Received: 19 December 2022 | Revised: 11 March 2023 | Accepted: 18 June 2023

DOI: 10.1002/tqem.22048

RESEARCH ARTICLE

WILEY

Fabrication of TiO_2 nanotubes with effect of water and in-situ condition for biomedical application

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Abstract

Synthesis of TiO_2 nanotubes on titanium alloys for environmental and energy applications are highly encouraged by medical industries. Formation of nanotubes on titanium material delivers superior properties in the view of phase transformation, surface morphological, nanomechanical properties, and corrosion resistances. In this research work, synthesis of TiO_2 nanotubes under 8 and 12 Vol. % of water content with in-situ voltage condition. The fabricated nanotubes surface morphology was analyzed with the use of HR-Sem. The formation of nanotubes surface has been identified with composite faces of smooth and rough (length of 1.6 and 1.8 μm) by the effect of water content and voltage variations. The nanomechanical properties were analyzed with nanoindentation Pmax received as max of 265 and min of 248 μN. Nanotubes strength depends on the nanotubes length. Potentiodynamic polarization analysis indicated that combination of smooth and rough surfaces was highly encouraging the corrosion resistances.

KEYWORDS

titanium, TiO_2 nanotubes, HR-Sem, nanoindentation, corrosion

1 | INTRODUCTION

TiO_2 nanotubes (NTs) have been investigated for a variety of applications and have become one of the most investigated nanostructures over the past decade since the first reports on self-ordered nanotube or nanopore growth on Ti or Ti alloys through electrochemical anodization by Assefpour-Dezfuly et al. (1984) and later by Zwilling et al. (1999), Gong et al. (2001), and Beranek et al. (2003). TiO_2 delivers superior mechanical qualities, resistance to corrosion in bodily fluids, and great biocompatibility (Indira, Shanmugam et al., 2021). However, titanium-based implants are often reported to be subjected to long term complications, mostly related to loosening of the implant–host interface and susceptibility of the implant to bacterial infections (Sivaprakash & Narayanan, 2021b; Zhang et al., 2021). Ti, as a bio-inert material, is incapable of actively interacting with the surrounding environment and promoting adequate cell adhesion, which are instead of critical points for the formation of the structural and functional direct connection between the living bone and the implant surface required to ensure long-term stability. The orthopedic implant material delivers a high implant life of 15 has been recorded (Geetha et al., 2009). The attachment between bone and materials are highly sensitivity matters (Ocampo et al., 2022). Different types of mechanism and functions are available for the surface modifications on titanium and other alloy materials. PVD, CVD, hydrothermal, sol-gel, micro-arc oxidation, electrochemical anodization, and various methods are available for make surface strong (Berger et al., 2010). Among these methods the electrochemical anodization is the simple and unique methods for the surface modification. The additional methods fabrication of TiO_2 or surface treatments are applicable for biomedical, solar, water treatment, gas sensors, cancer treatment, and etc. (Kunrath et al., 2018).

Many efforts have been made to enhance bone-implant contact, including transforming the surface topography of the substrate, chemically modifying the surface layer, and covering the implant with bioactive chemicals (Zhang et al., 2021). One of the most promising ways is to fabricate a TiO_2 nanotube array (TiNT) via direct electrochemical anodic oxidation of the titanium substrate. This strongly linked porous

