Journal of Population Therapeutics & Clinical Pharmacology

RESEARCH ARTICLE
DOI: 10.53555/8nhp8m77

TITANIUM INCORPORATED HYDROXYAPATITE TOWARDS TOOTH REGENERATION

Mohamed Rifaath*[1] Dr. Marina francis[2]

[1*]Department of ProsthodonticsSaveetha Dental College and HospitalsSaveetha Institute of Medical and Technical SciencesSaveetha University, Chennai-600 077, India
Email: 152001015.sdc@saveetha.com
[2]Department of ProsthodonticsSaveetha Dental College and HospitalsSaveetha Institute of Medical and Technical SciencesSaveetha University, Chennai-600 077, India
Email: marinafrancis26@gmail.com

***Corresponding Author: Mohamed Rifaath**
[1]Department of ProsthodonticsSaveetha Dental College and HospitalsSaveetha Institute of Medical and Technical SciencesSaveetha University, Chennai-600 077, India
*Email: 152001015.sdc@saveetha.com

Abstract:
Aim: To incorporate Titanium and hydroxyapatite towards tooth regeneration
Materials and method: Hydroxyapatite was synthesized by co-precipitation method using calcium nitrate and diammonium hydrogen phosphate in the ratio of 1.67.
Then TiO_2 nanoparticles dispersed using a bath sonicator, further introducing this into hydroxyapatite precipitates.Then wash the obtained nanoparticles using DD H2O and ethanol followed by the drying in a hot air oven at 120 °C for 12 h.
Results: According to ASTM standard upto 5% lysis is acceptable, in this case we observed below 0.8 % lysis at the concentration of 10mg/mL. It showed a more compatible nature of the material.
Conclusion: Elongated rod-like morphology showed the structure of TiO_2 and small rods as well as globule-like structures connected with the TiO_2 rods. Further, Ca, P, O, Ti, and C elements were confirmed from EDS spectra.

Keywords: Titanium, hydroxyapatite, tooth regeneration

Introduction:

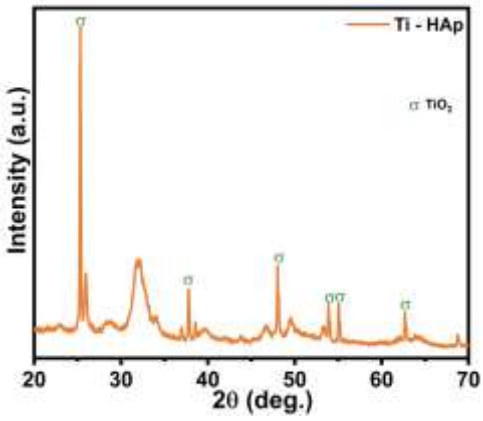
Bioceramics based on hydroxyapatite (HAp) have high biocompatibility, corrosion resistance, and very strong compressive strength, making them a desirable choice for implants(1). The scientific community has shown the most interest in HAp among the variety of calcium phosphates used in biomedicine, mostly because of its properties that support the processes of osseointegration and new bone production as well as its low toxicity and similarity to mineral bone(2). According to research conducted thus far, HAp-based materials have proven to be the most effective calcium phosphate compounds for bone grafting applications(3).Low density, great mechanical strength, and good biocompatibility have all been demonstrated with titanium(4). Although commercial titanium implants have an elastic modulus that is more than ten times greater than that of bone, human bones

have a much lower elastic modulus. Wolff's law states that commercial titanium implants will cause bone to atrophy and resorb around them, which will eventually result in implant movement and failure(5,6). Due to its biological and crystallographic similarities with hard tissue, hydroxyapatite is the developing bioceramic that has been the subject of the most research and is the most frequently employed in dentistry(7). Furthermore, it promotes good osseointegration by stimulating natural bone development surrounding the tooth implant. HA is mostly used as a covering material for titanium implants in implantology, and its impact on osseointegration, inflammatory response, and antibacterial activity was studied(7,8).iO2, a white pigment, is the most popular because of its high refractive index and brightness. The annual global consumption of this pigment is about four million tons. Additionally, TiO2 ranks among the top five NPs used in consumer goods and contributes 70% of the world's total pigment production volume. TiO2 can be found in toothpaste, paints, coatings, plastics, papers, inks, medications, and pharmaceuticals. Even as a pigment, it can be used to make skim milk whiter. TiO2 has also been a part of prosthetic implant articulation for a very long time. These implants can occasionally fail because the implant materials have degraded or because of a persistent inflammatory reaction to the implant material(9,10).The use of nanotechnology in the medical industry for medication delivery, therapy, diagnostics, and other purposes has resulted in a rapid increase. Because of their selectivity and physico-chemical properties compared to those of bulk materials, nanomaterials of various sizes and shapes are used for research. According to reports, drugs attached to nanoparticles offer greater advantages than traditional medicinal forms(11). Developing biomaterials to increase bone quantity and restore alveolar bone defects at the implant site is crucial since bone loss or insufficiency continues to be a major problem for implant integration and then functional loading. Due to its ultrathin structure and shape and wide variety of remarkable properties, including chemical, electrical, optical, and biological capabilities, among others, MXene, a vast new family of 2D materials, has recently demonstrated a significant potential in biomedical applications. Additionally, hydroxyapatite is a beneficial biomaterial with exceptional bioactivity and osteogenic potential(12). The aim of the study is to incorporate Titanium and hydroxyapatite towards tooth regeneration

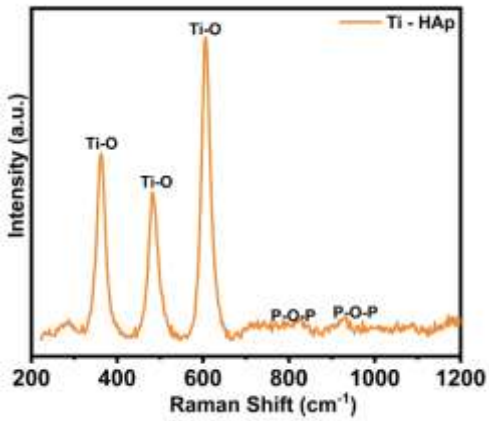
Materials and methods:

Hydroxyapatite was synthesized by co-precipitation method using calcium nitrate and diammonium hydrogen phosphate in the ratio of 1.67. Then TiO_2 nanoparticles dispersed using a bath sonicator, further introducing this into hydroxyapatite precipitates.Then wash the obtained nanoparticles using DD H2O and ethanol followed by the drying in a hot air oven at 120 °C for 12 h.

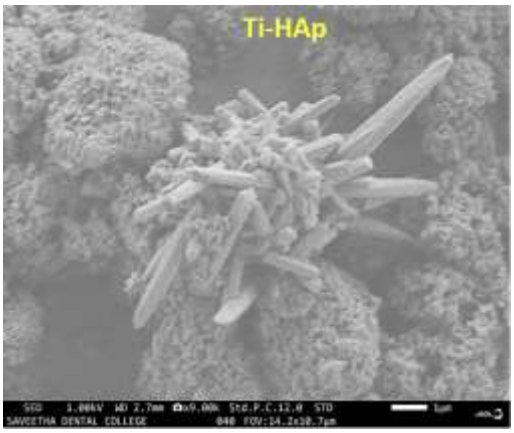
Results:



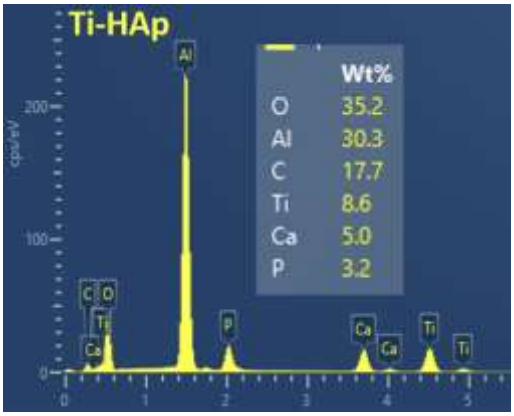
Graph 1: Represents X-ray diffraction, Diffracted peaks authenticate the prompt crystalline formation of $Ca_{10}(PO_4)_6(OH_2)$. Similarly, TiO_2 signatures also were observed through XRD results.



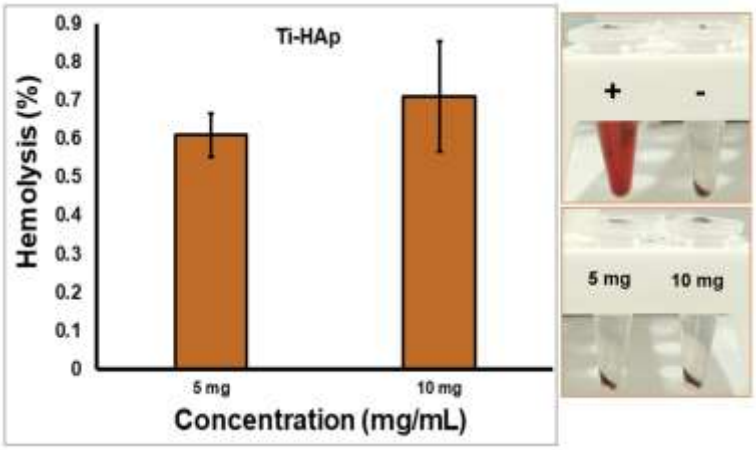
Graph 1: Represents Ti-O and P-O-P bonding was observed through Raman spectra that confirms the material formation



Picture 1: Represents Field Emission Scanning Electron Microscopy, Elongated rod like morphology showed the structure of TiO_2 and small rods as well as globule like structures connected with the TiO_2 rods.



Picture 2: Represents Energy Dispersive Spectroscopy, Further Ca, P, O, Ti, and C elements were confirmed from EDS spectra.



Graph 3: Represents Hemocompatibility Assessment,According to ASTM standard upto 5% lysis is acceptable, in this case we observed below 0.8 % lysis at the concentration of 10mg/mL. It showed a more compatible nature of the material.

Discussion:

Orthopedics and dentistry practitioners are increasingly interested in the creation of bioactive coatings on metallic implants to improve osseointegration. It has been demonstrated that hydroxyapatite (HA) covering induces bone growth and fosters bone-implant integration. Unfortunately, this hasn't been a successful coating material due to weak mechanical performance. Most recent studies have concentrated on adding various components to HA coatings to enhance mechanical characteristics. Tantalum (Ta) has attracted more interest recently because of its outstanding biocompatibility and resistance to corrosion(13).Because it has the capacity to encourage bone apposition, HA is renowned for its osteoconductivity. By substituting small amounts of silicon in the form of silicate groups into the HA structure, the bioactivity and biocompatibility can be further increased, proving that chemical modification of HA is an effective way to increase its osteoconductive potential(14).

Conclusion:

Ti-HAp was prepared using a feasible Co-precipitation method. Further we analyzed the structural, morphological and biocompatible properties of the material. Diffracted peaks authenticate the prompt crystalline formation of $Ca_{10}(PO_4)_6(OH_2)$. Similarly, TiO_2 signatures also were observed through XRD results. Elongated rod-like morphology showed the structure of TiO_2 and small rods as well as globule-like structures connected with the TiO_2 rods. Further, Ca, P, O, Ti, and C elements were confirmed from EDS spectra. Optimal blood compatibility was procured from Hemocompatibility assessment.

References:

1. Konovalenko VF, Ternovyi NK, Tuz EV, Protsenko VV, Solonitsyn EO, Abudayeh A, et al. Experimental substantiation of the use of hydroxyapatite - tricalcium phosphate bioceramics for replacing bone defects after tumor removal. Exp Oncol. 2021 Sep;43(3):237–41.
2. Mucalo M. Hydroxyapatite (HAp) for Biomedical Applications. Elsevier; 2015. 404 p.
3. Wang G, Lu Z, Zhao X, Kondyurin A, Zreiqat H. Ordered HAp nanoarchitecture formed on HAp-TCP bioceramics by “nanocarving” and mineralization deposition and its potential use for guiding cell behaviors. J Mater Chem B Mater Biol Med. 2013 May 21;1(19):2455–62.
4. Kumar A, Gori Y, Kumar A, Meena CS, Dutt N. Advanced Materials for Biomedical Applications. CRC Press; 2022. 293 p.
5. Luckey HA. Titanium Alloys in Surgical Implants. ASTM International; 1983. 294 p.
6. Li Y, Shui X, Zhang L, Hu J. Cancellous bone healing around strontium-doped hydroxyapatite in osteoporotic rats previously treated with zoledronic acid [Internet]. Vol. 104, Journal of Biomedical Materials Research Part B: Applied Biomaterials. 2016. p. 476–81. Available from:

http://dx.doi.org/10.1002/jbm.b.33417
7. Fu XK, Cao HB, An YL, Zhou HD, Shi YP, Hou GL, et al. Bioinspired Hydroxyapatite Coating Infiltrated with a Graphene Oxide Hybrid Supramolecular Hydrogel Orchestrates Antibacterial and Self-Lubricating Performance. ACS Appl Mater Interfaces. 2022 Jul 20;14(28):31702–14.
8. Jokstad A. Osseointegration and Dental Implants. John Wiley & Sons; 2009. 448 p.
9. Janus M. Application of Titanium Dioxide. BoD – Books on Demand; 2017. 242 p.
10. Parrino F, Palmisano L. Titanium Dioxide (TiO2) and Its Applications. Elsevier; 2020. 730 p.
11. Khurana V, Kwatra D, Shah S, Mandal A, Mitra AK. Emerging Nanotechnology for Stem Cell Therapy [Internet]. Emerging Nanotechnologies for Diagnostics, Drug Delivery and Medical Devices. 2017. p. 85–103. Available from: http://dx.doi.org/10.1016/b978-0-323-42978-8.00005-x
12. Rues S, Schmitter M, Kappel S, Sonntag R, Kretzer JP, Nadorf J. Effect of bone quality and quantity on the primary stability of dental implants in a simulated bicortical placement. Clin Oral Investig. 2021 Mar;25(3):1265–72.
13. Boskey AL, Maresca M, Ullrich W, Doty SB, Butler WT, Prince CW. Osteopontin-hydroxyapatite interactions in vitro: inhibition of hydroxyapatite formation and growth in a gelatin-gel [Internet]. Vol. 22, Bone and Mineral. 1993. p. 147–59. Available from: http://dx.doi.org/10.1016/s0169-6009(08)80225-5