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SPITALUL CLINIC DE URGENTA Bucuresti

Evaluation Of Inhibitory Effect Of Glycerol-Iron Oxide Layers On MRSA

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ABSTRACT

During the last years, iron oxide particles such as magnetite (Fe_3O_4) and maghemite (ɣ-Fe_2O_3), with various coatings and nanometric size, have been used in biological applications for diagnosis and/or cancer treatment. Recently, functionalized magnetic nanoparticles have been involved in numerous new biomedical and diagnostic applications such as magnetic resonance imaging (MRI), contrast agents, targeted drug delivery, molecular biology, DNA purification, cell separation, and hyperthermia therapy. Due to the particular magnetic properties of iron oxide nanoparticles and their biocompatibility researches have focused on developing iron oxide thin films for various biomedical applications. The main goal of this study was to obtain, characterize and evaluate the antimicrobial activity of glycerol-iron oxide thin films deposited by spin coating method. The inhibitory effect of glycerol-iron oxide thin films on *Methicillin-Resistant Staphylococcus aureus* (*MRSA*) was evaluated.

EXPERIMENTAL SECTION

The glycerol-iron oxide nanoparticles (GIO) were synthesized by coprecipitation method in air at room temperature and the glycerol-iron oxide thin films (GIO-TF) were deposited by spin coating method. The samples structure was investigated using X-ray diffraction (XRD) with a Bruker D8-Advance X-ray diffractometer in the scanning range 25–70° using Cu K_α (1.5416 Å) incident radiation and the morphology of the material was studied using a Quanta Inspect F scanning electron microscope (SEM). The top surface analysis of the thin films was also characterized by Glow Discharge Optical Emission Spectroscopy (GDOES) usinga GD Profiler 2 from Horiba/Jobin-Yvon. Furthemore the antibacterial properties of the glycerol-iron oxide thin films was evaluated against *MRSA* bacterial strain isolated from an abdominal wound after right hemicolectomy obtained from Polymed Medical Center, Bucharest, Romania.

RESULTS

The XRD investigations (Figure 1) of GIO-TF1 and GIO-TF2 demonstrated that the crystal structure of GIO nanoparticles did not changed after spin coating deposition procedure. The XRD patterns showed the characteristic peaks which are assigned to the (220), (311), (400), (422), (511), and (440) reflections of the mixture of the spinel phases maghemite (γ-Fe_2O_3) and magnetite (Fe_3O_4). The average particle sizes of GIO-TF1 and GIO-TF2 thin films calculated by Sherrer's formula [1] were estimated to be 18.7 ±1 nm and 27.8 ±1 nm.

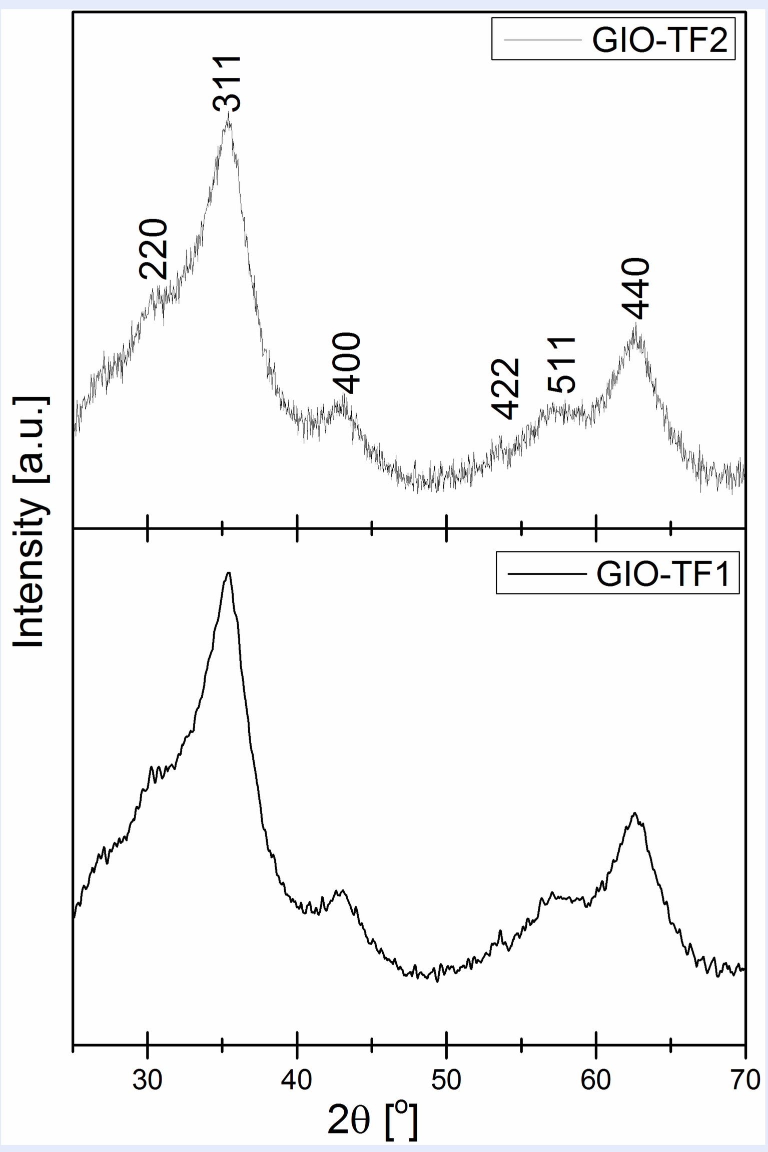

Figure 1: XRD patterns of GIO-TF1 and GIO-TF2 thin films

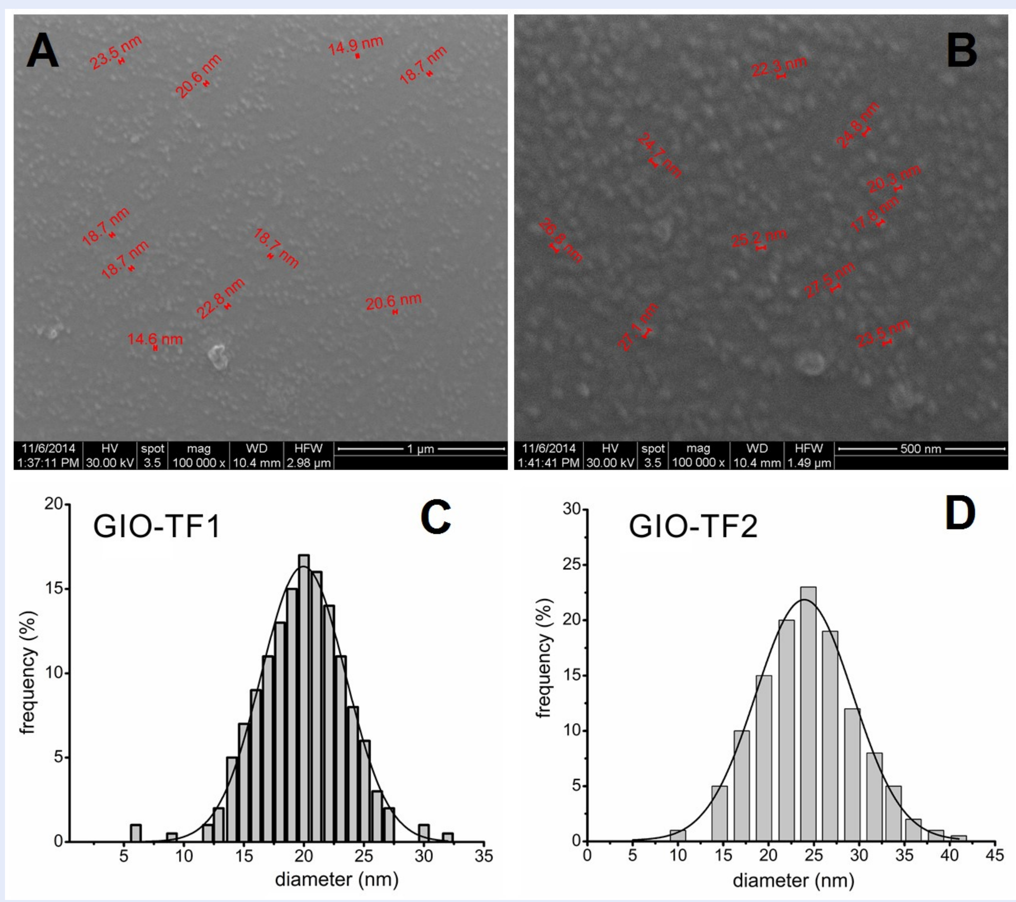

Figure 2: SEM images of GIO-TF1 (A) and GIO-TF2 (B) thin films. The mean nanoparticle diameters of GIO-TF1 (C) and GIO-TF2 (D) thin films [2].

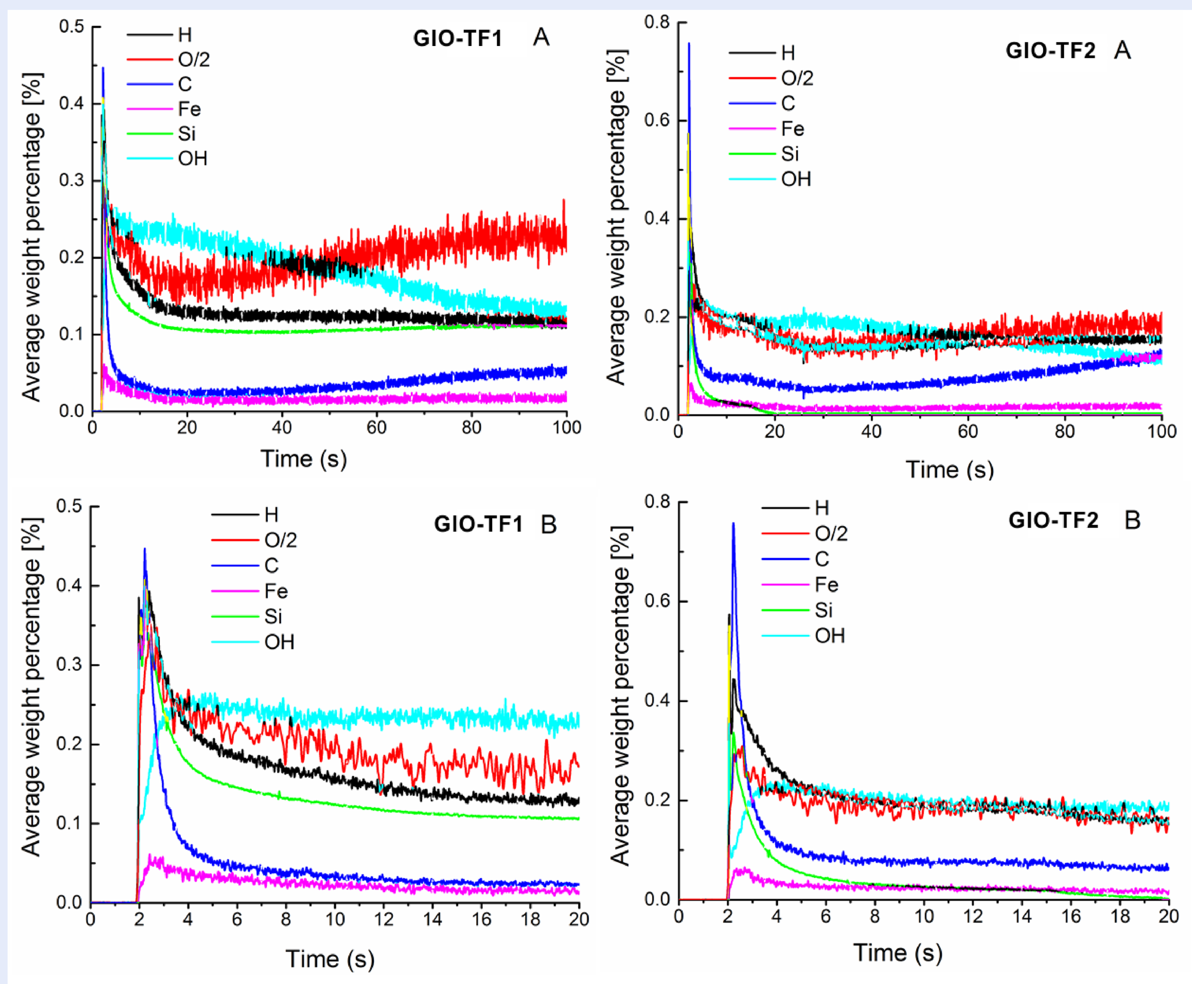

Figure 3: Typical GDOES composition depth profiles of GIO-TF1 A and GIO-TF2 A thin films after dispersion of glycerol-iron oxide nanoparticles in ethanol solution containing 25 mL and 50 mL glycerol under vigorous stirring. The GIO-TF1 B and GIO-TF2 B show zoomed in time regions 0–20 s [2].

The SEM images of GIO thin films (GIO-TF1 and GIO-TF2) showed a homogenous surface structure. The sizes of the glycerol-iron oxide microspheres obtained on the thin film surfaces exhibit a narrow size distribution (Figure 2). The results shown in Figure 3 reveal the distribution of the main elements of the coating and substrate along the depth direction including Fe, O, C, H, and Si. Figure 3 presents that the GIO-TF2 profile exhibits higher silicon concentrations compared to GIO-TF1 profile, while the oxygen concentration is slightly higher for GIO-TF1 compared to the GIO-TF2; this could be attributed to the coverage of the layer on Si over the sputtered area (4 mm). To highlight the antimicrobial effect of GIO-TF , the GIO-TF deposited on commercially pure Si (100) were exposed to the MRSA. After 2, 4, 6, 12, and 24 h the suspension was collected. After collection, the suspension was incubated on agar medium for 24 h. More than that, the number of colonies forming units per milliliter (CFU/mL) was established. In Figure 4 the antimicrobial effect depending on the time of contact with the surface of the GIO thin films for MRSA was presented.

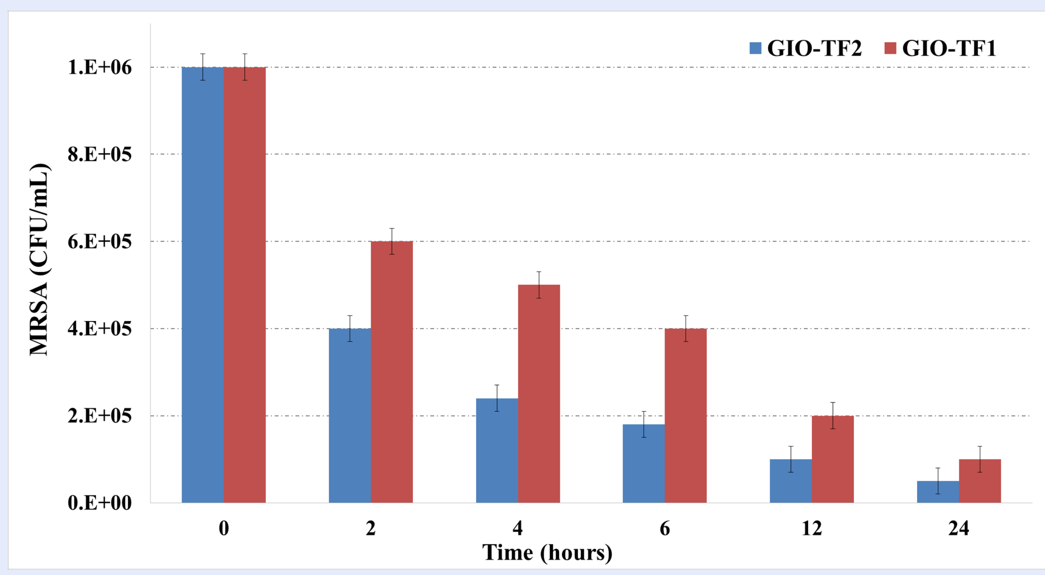

Figure 4: The antibacterial activity of GIO thin films against MRSA bacterial strain .

CONCLUSIONS

Glycerol-iron oxide thin films were obtained by spin coating deposition method on a silicon (111) substrate. The XRD patterns of glycerol-iron oxide thin films confirm the structure of glycerol coated iron oxide nanoparticles. SEM images emphasize that the structure of glycerol-iron oxide thin films is homogenous and the size of the spherical microspheres increases with the increase of glycerol amount. The GDOES spectra performed on glycerol-iron oxide thin films reveal the distribution of the main elements Fe, O, C, H, and Si. The thickness of thin films has been affected by the concentration of glycerol in the glycerol-iron oxide nanoparticles solution. The antibacterial studies revealed that the inhibition zone of MRSA bacterial strain increased when the glycerol amount in the samples increased. According to the results presented in this research, it can be concluded that the glycerol-iron oxide thin films possess antimicrobial properties against MRSA bacterial strain. In conclusion, we can say that the present research proposes a new antimicrobial product that could be used for various medical applications involving inhibition of antibiotic-resistant bacteria.

Acknowledgements:

These studies were supported by National PN II 131/2014 project.

References:

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2. C. L. Popa, A. M. Prodan, P. Chapon, C. Turculet, and D. Predoi, "Inhibitory Effect Evaluation of Glycerol-Iron Oxide Thin Films on Methicillin-Resistant Staphylococcus aureus," Journal of Nanomaterials, vol. 2015, Article ID 465034, 8 pages, 2015. doi:10.1155/2015/465034 .