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Sol-gel synthesis of nanocrystalline fayalite (Fe_2SiO_4)

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Abstract

Fayalite (Fe_2SiO_4), and other Fe-rich olivine, is often found in the reducing environments of the Moon, Mars, and other extraterrestrial bodies, but the oxidation state of the terrestrial mantle restricts the amount of Fe found in olivine on Earth. For this reason, synthetic fayalite is needed for use in planetary-analog and other studies. Here we present a method for the synthesis of nanocrystalline fayalite (nanofayalite) using a sol-gel technique. Iron(II) chloride, sodium ethoxide, and tetraethyl orthosilicate (TEOS) were reacted to produce a precursor gel, which was subsequently calcined under reducing conditions to crystallize nanofayalite. Powder X-ray diffraction analyses indicate that the produced nanofayalite is nearly pure, with minor amounts (0.5–3%) of metallic Fe in some batches. Scanning electron microscope images of nanofayalite crystals show euhedral to subhedral crystals that range in size between 100 and 150 nm. Estimates of specific surface area were determined by both the Brunauer-Emmett-Teller (BET) and Langmuir adsorption methods and indicate average surface areas of 27.7 and 45.3 m^2/g, respectively. Regulation of the redox environment was the critical challenge for this synthesis, but careful control of oxygen fugacity during reactant addition and mixing, sol-gel drying, and calcination ensured fayalite crystallization.

Keywords: Fayalite, nanofayalite, olivine, crystal synthesis, sol-gel, Fe_2SiO_4