Compound distribution determined by nanoLC-Orbitrap MS

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The Hayabusa2 mission is no less than the first opportunity to infirm or confirm theories about the formation of C-type asteroids [1], [2]. The origin and nature of the organic molecules Ryugu bears will tell which part of this chemistry takes place on this type of airless bodies and which part in inherited by accretion. The comparison with carbonaceous chondrite will be the method to evaluate if what has been interpreted from well-studied meteoritical samples is still valid for actual asteroid regolith.
This study focuses on the molecular mixture complexity observed thanks to the combination of two analytical methods: liquid phase chromatography and high-resolution mass spectrometry [3]. Samples from the first (named A106) and second (C107) encounter with Ryugu were washed with different solvents in order to extract the soluble organic compounds in a sequence of increasing polarity in Kyushu University. Each extract was separated on an amide column with limited volume and flow in a so-called nano-liquid-chromatography (nano-LC) protocol. The chemical separation is monitored through time by Orbitrap-mass-spectrometry (Orbitrap-MS).
This provides three observables for each compound present in the Ryugu soil extract: an intensity evaluating its relative abundance, a retention time depending on its structure and a molecular weight equivalent to its atomic composition. With thousands of different compounds, mixtures usually exhibit peculiar patterns in this three-dimensional framework. For instance, the relative abundance of phospholipids in terrestrial living cells varies by orders of magnitude if the carbon atoms number is odd or even, making contamination by fingerprints easy to detect. We used the ATTRIBUTOR routines developed at University of Grenoble Alpes to extract relevant patterns in the Ryugu extracts chromatograms [4].
The most remarkable feature found in both meteorites and Ryugu samples is a ubiquitous polymerization pattern [5]. Almost each measured mass is part of a network linking it to other molecules with one more carbon atom, two more hydrogen atoms or any combination of these. A typical bell-shaped intensity distribution indicates that the whole mixtures are likely to be of one single synthesis origin [6]. Variability of the distribution characteristics goes with a complex origin of subsequent processes. This type of mass and intensity patterns is difficult to find in other terrestrial natural samples.
The less polar molecules found in Murchison have extremely broad distributions, only matched by some of the Ryugu's compounds and other chondrites. For these molecules, the best analogues are solid residues generated out of gas mixtures in plasma chambers [7]. Experimental polymers synthesized in liquid phase or by irradiation of ices have significantly different polymerization patterns [8].
The chemical structure of compounds found in Ryugu slightly differs from the one in the CM2 Murchison chondrite. As of preliminary identification, the less polar compounds are similar between Ryugu and Murchison while the most polar molecules have significantly different retention times. Assuming polar compounds are more likely to be part of a reaction in liquid water, the discrepancy between Murchison and Hayabusa2 samples could be due to different degree of aqueous alteration on their parent bodies.

References

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