaboration and a caring mentor to several generations of students and postdocs, many of whom are prominent scientists in academic and industrial positions. His style is to sit down with students as they learn to write their first paper and work through the details one-on-one. He works hard to express himself well and has succeeded in passing that ability on to his students. He has a contagious sense of humor and a zest for life that includes being an active pilot (which has landed him on more FAA committees than he probably cares for at this time). He shares an enthusiasm for running, backpacking, and skiing with his wife, Patricia, and their five children.

It is not often that one gets the opportunity to thank a friend and mentor in public. We are privileged to have worked with one of the best and are pleased to call him friend. We join with Jack's many other friends and colleagues in wishing him a joyous 60th birthday, many more years of scientific productivity and investigation, and contentment with friends and family.

Peter B. Armentrout
Mary T. Rodgers

Guest Editors