

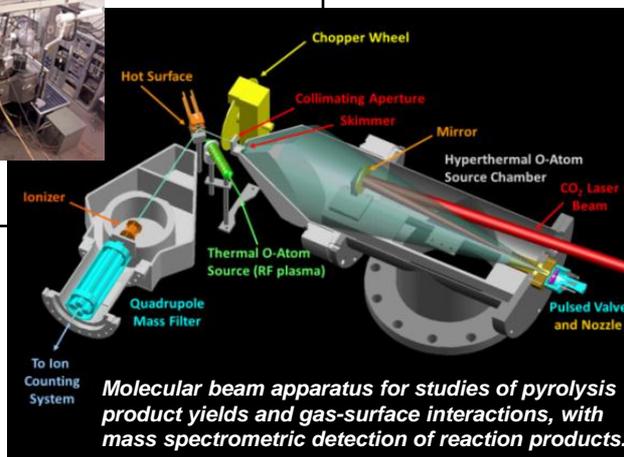
Uncovering the Chemical Processes during Atmospheric Entry of a Carbon/Phenolic Ablator: Laboratory Studies by *In Situ* Mass Spectrometric and Molecular Beam Techniques



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Research Objectives

- Transform our understanding of the ablation chemistry during atmospheric entry of carbon/phenolic composite TPS materials.
- Apply advanced molecular beam and mass spectrometric techniques to the generation of non-equilibrium data and knowledge for modeling TPS ablator behavior.
- Provide detailed data on the kinetics and dynamics of decomposition processes and gas-surface interactions for materials response models.
- Collect data *in situ*, as a function of time and temperature, with a highly sensitive mass spectrometer, as opposed to the current state of the art which conducts species analysis after decomposition.

- Move scientific knowledge and methodology from TRL 1 to TRL 2, and in so doing promote a transformation in material response models to TRL 4.

Approach

- Novel application of molecular beam and mass spectrometric techniques in vacuum, to obtain *in situ* experimental data for non-equilibrium phenomena.
- Ability to control sample temperature from ambient to >2200 K.
- Molar yields of pyrolysis gases detected in real time, allowing finite rate data to be obtained for the chemical decomposition processes.
- Measurements of permeation rates and reactive processes as a gas pulse passes through a slab of material, such as char or carbon preform.
- Detailed investigations of pyrolysis and boundary layer gases at char and carbon surfaces.
- Mass-loss rates and morphology evolution during bombardment of high-temperature phenolic and carbon/phenolic materials by well characterized beams of reactive gases.

Potential Impact

- Higher fidelity materials response models that accurately predict surface recession and temperature response of TPS materials during entry, descent, and landing for NASA missions.
- New methodology for studying non-equilibrium chemical processes in TPS materials – a resource that may be generally applied for TPS modeling and materials development.
- Design guidelines for a new generation of TPS materials that transcend current materials such as PICA.