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DIRECT DETERMINATION OF IRON DRUG RELEASED FROM TiO_2 NANOTUBES VESSEL

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Abstract

This study focused on using TiO_2 nanotubes as a vessel for drug release. the release of iron ion from titanium dioxide nanotubes was done. TiO_2 nanotubes synthesized by anodization. Anodization method was done using 60 volts between two titanium plate as an electrode. the distance between two electrodes 6.5 cm. the electrolyte, contained (0.5w/w NH_4F, 2w/w H_2O, 97.5 w/w ethylene glycol) the anodization process accomplished at room temperature. Scanning electron microscopy (SEM) was used for examine the morphology of the surface on synthesized TiO_2 nanotubes. SEM images show that the prepared tubes were within the nanoscale TiO_2 nanotubes mouth at 80 nm in diameter. Synthesized TiO_2 nanotubes used as vessel for iron drug release. The determination of iron which release from the tubes measured using spectrophotometric method. The percentage of drug release reached % 99.6.

Keywords: TiO_2 nanotubes, iron ions, drug release, spectrophotometric method

Introduction

Due to its high strength and low density, titanium and its alloys are now widely used in a number of applications. In the past decade TiO_2 nanotube arrays (TiNTs) grown by a self-organizing electrochemical anodization process have attracted tremendous scientific interest due to the combination of geometric features with an inherent photocatalytic activity. These days, titanium and its alloys are highly favoured for their great strength and low density in a variety of applications, including solar energy, water splitting and implants. For the material to be biologically active, surface modification is necessary. The simplest and most affordable form of surface modification for implantation is electrochemical anodization. Surface morphologies are essential for giving the substance bioactivity [1]. Additionally, titanium material that has had its surface transformed with TiO_2 (Titanium Oxide Nanotubes) nanotubes is non-toxic and can be used as biological material [2]. The fluoride content, water content, organic or non-organic solvent and distance between anode and cathode, anodization time all affect how well a material's surface bonds with nanotubes. For electrolytes with fluoride and water content, the optimal findings were reported [3, 4].

Additionally, the presence of water content has a big impact on how well the nanotubes' function. The best electrolyte mixture for creating TiO_2 nanotubes is one that contains both fluoride and water. Better corrosion resistance is delivered when TiO_2 nanotubes are produced in the presence of water and HF electrolyte [5]. Furthermore, it was claimed that the inclusion of the ethanol-water solution affects the outcomes of the nanotube [6]. Hydrogen content may be impacted by a rise in water content in the electrolyte, which can quickly enhance growth and material stability [7]. Due to its abundance (titanium is the ninth most abundant element in the Earth's crust), reasonable cost, lack of toxicity [5], great biocompatibility, and stability, it has a wide range of applications. A corrosion-resistant substance with typical size of under 100 nm is titanium nanotubes. They have unique bending characteristics including strong electron mobility and extremely high mechanical forces [6–9] and are one-dimensional. One of the key components in the elimination of organic waste is titanium dioxide nanotubes. The photochemical characteristics of TiO_2, such as its strong photocatalytic activity, are its most promising attributes. For this reason, the use of TiO_2 as a photocatalyst has been thoroughly investigated by numerous researchers since the 1950 [10]. Nanotechnology has boosted the development of various new nanomaterials and drug carriers for drug release applications. One of the most important materials is TiO_2 nanotubes. As drug carrier a wide range of nanoparticles [11] microgel [12] nanotubes [13] and polymeric micelles [14] have been explored. Especially, drug carriers based on nanotubes have various beneficial features due to their intrinsic high surface-to-volume ratio, well defined geometry and stable structure. From our knowledge this is first time the release drug determinied and the exactly concentration can be determined.

Experimental

Synthesis of TiO_2 nanotubes

Titanium foils that were 99.6% pure were sonicated in acetone to eliminate any left overs before anodizing. A high-voltage power source was used in the electrochemical anodization setup. A two-electrode electrochemical setup with a constant voltage of (60) V for (120) minutes was used to conduct the anodization procedure. The titanium metal surface was (1) cm^2 away from the electrolyte, and there were (6) cm between electrodes. The Ti plates served as the anode and cathode, and the electrolyte, which contained (0.5w/w NH_4F, 2w/w H_2O, and 97.5 w/w) at room temperature.

Preparing of TiO_2 for drug release

The prepared TiO_2 was dipping in 25 ppm iron (II) solution for 40 min. Then the plate was left and dried at air. Then the filled plate was dipped for 15 min in the mixture (5 ml 1,10-phenanthrolin, 8ml sodium acetate and 1ml hydroxy ammonium chloride). Then the absorbance of iron which was released from the filled TiO_2 nanotubes was determined using spectrophotometric method for comparing with standard solution the equation 1 was used.

$$\text{Ads\%} = (A^{\circ} - At / A^{\circ}) * 100\% \text{.............}(1)$$

The release was applied on drug such iron (III) hydroxide injection by following the same procedure.

Result and Discussion

1- Synthesis of TiO_2 nanotubes

Anodisation strategy has been made possible by recent advancements in the theory of self-ordering growth via anodic oxidation. Anodization is the most popular techniques for improving arrays of ordered nanotubes made of different metals, including Ti, Al, and others.

In the anodization process water in the solution reacts with the titanium metal surface leading to the formation of oxide layer under an applied electric field as seen in equation2, 3.

$$2H_2O \rightarrow 4H^+ + O_2 + 4e^- \quad \text{..........................} \quad (2)$$

$$Ti + O_2 \rightarrow TiO_2 \quad \text{............................} \quad (3)$$

TiO_2 oxide layer is then etched into as it is dissolved with assistance of fluoride ions as seen in equation (4)

$$TiO_2 + 4H^+ + 6F^- \rightarrow [TiF_6]^{2-} + 2H_2O \quad \text{...........} \quad (4)$$

Charctrization of TiO_2 nanotubes by scanning electron microscopy (SEM)

The samples were characterized using SEM. Under the SEM, the size and shape of the TiO_2 nanotubes were evident. The tubes are shown in the SEM images in (Figure 1) to be cylindrical and to have a self-organized structure. The typical tube diameters and the common tube sizes (5um) were (80-90nm) after 120 min anodization duration.

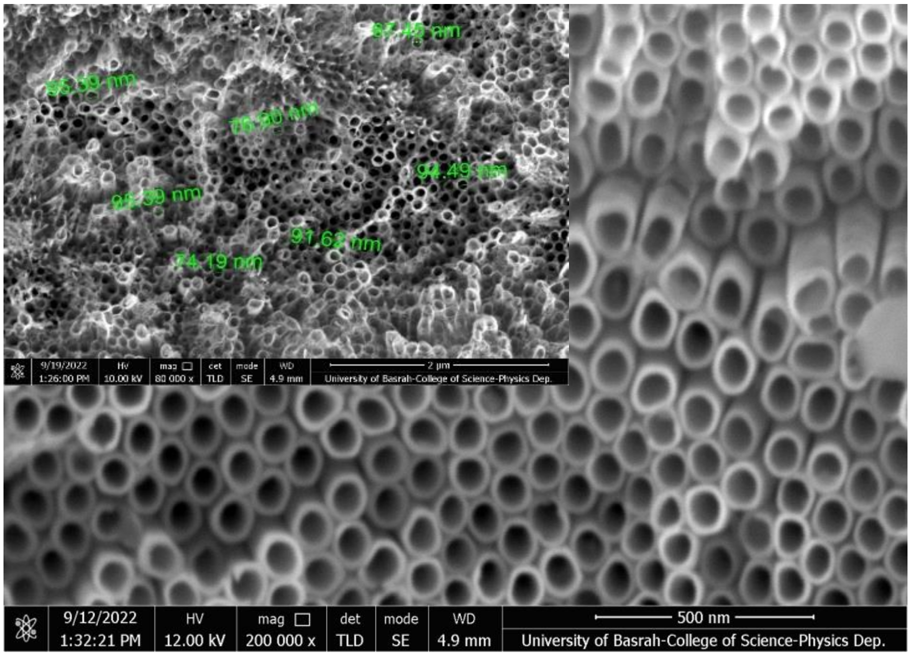

Figure 1. SEM image shows morphology of TiO_2 nanotubes

2- Application of synthesized TiO_2 nanotubes

Synthesized TiO_2 nanotubes were applied for drug release. first of all, the iron (II)was chosen as a sample for drug release the real sample from iron injunction was used. The photometric method using 1,10-phenanthrolin as a reagent is very sensitive method for determination of red-orange complex (iron (II)- 1,10-phenanthrolin). The parameters for the spectrometric method were studied such the maximum wavelength and the standard curve. The maximum wavelength 510 nm as shown in (figure 2).

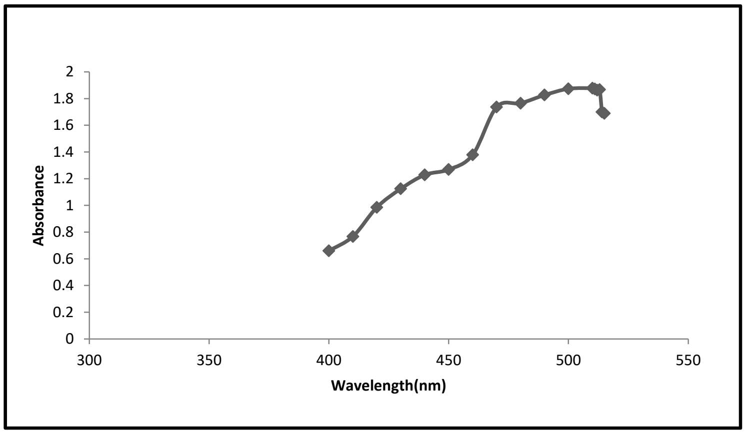

Figure 2. maximum wavelength or iron (II)-1,10-phenanthroline (λmax = 510 nm)

The standard curve was done for iron (II) in the range (5-25) µg/ml, as can be seen in (figure 3). The concentration of iron (II) ions (10) µg/ml was chosen for the examination of the release of iron. the equation 1 was applied for this measurement.

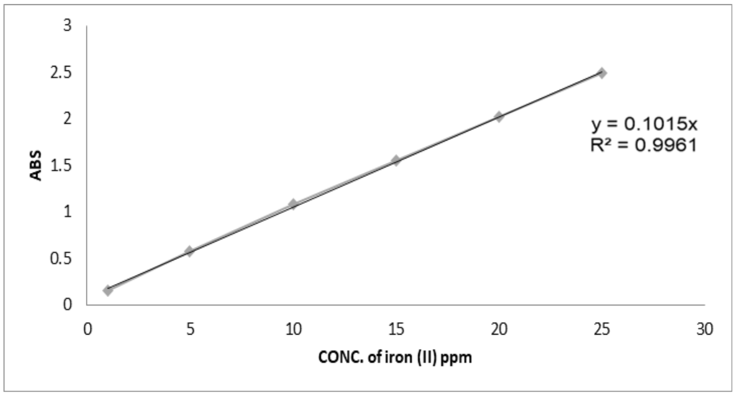

Figure.3 standard curve for iron (II)-1,10-Phenanthroline

The release was done for 70 min from the (figure 4) the maximum release found at the 10 min then the droop happens and the steady state was reached. The percentage of release at the maximum was 99.6.% as can be seen from (figure 5).

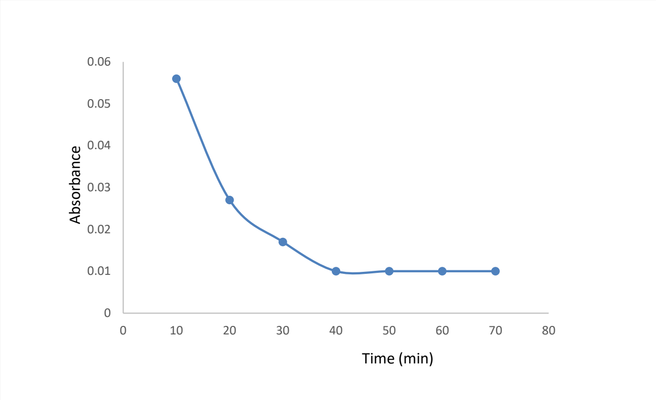

Figure 4. The release of iron (II) using TiO_2 nanotubes

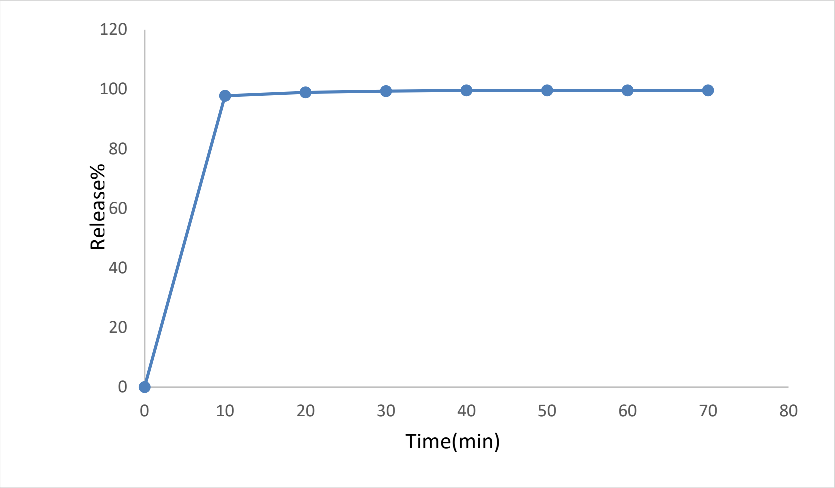

Figure.5 release percentage of iron (II)using TiO_2 nanotubes

Drug release using iron (III) hydroxide injection

This method was applied using real sample the drug of iron (III) hydroxide injection (100mg\2ml) and study of release as shown in (figure 6). The percentage of release reached to maximum 83.07% at 70 min then the steady state was reached.

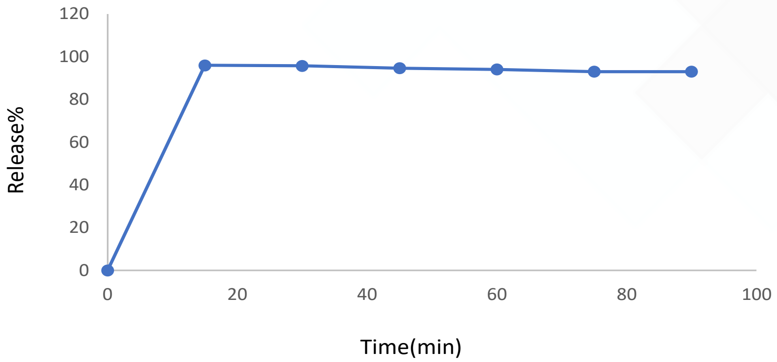

Figure 6. The platform of iron drug using TiO_2 nanotubes as a vessel.

Conclusion

In this study, TiO_2 nanotubes were made using an economical, fast and repeatable anodization process. Titanium dioxide nanotubes were distinguished using scanning electron microscopy (SEM). Synthesized titanium dioxide nanotubes were used as a vessel for drug release target. TiO_2 nanotubes were filled with iron (II) then the release was done. The concentration of iron (II) was determined using spectrophotometric method. The process was applied on iron drug (iron (III) hydroxide). It was found that TiO_2 nanotubes good vessel for release and by optimises the shape of TiO_2 nanotubes the release process can be optimized.

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