Tuning the infrared absorption band of CuS nanoparticles for photothermal ablation applications

J.C. Ferrer, F. Rodríguez, J.L. Alonso, J. Capmany, S. Fernández de Ávila

Dpto. Ingeniería de Comunicaciones, Universidad Miguel Hernández, Av. Universidad, s/n, Ed. Innova, Elche, Spain
jc.ferrer@umh.es

Treatment of tumors by means of photothermal therapy using semiconductor nanoparticles is a promising alternative to chemotherapy or radiotherapy since the former technique may be limited to the target of interest and avoids the side effects of the later. Photothermal ablation is based on the heating of nanoparticles adhered to tumors by an infrared radiation for which the tissues are transparent. In order to become effective, nanoparticles should convert the optical power into heat efficiently.

Copper sulfides vary widely in composition with Cu:S ratios from 0.5 to 2 including numerous stable and metastable phases still to be fully characterized. Depending on the crystal structure, CuS_x nanoparticles may show an absorption band at the near infrared spectrum. In this work, a simple study of the influence of the Cu:S mole ratio on the activation of the IR absorption band is presented. Besides, the heating of a colloidal solution of CuS_x nanoparticles by means of a IR laser diode is demonstrated.

Five samples of CuS_x nanoparticles were synthesized by mixing 0.5M $CuCl_2$ and Na_2S solutions in a 4% polyvinyl alcohol (PVA) solution as stabilizer agent. The Cu:S mole ratio of the five samples were 1:2, 1:1.5, 1:1, 1.5:1 and 2:1. The resulting solutions were optically clear with colors ranging from copper brown to olive green. Transmission Electron Microscopy (not shown) observations were performed in order to confirm the presence of nanoparticles in the solutions.

Figure 1 shows the absorption spectra of the five samples. A common absorption band at lower wavelengths is observed independently of the proportion between Cu and S. However, the optical absorption around a wavelength of 874 nm depends on this variable. A minimal absorption is observed for the sample with a Cu:S mole ratio of 1:2. The absorption band increases for 1:1.5 ration and attains a maximum for Cu:S = 1:1. A further addition of copper results in a slight decrease of the absorption band.

In order to show the potential of the nanoparticles to be used in photothermal ablation applications, the solutions were illuminated by a 1 W infrared diode (λ = 860 nm) and the temperature variation was measured with a PT1000 temperature sensor during 25 minutes. Figure 2 shows the temperature increment of a bare PVA solution used as reference and the temperature variation of the samples with the highest (1:1) and lowest (1:2) absorption band. The higher temperature reached by the 1:1 solution is obviously related to the higher absorption of the infrared band which converts optical power into heat more efficiently.

Figures

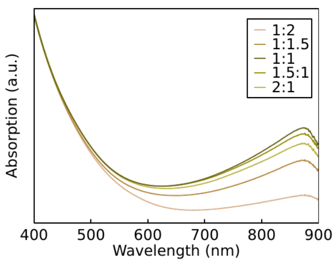

Figure 1: Optical absorption of CuS_x nanoparticle solutions with the Cu:S mole ratios shown in the inset.

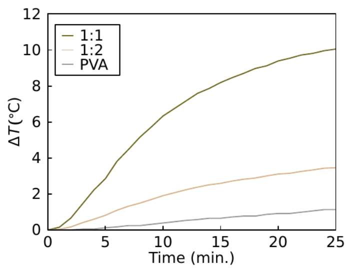

Figure 2: Temperature increment of the PVA reference solution and the samples with the highest (1:1) and lowest (1:2) IR absorption under ilumination of a λ = 860 nm laser diode.