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Differential analyses of ginger extract implant coating material: An in vitro study

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Abstract---Background: Different types of material were used as implants; the most common is titanium and its alloy, and recently zirconia acquired robust interest due to many desirable properties, Natural biocomposites recently received widespread attention as an active coating covering metallic implants due to their bioactivity, availability, and affordability. Aim: This study aims to present the evolvement and characterization of ginger extract materials overlying Yttria-stabilized tetragonal zirconia and PEEK substrate. Material and method: The methodology of the present study involved preparation of ginger extract powder twenty disc-shaped specimens with a dimension of 10 mm, from partially sintered Yttria-stabilized tetragonal zirconia polycrystal and PEEK . The naturally prepared ginger extract powder was deposited via cold spraying device. The prepared ginger extract characterized by particle size analyzer and ginger extract while The experimental specimens were characterized by, field emission scanning electron microscope (FE-SEM), energy-dispersive X-ray spectroscopy (EDX). Conclusion: naturally prepared ginger extract exhibit uniform distribution and good adherence to the samples Therefore, it can be used as a coating material for zirconia and PEEK implants with promising biological and mechanical properties.

Keyword---PEEK, zirconia, ginger extract, coating.

Introduction

Dental implants have been extensively used to support prosthodontic restorations, removable and fixed, and maxillofacial restorations, with a high degree of success (1) Different types of material were used as implants; the most common is titanium and its alloy, and recently zirconia acquired robust interest

due to many desirable properties (2). Polyetheretherketone (PEEK). It has good chemical resistance, high mechanical properties, and biocompatible. It is very much compatible with modern imaging technologies. It is tooth colored material and recently used as dental implant material wherever esthetics is a major concern.(3). The materials above, titanium, zirconia and PEEK are regarded as bioinert materials that necessitate the use of bioactive material, a coating overlying the bioinert substrate (4). The selection of the bioactive coat depends on physicochemical characteristics and the availability and affordability of the material. Natural biocomposites recently received widespread attention as an active coating covering metallic implants due to their bioactivity, availability, and affordability (5) Micro-nano organizational amendment of the implant's surface may improve bone conductivity and hydrophilicity and decrease the conducted stress (6).

The increased use of antibiotics leads to the development of antimicrobial resistance of microorganisms which has become a serious problem. (7)Therefore, there is a general need to find alternatives to chemotherapeutic agents for the treatment of diseases, especially those derived from plants that are readily available and have few side effects.(8) Ginger (Zingiber Officinale) is Herbal remedies widely used for years and for the wide treatment of unrelated diseases including arthritis, cramps, sore throat, infectious disease, pain, constipation, hypertension and fever (9). Alcoholic extracts of ginger have antiviral effects against mutans Streptococcus and Cidida nadida albicans, as well as against certain Gram-negative periodontal pathogenic bacteria (Porphyromonas gingivalis, Porphyromonas endodontilis and Prevatola intermedia). Periodontitis is "an inflammatory disease of the supporting tissues of the tooth, characterized by a loss of connective tissue and connective tissue." The main causative agent of pharyngontitis is the bacterium of subgenital plaque.(10).

Periodontitis is generally considered a polymicrobial disease and is more relevant to complex interactions between specific pathogens than to individual species. Three of these bacteria, Aggregatiebacter actinomystem comitans, Tenerella forsythia and Porphyromonas gingivalis have been officially designated as causative agents of pyorrhoiditis. Many studies recommend that detection of certain pathogens, particularly aggravator actinomycetim comitans and porphyromonas gingivalis, may not be present for a long time after treatment if the outcome of periodontal treatment is high (10).

Material and Methods

Plant materials

Ginger (Zingiber officinale) was purchased from local market of medical herbs. The plants were brought to the laboratory and thoroughly washed in distilled water and dried in shade at room temperature then stored in a plastic zip bag in at 4°C until use.

Powdered Ginger extract Preparation

Plant materials were finely grinded to powder by using a blender. One hundred gram of ginger mixed with one liter of sterile deionized water and kept in a water bath at 60ºC for five hours, then filtered through sterile filter paper "Whatman, UK". The filtrates were exposed at 40 ºC to a hot air oven for evaporation of water. The filtrates were kept at 4 ºC until use .(11)

Particle size analyzer

Laser Diffraction. This method, measures the light scattering when a particle passes through a laser beam. The angle of scattered light is directly related to the particle size where the larger particles scatter the light as narrow angles with high intensity and smaller particles scatter the light at wider angles with low intensity. This phenomenon is known as the "Fraunhofer diffraction theory". Laser diffraction has a wide detection range (0.2–2000 μm) and is fast and reliable.so we use this test to analyse the ginger extract. Powder was used in its particle sizes, without any treatment filled into the glass tube and then pushed for homogeneous packaging of powder particles

FTIR

The ginger aqueous extract powder samples were characterized by FTIR Spectrometer Model Spectrum TWO Perkin Elmer figure. 2.3 FTIR-spectrometer was used to recognize the functional group of ginger extract component by the means of measuring the transmission or absorption of infrared spectrum.

Sample preparation and surface treatment of the samples

10 mm in diameter and 3 mm thicknes circular samples of both zirconia and PEEK samples where made. These samples subjected to surface treatment by grit blasting technique The zirconia and peek samples were grit-blasted in a heavy-duty blast cabinet (Clarke power products, UK) using ultra-pure (99.81%) aluminium oxide (Al2O3) blast media having an angular grain shape, a mean particle size of 220 μm. Grit-blasting was performed at an air pressure of 1.72 bar, through a 4 mm diameter spray nozzle. The nozzle was held perpendicular to the surface at a distance of approximately 300 mm and moved back and forth along the loading direction. Treatment times 20 s were used,. Grit-blasted specimens were cleaned with acetone, and ultrasonically rinsed in a DIW bath for 5 min to remove alumina particles deposited during grit-blasting.(12)

Coating technique

The coatings were sprayed using a cold spray system. Premixed solution of 50% concentration of ginger extract and gelatin binder were fed by a high pressure solution feeder into air stream through a converging-diverging (de Laval) nozzle. The gas pressure in the nozzle pre chamber were varied from 25-38 bars. The nozzle was kept normal to the substrates with a standoff distance of 25 mm. covering an area of 3"x1.5".. Coatings were sprayed on grit blasted and acetone cleaned ziconia as well as PEEK samples.. (13)

Figure 1. Cold spray coating machine

FESEM

The most powerful version of a SEM are the field emission scanning electron microscopes (FESEM) that can gives very clear images of a sample as small as 1½ nanometers. The information about the sample like the looking of the surface can be obtained by using a beam of electrons that shot towards the samples, after the interaction of the electrons with the surface molecules it relay the information back to the user. Therefore the field emission scanning electron microscopy was used to examine surface morphological topography of the two groups of ziroconia and two groups of PEEK . Before imaging in (FESEM) each specimen was put in ion sputter to form gold ion sputtering to obtain better images

Elemental Analysis with Energy Dispersive X-Ray (EDX)

It is an x-ray technique which is also referred to as (EDX) or (EDS) used to identify the materials elemental composition, mapping of the elemental of the analyzed sample and image analysis, for each group 3 disks were examined, The systems of EDX are usually attachments to SEM or Transmission Electron Microscopy (TEM) systems where the microscope imaging capability of identifies the specimen of interest. (14) The EDX generated data consist of spectra that show peaks which are corresponding to the elements making up the true composition of the analyzed sample. The study the EDX analysis was made for ginger coated zirconia and PEEK groups within the SEM instrumentation by taking three different points on each sample.(15)

Result

Analysis of particle size

The results of this test proved that the particle size of had a particle size approximately 155 nanometers as shown in figure (2). This test was conducted in the Technology University / center of nanotechnology and advances researches.

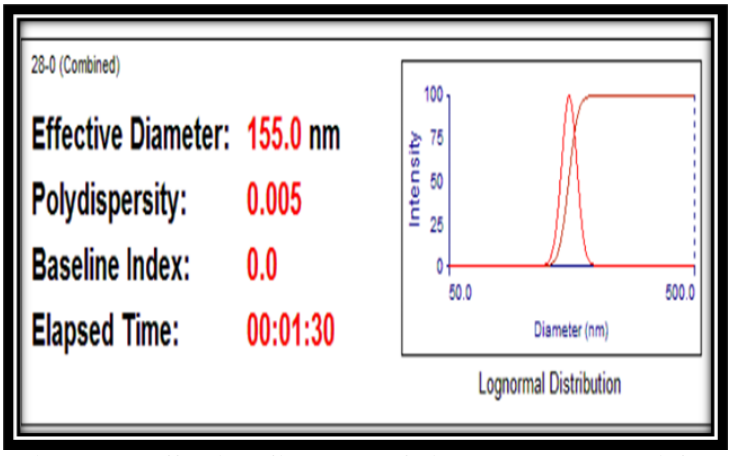


Figure 2. Effective diameter of ginger extract particles

FTIR

FTIR of ginger extract powder is shown in figure (3). the main functional groups for ginger extract were OH stretch H-bonded at wave number 2923.46 cm-1 , Alkane Metil –CH3 at wave number 1113.02 cm-1 , O-H bend of aromatic phenol at wave number 667.78 cm-1 , C≡N nitrile group at wave number 2329.50 cm-1 and C≡C alkyne goup at wave number 2357.81 cm-1. (16)

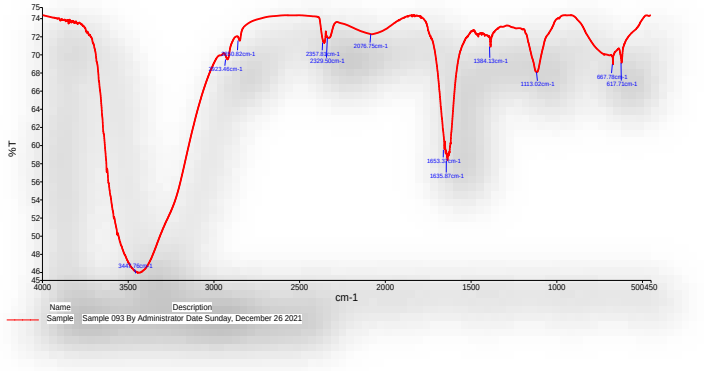


Figure 3. FTIR plot of ginger extract powder

FESEM

In the FESEM micrograph of coated disc shown in Figure (4)

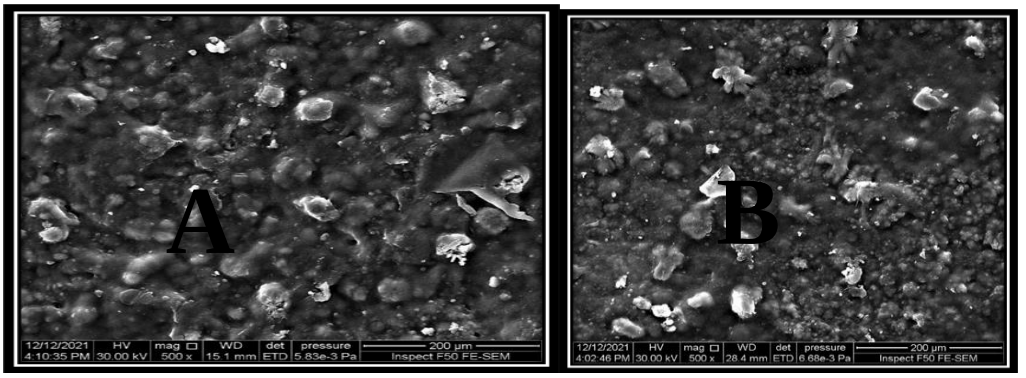


Figure 4. A- coated PEEK samples B- coated zirconia Samples

Elemental Analysis with Energy Dispersive X-Ray (EDX)

Elemental analysis by EDX, An EDX spectrum manifestation the atom peaks correlate with the greatest X-rays received energy levels; the greater peak in a spectrum, the more element concentrated (17). The conditions of the EDX analysis for ginger coated PEEK and zirconia that were used in this study was shown in figure (6) and (8) respectively.The EDX patterns of ginger coated PEEK and zirconia substrate were shown in figure (5 and 7) respectively, which indicates the appearance of energies of carbon , nitrogen and oxygen indicating the main elemental composition of hydrocarbon ,and some trace amount of other element like sodium , Sulphur, phosphate , chloride and magnesium.

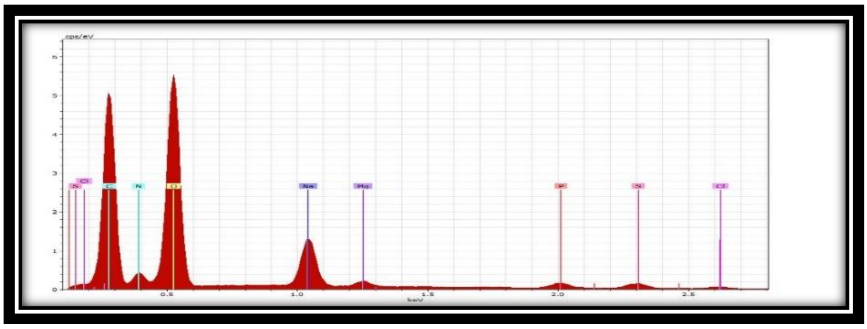
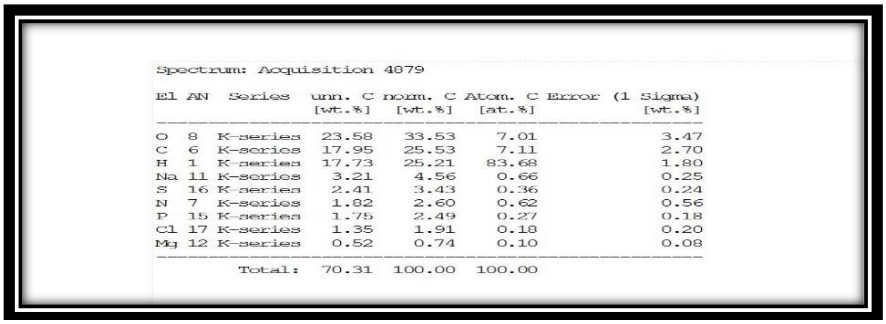


Figure 5. SEM\EDX analysis of the ginger coated PEEK samples



Spectrum: Acquisition 4879

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]
O	8	K-series	23.58	33.53	7.01	3.47
C	6	K-series	17.95	25.53	7.11	2.70
H	1	K-series	17.73	25.21	83.68	1.80
Na	11	K-series	3.21	4.56	0.66	0.25
S	16	K-series	2.41	3.43	0.36	0.24
N	7	K-series	1.82	2.60	0.62	0.56
P	15	K-series	1.75	2.49	0.27	0.18
Cl	17	K-series	1.35	1.91	0.18	0.20
Mg	12	K-series	0.52	0.74	0.10	0.08
		Total:	70.31	100.00	100.00	

Figure 6. The conditions of the EDX analysis ginger coated PEEK samples

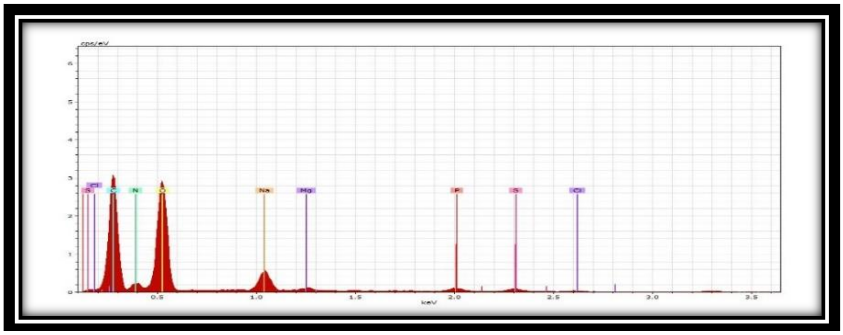


Figure 7. SEM\EDX analysis of the ginger coated zirconia samples

Spectrum: Acquisition 4880

El	AN	Series	unn. C [wt.%]	norm. C [wt.%]	Atom. C [at.%]	Error (1 Sigma) [wt.%]
H	1	K-series	49.48	49.48	93.69	4.97
O	8	K-series	22.68	22.68	2.70	2.95
C	6	K-series	17.42	17.42	2.77	2.31
Na	11	K-series	3.75	3.75	0.31	0.26
S	16	K-series	2.09	2.09	0.12	0.17
P	15	K-series	1.61	1.61	0.10	0.14
N	7	K-series	1.58	1.58	0.22	0.39
Cl	17	K-series	0.91	0.91	0.05	0.12
Mg	12	K-series	0.48	0.48	0.04	0.06
		Total:	100.00	100.00	100.00	

Table 8. The conditions of the EDX analysis ginger coated zirconia samples

Discussion

In this study, we presented a method of homogeneous ginger extract coating deposition on a PEEK and zirconia implant surface. Although PEEK has mechanical properties that complement native bone tissue after implantation, it is a bioinert material. An aromatic ring and polyester functional groups in its chemical structure render it hydrophobic and resistant to protein and cell adhesion. It is known that the association between PEEK materials and bone tissue weakens with time after implantation.(18, 19). The particle sizes of the prepared ginger extract powder were investigated via laser particle size analyzer. The average particle size of the ginger extract powder ranged 155 nm. FTIR of ginger extract powder is shown in figure (3). the main functional groups for ginger extract were OH stretch H-bonded at wave number 2923.46 cm-1 , Alkane Metil –CH3 at wave number 1113.02 cm-1 , O-H bend of aromatic phenol at wave number 667.78 cm-1 , C≡N nitrile group at wave number 2329.50 cm-1 and C≡C alkyne goup at wave number 2357.81 cm-1. (16)

In the FESEM micrograph of coated disc shown the appearance of Ginger extract coat material as continuous, cracks free, uniformly distributed on the PEEK and zirconia substrate with small aggregate areas as seen at different magnifications. As seen in Figure (4) The FESEM micrographs of the ginger extract coating were similar in appearance to the electrodeposited and electrostatic sprayed coatings reported by other authors. The advantage of such a dentate morphology on the PEEK and zirconia implant surface is that it can reduce the surface area which

bears shearing strength while increasing the surface area bearing compressive strength.(20). FESEM revealed that the roughness of the ginger extract coating surface was favorable. This roughness is crucial in ensuring that the bone tissues and implants will bond, thereby enhancing osseointegration and improving the prognosis of implant treatments. The EDX patterns of ginger coated PEEK and zirconia substrate were shown in figure (5 and 7) respectively, which indicates the appearance of energies of carbon, nitrogen and oxygen indicating the main elemental composition of hydrocarbon ,and some trace amount of other element like sodium , Sulphur, phosphate , chloride and magnesium. The other trace element ensure that ginger natural extract.

Conclusion

Within limitation of the study, cold spray coating method can be used to produce uniform layer with proper distribution and homogeneity of the coating material. Favorable surface roughness achieved and good adherence to both PEEK and zirconia substrate

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