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Raman spectra of nitrogen-containing biomarkers obtained using a handheld instrument at winter mountain conditions

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In this study a performance and feasibility of commercially available handheld Raman spectrometer was tested as an approximation to the Raman spectrometers that are to be used on the future robotic planetary surface exploration missions focused mainly on the search of the traces of life. The conditions on the Alpine test site (low temperature, snowstorm and increased radiation from Sun) were far from the common laboratory conditions and can be considered to be relatively extreme. Well-resolved Raman spectra of examples of mainly nitrogen-containing compounds were acquired using a portable Raman instrument (Ahura First Defender XL) outdoors at a low ambient temperature of -15°C and at an altitude of 2860 metres in the Austrian Alps. The rugged handheld Raman spectrometer tested here is equipped with a 785 nm diode laser and fixed frontal probe. Primary purpose of this type of instruments is to serve as tools for drug and explosives detection. Solid form of formamide, urea, 3-methylpyridine, aniline, 1-(2-aminoethyl)piperazine, indoline as well as two nitrogen-free compounds indene and benzofuran were detected unambiguously under these complex field conditions. Studied compounds were chosen as representatives of aliphatic and aromatic heteroatomic molecules that can potentially be found in the frame of Titan tholins. The main Raman features (strong, medium and partially weak bands) were observed at the correct wavenumber positions (with a spectral resolution 7 – 10 cm^{-1}) in the wavenumber range 200 – 1600 cm^{-1}. The results obtained demonstrate the possibility to apply a miniaturised Raman spectrometer as a key instrument for investigating the presence of nitrogen-containing organic compounds and biomolecules outdoors under low temperature conditions. Within the payload designed by ESA and NASA for future missions, focussing not only on Mars but also on the outer solar system worlds like Titan and Europa, Raman spectroscopy represents an important instrument for the detection of biomolecules relevant to life processes on planetary surfaces or near sub-surfaces.