In-Situ Landing Analysis of a Jupiter Trojan Asteroid Using a High Resolution Mass Spectrometer in the Solar Power Sail Mission

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The Solar Power Sail (SPS) mission is one of candidates of the upcoming strategic middle-class space exploration to demonstrate the first outer Solar System journey of Japan. The mission concept includes in-situ analysis of the surface and subsurface (up to 1 m) materials of a Jupiter Trojan asteroid using high resolution mass spectrometry (HRMS). The current mission sequence proposes the launch in late 2020s, and rendezvous to a D or P type Trojan asteroid of ~20-30 km in diameter in 2030s.
The key questions for the Jupiter Trojan asteroid exploration are: (1) constraining planet formation/migration theories, (2) evolution and distribution of volatiles (water and organics) in the Solar System, (3) origin of Earth’s water, and (4) surface processes of Jupiter Trojan asteroids.
We plan to analyze volatile materials on the Jupitar Trojan, for their isotopic and elemental compositions using a HRMS with a combination of pyrolysis ovens and gas chromatography (GC) columns. This HRMS system allows to measure H, N, C, O isotopic compositions and elemental compositions of molecules prepared by various pre-MS procedures including stepwise heating up to 600ºC, pyrolysis-GC, and high-temperature pyrolysis with catalyst in order to decompose the samples into simple gaseous molecules (e.g., H_2, CO, and N_2). The required mass resolution should be at least 30,000 for analyzing isotopic ratios (e.g., $H_2{}^{16}O$, $HD^{16}O$ and $H_2{}^{18}O$ for H and O isotopic measurements) for simple gaseous molecules. For elemental compositions of molecules/ions, mass accuracy of ~10 ppm is required to determine elemental compositions for molecules with *m/z* up to 300 (as well as compound specific isotopic compositions for smaller molecules). Our planned analytical sequences consist of three runs for both surface and subsurface samples. In addition, ‘sniff mode’ which simply introduces environmental gaseous molecules into a HRMS will be done by the system. The details of the analytical methods and apparatus are under developments.

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