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Liposomes containing titanium dioxide nanoparticles (Short communication)

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Abstract

The paper presents the obtaining of liposomes containing titanium dioxide nanoparticles by using the ultrasonication method. Natural lecithin and titanium dioxide doped with Au+ ions were used for obtaining the liposome micro/nanocapsules and these were analyzed by scanning electron microscopy, transmission electron microscopy, and energy-dispersive X-ray spectroscopy. Generally, the liposomes have not a higher uniformity, being formed by agglomerated capsules with various diameters up to 500 nm, as is revealed by SEM and TEM analyses. These liposomes contain titanium dioxide nanoparticles as is demonstrated by EDS analysis. The composition of liposomes containing titanium dioxide was: 25.5-49% lecithin, 1.3-2% TiO2, and 48.8-73.2% water (on the basis of EDS analysis).

Keywords: liposomes, titanium dioxide, nanoparticles, nanocapsules, SEM, TEM, EDS

1. Introduction

The most used matrices for protection and controlled release of various organic and inorganic compounds are liposomes. Liposomes are microspheres containing empty cavities resulted by phospholipids assembling in water. Generally, the membrane has two or more double lipidic layers, which contain aqueous phase where they are suspended [1-5].

Due to the amphiphilic character of phospholipids and to the "closed" architecture, liposomes can encapsulate hydrophobic molecules in the double layered membrane or hydrophilic compounds in the inner aqueous cavity, as well as amphiphilic compounds.

These special properties of liposomes generating various applications such as: models for biological membranes and carriers for drugs [1,2]. Drug compounds can interact with liposomes according to their solubility and polarity; these can be inserted in the lipidic bilayer region, intercalated in the polar groups region, adsorbed on the membrane surface, anchored by a hydrophobic chain, or encapsulated in the aqueous inner cavity of liposomes.

The first type of liposomes was multilamellars and was obtained by lipid-water interaction in different ratios. Modern liposomes are unilamellars, with well defined characteristics. Obtaining methods belong to the inverse phase evaporation (large unilamellars vesicles – LUV, with diameters of 100-1000 nm) and ultrasonication (small unilamellar vesicles – SUV, with diameters of 25-100 nm) [1]. Some liposomes

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are formed as polymer/liposome composites, in order to enhance the bioavailability and stability [5].

The analysis of liposomes is made by X ray diffraction, electronic microscopy, analytical ultracentrifugation, size exclusion chromatography (gel chromatography), with the modified method: high performance size exclusion chromatography (HPSEC) [4].

In the pharmaceutical field liposomes have a great number of applications [4,6-10], the main problem being their stability in the sanguine flux. Stable liposomes contain polymeric moieties attached to the lipidic layer (even on one face or both faces of liposome membrane) have been obtained (Stealth liposomes) [11]. These liposomes have applications in the encapsulation of some anticancer (anthracyclins), antifungal, antiviral, or antibiotic drugs.

In the food field liposomes are used for the controlled release of proteinases in order to enhance the developing of aromas from some special types of cheese, for the encapsulation of food aqueous phases for reducing the vapor pressure, for encapsulation of some food enzymes, antioxidants, non-volatile flavor compounds, food dyes, and vitamins [3].Titanium and titanium dioxide are widely used in biomedical applications. In order to enhance the bioavailability of these compounds some liposome nanocapsules containing titanium dioxide were obtained by using lecithin [12,13] and these liposomes can be decomposed upon illumination with near-UV light [12].

In this short communication we studied the obtaining of lecithin liposomes containing nanoparticles of titanium dioxide doped with 1% Au+ ions with biomedical and/or food applications and evaluate the type and dimensions of liposomes by electronic microscopy and the composition of these liposomes by energy-dispersive X-ray spectroscopy.

2. Materials and Method

Materials. Titanium dioxide doped with 1% Au+ ions was obtained previously by sol-gel route according to [14]; the nanocrystals have dimensions between 10 and 40 nm. Lecithin used for obtaining the liposomes was separed from soybeans and has the following composition: 35% phosphatidylcholine, 25% phosphatidylethanolamine, 15% phosphatidylinositol, 7.5% phosphatidic acid, and other phospholipids (from HPLC analysis of soybean lecithin).

Obtaining the liposomes containing titanium dioxide nanoparticles. Lecithin liposomes containing titanium dioxide were obtained by ultrasonication method. First, 0.025 g TiO2 doped with 1% Au+ was suspended in 10 ml distilled water and the suspension was ultrasonicated in a flask (under cooling on ice) by using an Ultrasonic Liquid Processor Vibra Cell VC 505, 500 W, with the following conditions: amplitude 80%, ultrasonication time 15 minutes, pulse on 30 s, pulse off 15 s. Liposomes contain titanium dioxide were obtained from 0.0145 g soybean lecithin which are ultrasonicated in the same conditions with 4 ml distilled water and 1 ml TiO2 suspension. After decantation, the liposome suspension was separed and analyzed by SEM, TEM, and EDS analyses.

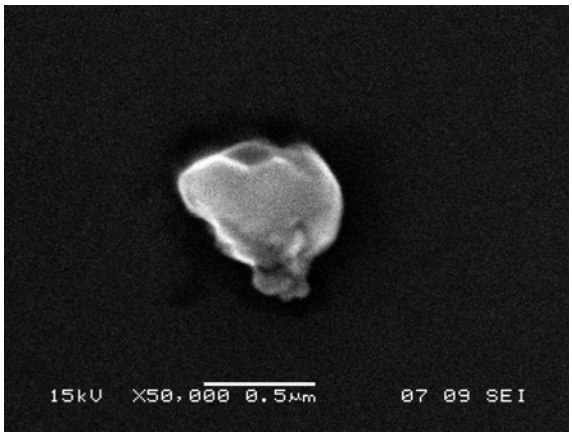
Scanning electron microscopy (SEM) analysis / Energy-dispersive X-ray spectroscopy (EDS). Morphological and dimensional analysis of the liposomes containing titanium dioxide nanoparticles was performed by using a JEOL JSM 5510-LV apparatus coupled with EDS system, voltage of 15 kV, 300-150000x magnitude level. SEM analysis was performed on the non-covered and carbon-coated liposomes for EDS analysis. Carbon deposition was performed by using a JEOL JEE 4B vacuum evaporator, at a vacuum of 10-5 torr.

Transmission electron microscopy (TEM) analysis. TEM was performed on a JEOL JEM 1010 apparatus, with a Mega View III CCD camera for acquisition of images and an acceleration voltage of 100 kV.

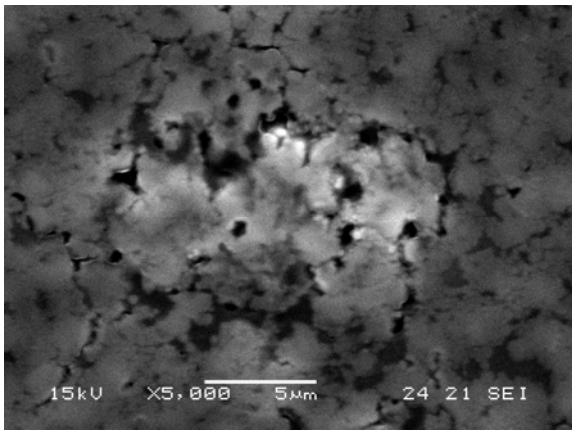
3. Results and Discussion

Liposomes containing titanium dioxide doped with Au+ ions were obtained as a cream-colored translucent suspension (after the decantation of the resulted suspension, the non-encapsulated titanium dioxide nanocrystals being separed on the bottom of the ultrasonication flask).

SEM analysis of the uncoated and carbon-coated liposomes revealed that the liposomes have a non-spherical shapes with dimensions from 100 to 500 nm (Figures 1a and 1b).

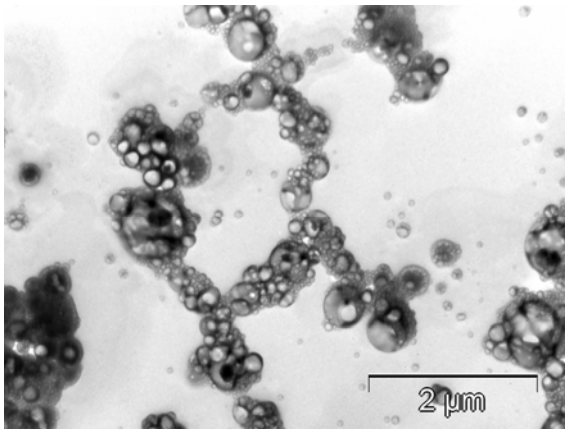


(a)

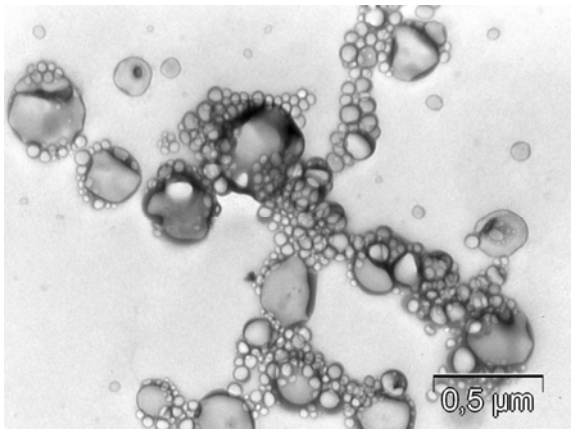


(b)

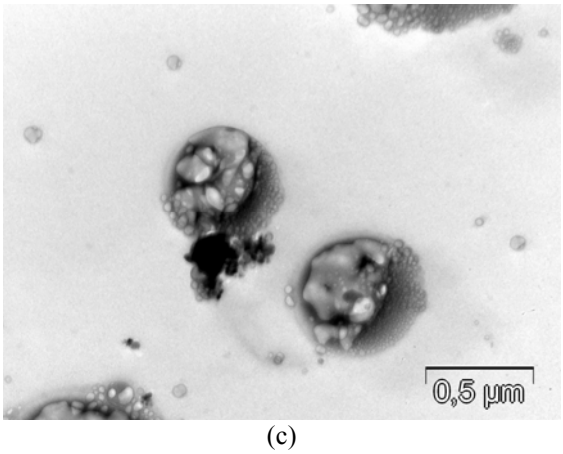
Figure 1. SEM (normal and carbon-coated) images (a and b) of liposomes containing titanium dioxide



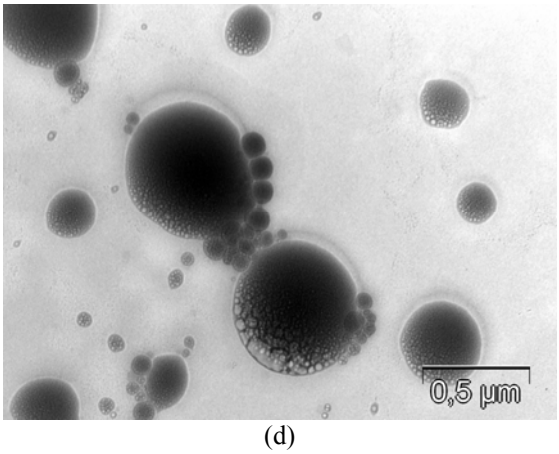
(a)



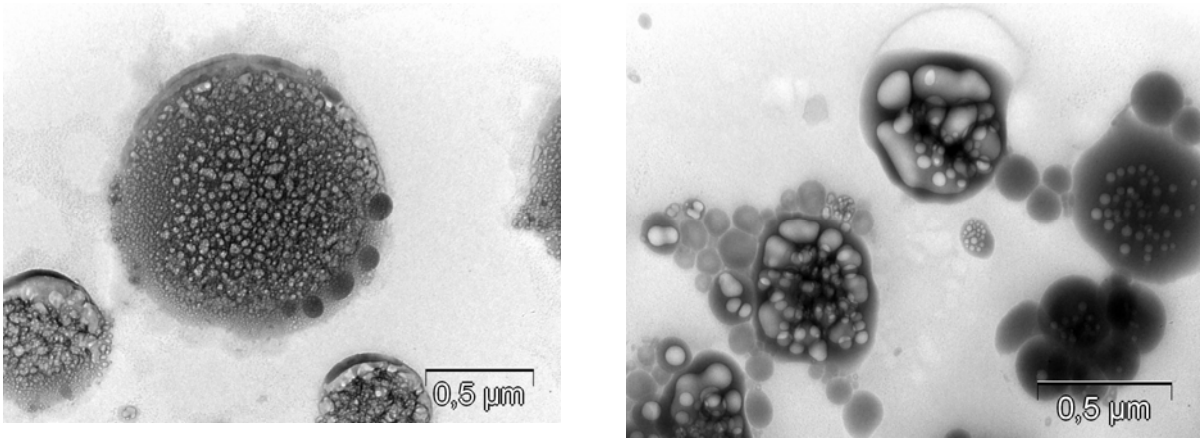
(b)



(c)



(d)



(e) (f)

Figure 2. TEM images for liposomes containing titanium dioxide

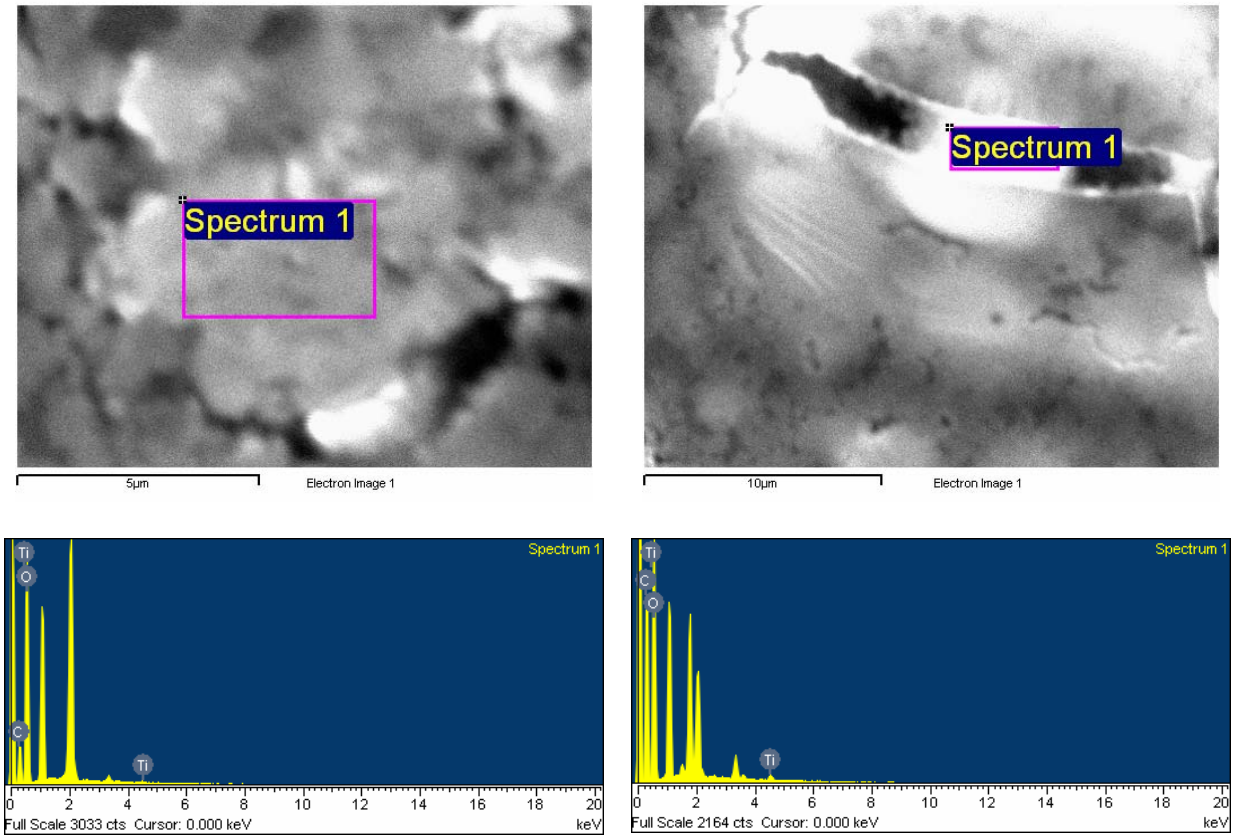


Figure 3. EDS analyses of liposomes containing titanium dioxide for two relevant nanocapsules (1.3% and 2% TiO_2, left and right images, respectively)

More relevant images are obtained by TEM analysis of liposomes containing TiO2 nanoparticles; thus, most of the liposome nanocapsules appear as conglomerated structures in arcuated formations or in a chaotic disposition, which are formed by agglomerated liposomes with various diameters (Figures 2a and 2b).

Some liposomes have attached electrondensely formations, probably titanium dioxide nanoparticles (Figure 2c). The process of attaching of small liposomes and the growing of these liposomes is also present (Figures 2d, 1e, and 1f).

In order to evaluate the encapsulated titanium dioxide EDS analysis of carbon-coated liposomes was performed. Two significative images and spectra were obtained.

For the first one (Figure 3, left) the concentration of the relevant elements were: C 19.8%, O 79.4%, and Ti 0.8%, and for the second (Figure 3, right), these concentrations were 38.2%, 60.5%, and 1.2%, respectively. Au+ ions cannot be evaluated due to the lower concentration of this element. By knowing the elemental composition of the lecithin (C 73%, N 1.5%, O 20.9%, and P 4.6%) and the EDS data, the approximative composition of the obtained liposomes can be evaluated. Thus, for the first case, lecithin is in concentration of 25.5%, titanium dioxide 1.3%, and water 73.2%. In the second case lecithin was in a higher concentration of 49.1%, titanium dioxide 2%, and water 48.9%.

4. Conclusion

The following conclusion among the obtaining and analysis of liposomes containing titanium dioxide nanoparticles doped with Au^{+} ions can be drawn: (1) it is possible to obtain lecithin liposomes containing titanium dioxide nanoparticle by using the ultrasonication method, with possible applications in food antimicrobials or pharmaceutical formulations; (2) the lecithin liposomes containing titanium dioxide have irregular shapes, are multilamellar, and the capsule diameters are in a wide range from ~100 nm up to ~500 nm; (3) the TiO_2/lecithin ratio in the obtained liposomes is approximately 0.05.

Acknowledgements

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5. References

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