Electron microscopy observations on the Structure of Synthetic Opal

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Abstract

Electronoptical observations on synthetic opals have been carried out.
The experimental production of synthetic opals follows the Stöber process - named after the developer. This process results in the synthesis of uniform, colloidal nano-particles from a solution of ethanol, water, ammonia solution, and tetraethylorthosilicate, Si(C2H5O4)4 (TEOS). Some parameters, e.g., the concentration of the ammonia solution, were adjusted slightly during the experimental progress to produce larger nano-particles. All syntheses of opals were sedimented and dried simultaneously. The opals were not sintered and the pore space was not filled. The resulting opals were observed using the Scanning Electron Microscope IT500 from JEOL.

For comparison, natural opals and SiO2-fibres from marine solutions were examined to compare their precipitation and growth structures to that of experimentally synthesised opals. An X-ray diffraction analysis was conducted to confirm that the produced material is amorphous. The selected composition of the solution and the chosen drying processes resulted in opal thin layers ($\leq$1 mm) rather than larger synthetic opals. Optimal results with regard to opalescence were achieved with thinly spread dispersion volumes of
After successful synthesis, the synthetic opals were heat treated at 200, 400, 600, 800, 1000, and 1200∘C. The resulting change in nano-structure and molecular structure was observed by Scanning Electron Microscopy, Fourier-Transform infrared spectroscopy and Raman spectroscopy. A thermal analysis was conducted in the form of a thermogravimetric analysis and differential scanning calorimetry. With rising temperature during heat treatment, synthetic opals lose water and the network of silica tetrahedra becomes stronger. At temperatures around 1200∘C a change of the molecular interconnections occurs. The material starts to be more similar to α-cristobalite or silica glasses.

Keywords: opal, electron microscopy, nanoparticles, nanostructure

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