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IR Spectroscopy of ammoniated phyllosilicates and mixtures with relevance for dwarf planet (1) Ceres

S. De Angelis (1), M. Ferrari (1), S. Stefani (1), A. Raponi (1), M.C. De Sanctis (1), G. Piccioni (1), E. Ammannito (2)
(1) Institute for Space Astrophysics and Planetology, IAPS-INAF, Rome Italy, (simone.deangelis@iaps.inaf.it) (2) Italian Space Agency – ASI, Rome, Italy

Introduction

The surface composition of (1) Ceres has been revealed with great detail by VIR spectrometer high resolution observations [1] on board Dawn spacecraft [2]. Spectroscopic observations in the infrared range 1-5 µm have showed an average surface composition consisting of a mixture of Mg-phyllosilicate, (Mg,Ca)-carbonate, a dark absorbing phase and NH_4-phyllosilicates [3], and bright areas locally composed by mixtures of Na-carbonates, phyllosilicates, a dark phase and ammonium compounds [4]. The reproduction in laboratory of such mineral mixtures is thus of interest in order to better constraint and interpret remote-sensing observations. In this work we focus on the preparation and IR spectroscopic measurements in laboratory of NH_4-phyllosilicates and mineral mixtures.

1. Sample preparation and experimental setup

A set of 8 phyllosilicates were chosen from Clay Minerals Society, grinded and dry sieved to a fine grain size (d<36 µm). Ammonium phyllosilicates were then prepared following a procedure similar to what described in Bishop et al. 2002 [5]. All powders were immersed in excess (10:1 vol/mass) solutions of ammonium hydroxide (30% NH_3 in H_2O) for several days, centrifuged and decanted: this cycle was repeated more times, and finally samples were dried. Splits of these samples were separated and treated with a leaching procedure. Other endmembers, concerning the average mixture, were prepared in the form of d<36 µm-powders, specifically antigorite, (Ca,Mg)-carbonate and magnetite. A set of 8 different mixtures has been then prepared, keeping fixed antigorite, dolomite and magnetite, and varying the NH_4-clay mineral constituent.

All end-members have been spectrally characterized by means of visible/infrared spectroscopy. Spectra in the VNIR have been acquired with a FieldSpec Pro in the 0.35-2.5 µm range, with 6 mm spatial resolution and spectral resolution 3÷8 nm. Fourier Transform Infrared Spectrometer (FTIR-PLAB) Vertex-80 was used in reflectance mode to acquire spectra of powders, with spectral resolution 2 cm^{-1}, spatial aperture of about 6 mm, in the spectral range 1.3-14 µm, using an MCT detector. Each acquisition was performed by summing 256 scans in order to increase S-N ratio. Reflectance spectra were acquired from all endmembers, and separately from phyllosilicates, NH_4-phyllosilicates and "leached" NH_4-phyllosilicates, and finally from mixtures.

Clay minerals endmembers		
Sepiolite	SEPSP1	
$(K_{0.01})[Mg_{5.54}\ Al_{0.35}\ Mn_{0.02}\ Fe^{2+}_{0.04}\ Fe^{3+}_{0.14}][Si_{7.90}\ Al_{0.1}]O_{20}(OH)_4$		
Rectorite	RAR1	
$(Na,Ca)Al_4(Si,Al)_8O_{20}(OH)_4{\bullet}2(H_2O)$		
Nontronite-1	NAU1	
$(M^{+}_{1.05})[Si_{6.98}Al_{1.02}][Al_{0.29}Fe_{3.68}Mg_{0.04}]O_{20}(OH)_4$		
Nontronite-2	NAU2	
$(M^{+}_{0.72})[Si_{7.55}Al_{0.45}][Fe_{3.83}Mg_{0.05}]O_{20}(OH)_4$		
Illite-1	IMT2	
$K_{0.65}Al_{2.0}[\ ][Al_{0.65}Si_{3.35}O_{10}](OH)_2$		
Illite-2	ISCZ1	
Montmorillonite	SCA3	
$(Mg_{0.45}Ca_{0.15}\ Na_{0.26}\ K_{0.01})[Al_{2.55}\ Fe^{3+}_{0.12}\ Mn_{tr}\ Mg_{1.31}Ti_{0.02}][Si_{7.81}Al_{0.19}]O_{20}(OH)_4$		
Hectorite	SHCA1	
$(Mg_{0.56}\ Na_{0.42}\ K_{0.05})[Mg_{4.60}\ Li_{1.39}\ Mn_{tr}Ti_{0.01}][Si_{7.75}\ Al_{0.17}\ Fe^{3+}_{0.05}]O_{20}(OH)_4$		

Tab.1. Clay minerals endmembers.

2. IR Spectral measurements: results

In fig.1 an example of spectra acquired on nontronite endmember (NAU-1) is shown, in which the nontreated sample (blue line) is compared with the NH$_4$-treated sample (green). The full spectral coverage has been subdivided in five ranges for clarity, specifically 0.35-2.5 µm (FieldSpec) and then 1.3-2.5 µm, 2.5-4.1 µm, 4-6 and 6-14 µm for FTIR data. The ammoniated sample is characterized by the occurrence of several new features in four of the five displayed ranges, although a global change in the overall spectrum is visible in the full range; namely a substantial decrease in reflectance level is observed, together with a reduction of spectral contrast. New absorption bands putatively attributable to NH$_4^+$ ions appear near 2 and 2.1 µm, near 3.1 µm and at 7 µm.

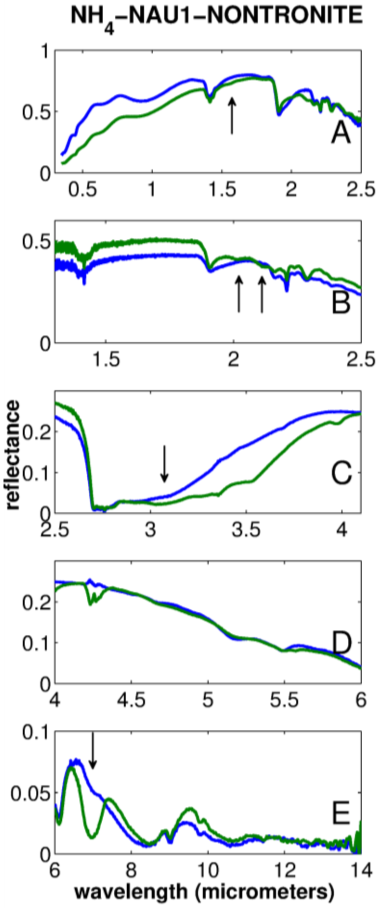

Fig.1. Nontronite NAU-1. Untreated sample (blu line) vs NH$_4$-treated sample (green line). A: 0.3-2.5 µm. B: 1.3-2.5 µm. C: 2.5-4.1 µm. D: 4-6 µm. E: 6-14 µm. The NH$_4^+$ 3.1-µm band here appears as a bump overlapped with the water band at 3 µm, which is difficult to remove unless heating the sample in vacuum.

In fig.2 the VIR average spectrum of Ceres (purple line) [3] is compared with mixture spectra measured with FTIR. Here the mixture is composed by serpentine-antigorite, dolomite, magnetite and NH$_4$-NAU1 (nontronite). Laboratory spectra show a good matching with VIR spectrum; the agreement is better for what concerns the OH$^-$ 2.7 µm-band of serpentine and the 4 µm-band of carbonate. The feature near 3.1 µm due to NH$_4^+$ in laboratory spectra is evident, although additional adsorbed water is present in the sample and influences the band.

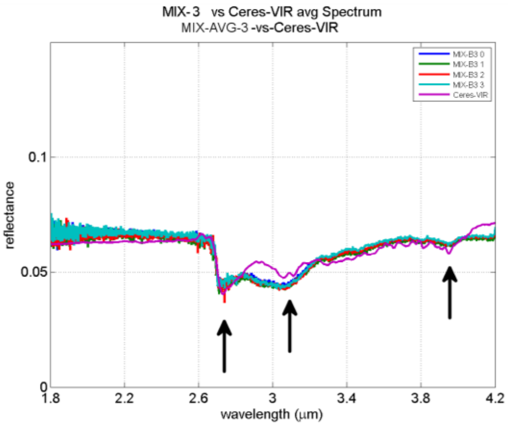

Fig.2. Dawn-VIR average spectrum of Ceres (purple line) vs Mixture AVG-3 laboratory spectra. Arrows indicate, from left to right, absorptions in the mixture due to antigorite (2.72 µm), NH$_4^+$+H$_2$O (3-3.1 µm) and dolomite (4 µm).

3. Summary and Conclusions

Treatment of phyllosilicates with ammonia shows that different minerals behave in different ways: NH$_4^+$ ions are easily accepted by several crystal structures (nontronite, montmorillonite), while other structures accept these ions with difficulty. Laboratory spectra of the mixture show a good agreement with VIR spectrum. Further work is ongoing to remove adsorbed water from phyllosilicates, in order to facilitate NH$_4^+$ inclusion in mineral structures, and to separate NH$_4^+$ and OH$^-$ absorption features in the 3-µm spectral region.

Acknowledgements

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References

[1] De Sanctis M.C.,et al.,Space Sc.Rev,369,163-329, 2011
[2] Russell C.T., et al., Planet. Sp. Sci., 52, 465-489, 2004.
[3] De Sanctis M.C., et al., Nature, vol.528, 241-244, 2015.
[4] De Sanctis M.C., et al., Nature, vol.536, 54-57, 2016.
[5] Bishop J.L., et al., Planet. Sp. Sci., 50, 11-19, 2002