PHOTOPROCESSING OF ORGANIC MATERIAL ON CERES: LABORATORY STUDIES ON CHEMICAL EVOLUTION OF A WET SMALL BODY. Brucato J.R.1, De Sanctis M.C.2, S. Pagnocini 3,1, Poggiali G.4,1, Ferrari M.2, De Angelis S.2, Palumbo M.E.3, Baratta G.3, Mennella V.6, Fulvio D.6, Popa C.6, Strazzulla G.5, Scirè C.5, 1INAF - Osservatorio Astrofisico di Arcetri, Firenze, Italy (john.brucato@inaf.it); 2INAF-IAPS Istituto di Astrofisica e Planetologia Spaziali, Roma, Italy; 3Department of Physics and Astronomy, University of Firenze, Firenze, Italy; 4LESIA-Observatoire de Paris, Université PSL, CNRS, France; 5INAF - Osservatorio Astrofisico di Catania, Catania, Italy; 6INAF-Osservatorio Astronomico di Capodimonte, Napoli, Italy

Introduction: Ceres is the largest object of the Solar System main belt with a complex geological and chemical history, which experienced extensive water-related processes and geochemical differentiation [1]. Ceres’ surface is characterized by dark materials, phyllisilicates, ammonium-bearing minerals, carbonates, water ice, and salts. In addition to a global presence of carbon-bearing chemistry, local concentration of aliphatic organics has been detected by Dawn mission [2]. In the main frame of a national program of the Italian National Institute of Astrophysics INAF, we started a series of laboratory studies on physicochemical evolution of organic material interacting with minerals thought to be present on Ceres. The goal is to understand the transformations induced on these samples by processing with ultraviolet radiation, neutral atoms, and fast ions, under experimental conditions that simulate the environment of Ceres. Thanks to the combined experimental activities and through the comparison with the observations of the VIR spectrometer aboard the Dawn mission, we aim to understand the origin and evolution of organic material observed on Ceres. The Dawn mission, thanks to the data collected by the Italian instrument VIR [3], showed clear evidence of a high amount of aliphatic organic material on the surface of Ceres [4, 5, 6]. This evidence has raised new questions about the origin and preservation of this material, especially when considering its high estimated abundance and the mineralogical context (Fig 1).

Diffuse FTIR reflectance spectra were acquired in vacuum at 5x10^{-6} mbar using Bruker VERTEX v70 interferometer. Spectra of simulants are resembling the Ceres surface composition (Fig. 2). We irradiated the sample in the vacuum chamber at room temperature using an UV-enhanced Newport Xenon lamp (wavelength range 185 - 2000 nm) to simulate the solar radiation. The radiation emitted by the lamp was collimated through an optical fiber directly to the sample. The photon flux was 2.75x10^{17} ph. cm^{-2} s^{-1} in the 200-400 nm spectral range as measured through a single monochromator Spectro 320 spectrometer. The simulants were irradiated at increasing fluence up to irradiation time of about 7 hours and the degradation process was monitored in real time with FTIR spectroscopy by measuring the changes in the spectral features (band areas). In Fig. 3 the reflectance spectra of the simulants as prepared and after UV irradiation at 180, 2280, and 21180 s are showed. The bands area of NH3 at 3 µm and aliphatic CH2/CH3 at 3.4 µm are decreasing as the irradiation fluence increases with time.
silicates.

However, this result would not be able to explain the detectable time scale of million years. Further experiments are planned to investigate the photodegradation processing at cryogenic temperatures.

Discussion: As showed by VIR, the ammoniated band is ubiquitous on Ceres, which is in contrast with the fact that we expected the ammoniated band to be completely degraded. In fact, the half-lifetime obtained in this work is too short compared the resurfacing processes that are estimated to act on Ceres in millions of years. However, the photodegradation act on the first molecular layers of the surface exposed to the radiation. Furthermore, the visible and near infrared spectra detected by VIR are diffused by the first millimeters of the surface at a depth that cannot be affected by UV radiation. Therefore, the spectra are a combination of processed superficial material and underlying layers of the Ceres surface, which may retain the primitive characteristics of material rich in organic. However, it should be noted that in addition to UV, the surface is constantly bombarded by solar energetic particles (SEP) and galactic cosmic rays (GCR). This radiation also has the effect of breaking chemical bonds such as UV photons, but penetrating meters into the surface can alter deeper layers. These results suggest that there must be a resurfacing mechanism that acts on a much shorter time scale than the geological one. Diffusion of organic matter and ammonia towards the surface coming from the deeper unprocessed layers of the order of meters cannot be excluded. This could occur by thermal conductivity due to diurnal and annual solar irradiation. This is a first result of a broader work that we are conducting within various INAF institutes with the aim to understand the effects of irradiation processes with UV, ions and hydrogen atoms on Ceres surface.

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References: