Characterization of Nanoporous Titanium Dioxide Films for Biomedical Applications

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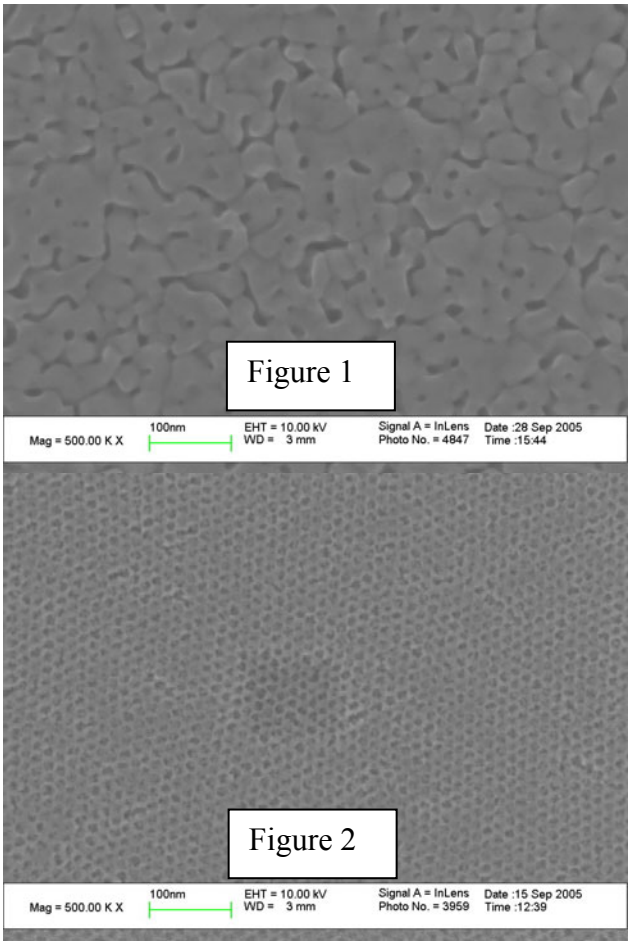
Statement of Purpose: A designed experiment was performed to explore the physical characteristics of nanoporous titanium dioxide films designed for implant based drug delivery in humans, under various manufacturing conditions. The surface was characterized by surface area, porosity, infrared vibration modes, thickness and composition. Titanium dioxide was chosen because its biocompatibility is presently exploited in a variety of biomedical applications. The manuscript contained herein further suggests that nanoporous films can be satisfactorily deployed on medical implants for drug delivery purposes. For a successful drug delivery device, targeted medications need to be delivered at a rate and duration with predetermined therapeutic values while avoiding local toxicity. In order to fulfill this objective, the specific aim of this experiment was to modify the physical characteristics of the implant surface to achieve desirable drug elution rate, quantity and duration.

Methods: The characterization was performed by exploring the end and intermediate points in the respective selected ranges of the variable space of interest. The selected manufacturing variables and their corresponding ranges in this exercise were: the amount of precursor ($TiCl_4$: 1.5 to 2.5 grams), the amount of block copolymer (Pluronic P-123: 0.2 to 1.0 grams), the aging time (4 to 24 hours), the aging temperature (35°C to 65°C), the calcination time (3 to 6 hours) and the calcination temperature (300°C to 600°C). The designed experiment also included five replicated runs to determine the stability of the observations made. The respective films produced were characterized employing porosimetry, ellipsometry, profilometry, interferometry, Fourier transform infrared spectroscopy (FTIR), scanning electron microscopy (SEM) and photoelectron spectroscopy (XPS).

Results / Discussion: The reported synthesis methods of nanoporous titanium dioxide films currently available in the literature either focus on specific preparation conditions [1-3], or isolated preparation variables, such as calcination temperature, are explored [4-5]. A similarly fragmented description emerges in the case of other nanoporous films such as nickel oxide [1, 6-7], silica [1, 8-10], and alumina [1, 11-12] to name a few. Thus, the aforementioned reports lack an exhaustive exploration of the variables of interest when synthesizing nanoporous films. The observed results reported herein indicate that by a judicious selection of the preparation conditions it is possible to tailor a wide variety of film characteristics ranging from amorphous with a porosity <10%, pore size >12 nm and a surface area of ~80 m^2/g (Figure 1), to crystalline morphology with porosity > 44%, pore size of 10 nm and a surface area >230 m^2/g (Figure 2).



Conclusions: The mechanical and optical characteristics of nanoporous titanium dioxide films can be adjusted to fit specific requirements in terms of porosity, index of refraction, thickness and crystalline morphology by employing the synthesizing conditions described herein. Therefore, by tailoring film characteristics we anticipate being able to match drug delivery requirements to specific films characteristics.

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