Assessing the Small carry-on Impactor debris operated by the Hayabusa2 mission: an evaluation by FT-IR, micro-Raman, STXM and NanoSIMS.

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On-going mission of the JAXA Hayabusa2 (the C-type asteroid Ryugu) is a combination of an asteroidal sample return and detailed spectroscopic observations to understand the Solar System evolution from the point of view of organics, and water as hydrous minerals [1]. The Hayabusa2 spacecraft was thought to be successfully obtained the Ryugu samples (an expected total amount of ~ 100 mg) from surface and subsurface on Feb. and Apr. 2019 and will return to the Earth on Dec. 2020. To obtain the fresh subsurface samples of the Ryugu asteroid, Small Carry-on Impactor (SCI) [2] was used to generate an artificial crater on the surface. A driving force of the SCI was made by HMX (High-Melting Explosive; cyclotetramethylenetetranitramine; $C_4H_8N_8O_8$, 296.15) together with HTPB (Hydroxyl Terminated Polybutadiene), IDP (Isodecyl palargonate; $C_{19}H_{38}O_2$) and IPDI (Isophorone diisocyanate; $C_{12}H_{18}N_2O_2$) [2]. Takano and coworkers [3] reported analytical results of SEM-EDS (Scanning Electron Microscopy / Energy Dispersive X-ray Spectroscopy), TD-GC/MS (thermal desorption-gas chromatography/mass spectrometry), SPME (Solid-phase micro extraction)-GC/MS, and isotope mass spectrometry for N and C isotopes. They found volatiles of aliphatic and aromatic carbon structures, and the several functional groups (hydroxyl, aldehyde, nitrile, and carboxyl) [3].

The explosion products generated by their chemical reactions with HMX, HTPB, IDP and IPDI should be investigated prior to analysis of the Ryugu samples because those materials might be possible contaminants in the subsurface samples in the sample container. It is, therefore, necessary to analyze the SCI fragments and its products using the same analysis techniques. These results will provide relevant information to the initial analysis in advance the arrival of the Ryugu samples to the Earth.

In this study, we will report analytical results of the experimental explosion-products of the HMX mixture under Ar condition utilizing an optical microscope for micrometer-scale texture, SEM-EDS for texture and major elements, microFT-IR for functional groups, micro-Raman for structures of carbonaceous materials, STXM (Scanning Transmission X-ray Microscopy) for sub-micrometer-scale functional groups of carbon, nitrogen and oxygen, and NanoSIMS (nano-scale Secondary Ion Mass Spectroscopy) for hydrogen, carbon and nitrogen isotopes.

[1] Tachibana et al. (2014) Geochemical Journal 48, 571-587. [2] Saiki et al. (2013) Acta Astronautica 84, 227-236; Saiki et al. (2016) Space Science Reviews 208, 165–186. [3] Takano et al. (2014) in Hayabusa 2014: 2nd Symp. Solar System Materials, P03.

Keywords: Hayabusa2 mission, Small carry-on Impactor

