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Embedding Silicon Dioxide Nanospheres for Homogeneous Incorporation onto a Resin Matrix

L. Baez-Castillo[1], E. Ortiz-Rascón[2], I. López-Miranda[1], R. Carrillo-Torres[1] and M.E. Álvarez-Ramos[1].

[1.] Departamento de Física, Universidad de Sonora (UNISON), Col. Centro, Hermosillo, Sonora, México.
[2.] CONACYT - Departamento de Física, Universidad de Sonora (UNISON), Col. Centro, Hermosillo, Sonora, México.

The optical properties of tissue affect both diagnostic and therapeutic applications of light in medicine; the ability of light to penetrate the tissue and its detection is a key factor for diagnostic applications. Thus, to determine the optical properties of tissue is the first step toward the properly design of devices [1]. The development of medical imaging systems has required the use of tissue simulating materials to mimic the optical properties of human or animal tissues. The optical properties of these phantoms are usually inconsistent and change over time, making comparison of different imaging systems a serious problem. The use of a reliable and reproducible phantom in any laboratory with constant and confident optical properties is the main goal of using silica (SiO_2) nanoparticles to develop this standard [2]. There are several types of optical phantoms often consisting of a bulk material like silicone, epoxy resin, or poly(vinyl)-alcohol, with embedded scatterers and absorbers, allowing fine-tuning of the optical scattering and absorption properties of the sample as required for the intended application [3]. Despite their high cost, silica micro and nanospheres have become increasingly popular for use within optical phantoms as the concentration required to achieve a designed scattering or absorption coefficient is easily calculated using Mie theory [3,4].

Our scattering optical phantoms are composed of silica nanoparticles embedded into a resin matrix. The silica nanoparticles were synthetized using a modified version of the Stöber Method, involving controlled hydrolysis, catalyzed on an alcoholic medium [5]. The reagents used were: tetraethylorthosilicate (TEOS, $Si(OC_2H_5)_4$) as precursor of silica, ethanol and deionized water as solvents and ammonia hydroxide (NH_4OH) as a catalyst. The synthesis was performed at room temperature with magnetic stirring for 24 hours. In this method it was possible to control the size of the silica nanoparticles by varying only the water vs ethanol ratio contained in the solution, and by keeping the amounts of the TEOS and NH_4OH reactants constant [6]. The final suspension was then centrifugated and washed to obtain nanospheres suitable for their incorporation through manual mixing into a polyester resin.

To analyze the appropriate incorporation of the silica nanoparticles into the polyester resin, samples of the resulting mixture were measured by using a scanning electron microscope (SEM) model FE-SEM JEOL JSM-7800F, the resulting images are shown in figure 1, where the homogeneous incorporation of the nanospheres can be appreciated for different magnifications.

The improved method offers monodisperse, reliable and reproducible silica nanoparticles for creating phantoms with uniform scattering and absorption coefficient [7], which are also homogeneously distributed within the polyester resin matrix. These results prove that it is possible to modulate the size and the concentration of silica nanoparticles in an aqueous solution and to resuspend them into the polyester resin matrix achieving a homogeneous mixture. The possible use of these spherical nanoparticles for mimicking optical properties of biological tissue is subject of ongoing work [8].

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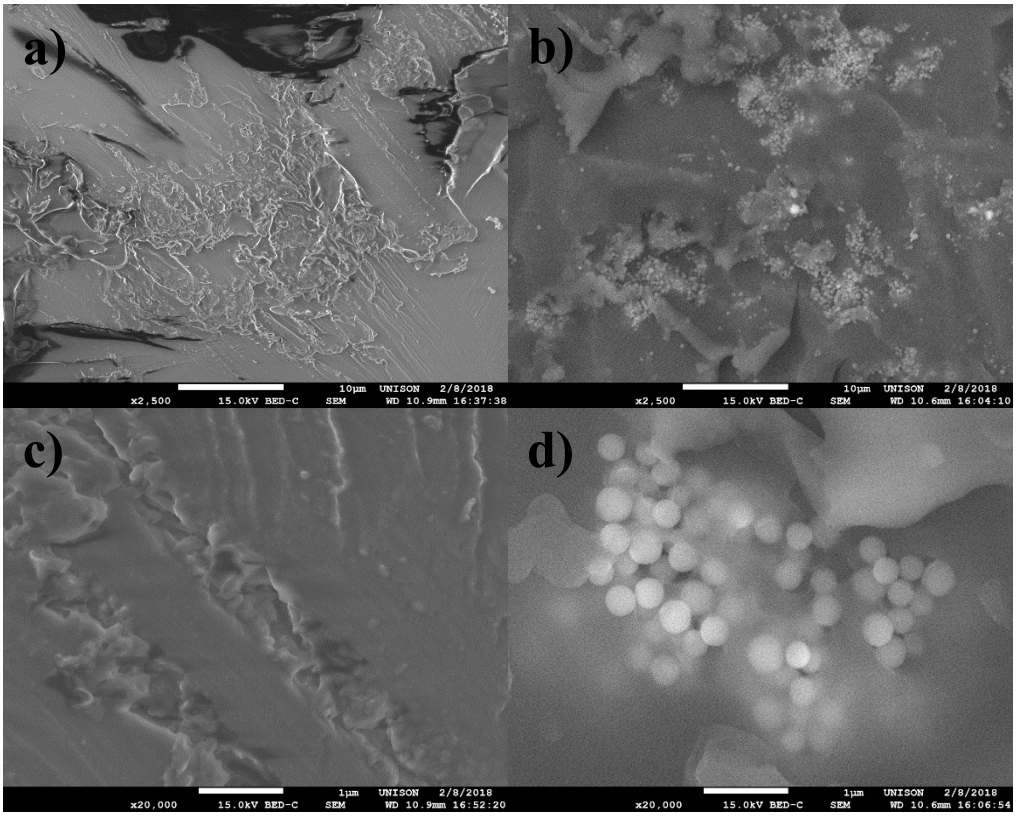

Figure 1. Up: SEM images of the polyester resin previously to the addition of the silicon dioxide nanospheres (a) and after the incorporation of them (b) the scale bar shows 10 microns. Down: SEM images of the polyester resin previously to the addition of the silicon dioxide nanospheres (c) and after the homogeneous incorporation of them (d) with the scale bar showing 1 micron.

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