Polycyclic Aromatic Hydrocarbons in collisions with atoms

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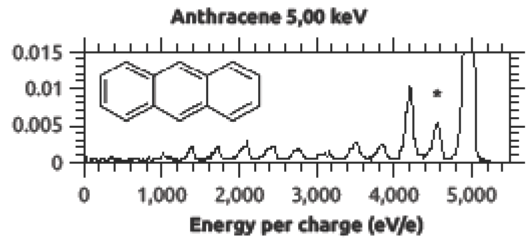
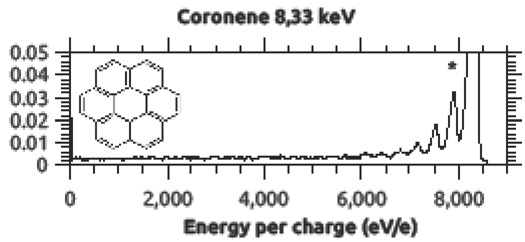
Polycyclic Aromatic Hydrocarbons (PAHs) are an important component of interstellar dust and gas and are probably responsible for the ubiquitous infrared emission bands present in the spectra of many galactic and extragalactic sources [1]. The processes by which PAHs and other large molecules (e.g. fullerenes) are formed and destroyed in the interstellar medium are not yet understood. For example, collisions between PAHs and ions in interstellar shocks are thought to be important destruction mechanisms, but fragmentation cross-sections and the related dissociation energy barriers are mostly not known. Experiments on collisions between PAH ions and atoms, particularly in the 100 eV energy regime, may elucidate the role of such collisions in the processing of interstellar carbon.

We will present the results of collision induced dissociation (CID) experiments between small (6 to 24 carbon atoms) PAH (or nitrogen substituted PAHN) ions and rare gases conducted at center-of-mass energies (for helium) of around 100 eV. The results differ qualitatively from previous work, particularly in the CH_x loss channel (marked * in the figures), which is much more prominent than is typically observed and here it even becomes dominant for the larger PAHs. In thermally driven processes such as photo-induced dissociation, evaporation of H-atoms and C_2H_2 units are typical results of the lowest energy decay pathways. For the present collisions, fragmentation is frequently initiated by prompt knock-outs of single carbon atoms, after which the excited fragment ion may decay further. Parallel theoretical work reveals that nuclear stopping is the main source of energy deposition in collisions with helium while electronic stopping becomes more significant for heavier target gases.





We find that the larger PAHs, and those with more compact structures so called peri-condensed PAHs, are less likely to decay further following single carbon knock-outs, while PAHNs are more likely to decay further due to the lower dissociation energy for HCN loss compared to C_2H_2 loss [2]. These results have important implications for astrochemistry by suggesting efficient routes to highly reactive fragments with unsaturated carbon atoms. In contrast, photo-absorption favors more stable and less reactive fragmentation products.

The electrospray ion source used in this work, or a copy of it, may also be mounted at the DESIREE double electrostatic ion storage ring [3]. This will enable collisions with a variety of ions at low (10 K) temperatures and with center-of-mass energies in the meV range.

References:
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