

Reflectance Spectra of Synthetic Ortho- and Clinoenstatite in the UV, VIS, and IR for Comparison with Fe-poor Asteroids

Kathrin Markus (1,2), Gabriele Arnold (2), Harald Hiesinger (1), and Arno Rohrbach (3)

(1) Westfälische-Wilhelms Universität, Institut für Planetologie, Münster, Germany (kathrin.markus@uni-muenster.de), (2) DLR, Institute of Planetary Research, Berlin, Germany, (3) Westfälische Wilhelms-Universität Münster, Institut für Mineralogie, Germany

Major rock forming minerals like pyroxenes are very common in the solar system and show characteristic absorption bands due to Fe^{2+} in the VIS and NIR [e.g., 1, 2]. The Fe-free endmember enstatite is also a common mineral on planetary surfaces like asteroids and probably Mercury [3] and a major constituent of meteorites like aubrites [4] and enstatite chondrites [5]. Reflectance spectra of these meteorites as well as the enstatite-rich or generally Fe-poor asteroids like the asteroidal targets of the Esa Rosetta mission (2867) Steins [6] and (21) Lutetia [7] are often featureless in the VIS and NIR lacking the absorption features associated with iron incorporated into the crystal structure of silicates. Fe-bearing orthopyroxenes show diagnostic absorption bands at $\sim 1 \mu\text{m}$ and $\sim 2 \mu\text{m}$. While systematic changes in positions and depths of these bands with changes in Fe- and Ca-content of orthopyroxenes have been extensively studied [e.g., 2, 8], almost Fe-free enstatite is so far only spectroscopically investigated by [2].

For a better understanding of these Fe-poor bodies the availability of laboratory spectra of Fe-free silicates as analog materials are crucial but terrestrial samples of enstatite usually contain several mol% of FeO with pure enstatite being extremely rare. For easy availability of larger amounts of pure enstatite we developed a technique for synthesis of enstatite. These enstatite samples can be used as analog materials for laboratory studies for e.g. producing mixtures with other mineral samples.

Enstatite has 3 stable polymorphs with clinoenstatite, orthoenstatite, and protoenstatite being stable at low ($<700^\circ\text{C}$), intermediate ($>600^\circ\text{C}$), and high ($>1000^\circ\text{C}$) temperatures [9]. Orthoenstatite and protoenstatite are orthorhombic, while clinoenstatite is monoclinic. Orthoenstatite is abundant in terrestrial rocks and in meteorites. Clinoenstatite is known from meteorites [5, 9]. Both polymorphs of enstatite therefore exist on the parent bodies of aubrites and enstatite chondrites. Clinoenstatite in enstatite chondrites and aubrites formed presumably by crystallization from a melt and subsequent quenching and mechanical deformation (brecciation) [5].

We synthesized powders of orthoenstatite and clinoenstatite. Following the synthesis we used XRPD to discriminate between the polymorphs. The grain sizes of the samples were determined using SEM pictures of the samples and are comparable to the $<25 \mu\text{m}$ sieving fractions of our terrestrial samples with some additional larger grains. The orthoenstatite sample is slightly coarser than the clinoenstatite sample. We collected reflectance spectra of both enstatite samples ranging from $0.25 \mu\text{m}$ to $17 \mu\text{m}$ using the Vertex 70v and Vertex80v at IR/IS facility at the Institut für Planetologie at the University Münster and the Institute of Planetary Research at DLR in Berlin.

In the VIS and NIR both samples show weak absorption bands. The clinoenstatite shows absorption bands at $1.75 \mu\text{m}$ and $0.90 \mu\text{m}$. Both absorptions bands can be attributed to minor amounts of Fe^{2+} in M2 positions of the clinoenstatite. The orthopyroxene shows several weaker absorptions bands between $0.4 \mu\text{m}$ and $1 \mu\text{m}$ which are due to Fe^{3+} and possibly Ti. Both samples show a steep red slope in the UV while spectral slopes in the VIS and NIR are almost neutral with only a slightly reddish slope in the VIS.

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