Synthetic Cryolite Nanoparticles: A Potential Rare Earth Doped Host Material Capable of Matching the Refractive Index of Numerous Vascularized-Tumor Fluids

Dhawan, Nikhil

Rare-earth-doped nanoparticles (ReNPs) are capable of generating optical emissions for imaging molecular events. ReNPs typically consist of a host material and rare earth dopants. Though serving the function of preventing surface contaminates from attenuating light, the host material is responsible for site-scattering due to a refractive index mismatch with the surrounding medium. Site-scattering contributes to a decrease in ReNP penetration depth, phosphor brightness, and image clarity. The potential of Cryolite (Na_3AlF_6) as a host material to reduce scattering was investigated by attempting to dope Cryolite with Yb^{3+} and Er^{3+} using a hydrothermal co-precipitation method and tuning its refractive index to match that of vascularized-tumor fluids. Undoped Cryolite was hydrothermally synthesized using a novel procedure without HF. Field emission scanning electron microscopy and energy-dispersive-X-ray spectroscopy showed that Yb^{3+} and Er^{3+} were not incorporated into the Cryolite lattice using the hydrothermal co-precipitation method. X-ray diffraction of samples synthesized in acidic and Na^+ deficient environments indicated the formation of another sodium fluoroaluminate phase, Chiolite ($Na_5Al_3F_{14}$). Rietveld analysis indicated that as the ratio of $NaOH:Al_2O_3$ in precursor solutions decreased, the % Chiolite in the system increased. Refractive index (N) measurements revealed that as the amount of Chiolite in the sample increased, the refractive index of the system increased, moving towards Nchiolite. The results demonstrated that the refractive index of the Cryolite/Chiolite system can be tuned between [Ncryolite] and [Nchiolite], showing the feasibility of matching the refractive index of the target biological system and eliminating site-scattering losses ReNPs in-vivo.

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