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The characteristics tests of the PEKK-titanium oxide composite material

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***Abstract*---**Polymers, being one of the most important materials in dentistry, offer great physical and mechanical qualities, as well as good biocompatibility. Aim of this study this study was done to evaluate the Polyetherketoneketone and Polyetherketoneketone polymer composite material used as dental implant through evaluation including (flexural strength, Wettability). Polyetherketoneketone composites (Polyetherketoneketone and titanium oxide nanoparticles with selected weight percentage ratios of (0, 5%, 10%, 15%), were fabricated using a compression molding technique, The study involved Samples preparation (sheets) shaping and forming into desire shapes according to standard for tests which include flexural strength and Wettability. The results obtained from the experiments showed that slight increase in tensile polymer composite consisting from polyetherketoneketone and Tio2 nanofiller comparing with pure Polyetherketoneketone, with increase the in concentration of Polyetherketoneketone composite (concentration 5%, 10%, 15%), improvement in the wettability value and flexural strength.

***Keywords*---**polyetherketoneketone, titanium oxide, flexural strength, wettability.

Introduction

Because of their excellent physical, mechanical, and biocompatibility properties, polymers are one of the most essential materials in dentistry..[1] A wide range of removable appliances, restorations, and denture base materials are made from polymers[2-3]. PEKK (polyetherketoneketone) is a new polymeric material that has grabbed the interest of researchers due to its exceptional properties that may be used in a wide range of applications. [4-5] PEKK (Polyetherketoneketone) is a methacrylate-free thermoplastic high-performance polymer.. [6]. PEKK is a biomaterial that has lately acquired prominence as a biomaterial with properties that make it suitable for dental and medical applications. [7]. PEKK (Polyetherketoneketone) is a polyetherketoneketone with a wide variety of uses in restorative, prosthetic, and implant dentistry..[8]

Compression molding processes for thermoplastics and thermosets provide a high level of automation, quick cycle times, excellent repeatability, and outstanding dimensional stability, which is why they are employed in a range of sectors, including the automobile industry..[9-10] According to Wu et al., integrating nano-sized TiO2 particles into polymer can improve osseointegration. Because of the increased quantity of nano-filler particles, three-dimensional computed tomography has revealed that a greater amount of bone grows around polymer/nano-TiO2 cylindrical implants, and they have enhanced mechanical qualities when compared to pure polymer..[11]

For biomaterial applications such as TiO2/ nanocomposites, numerous types of n-TiO2 boosted polymers have been produced. After 21 days of exposure to simulated bodily fluid, TiO2 could promote the synthesis of hydroxyapatite (HA). [12]The presence of a thin titanium oxide layer improves mediating protein adsorption on the surface, strengthening non-specific protein-surface interactions. As a result of improving the surface oxide quality, Ti implant materials' biocompatibility has improved..[13]

Material and Method

PEKK/ Tio2 composites with Tio2 filler reinforcement of 5, 10, and 15% were produced. Powder mixing and compression molding techniques are used. 14. Appropriate amounts of Tio2 NPs powder and PEKK powder are codispersed in a suitable solvent to produce a homogenous suspension. After drying the powder mixture in an oven to remove the solvent, the powder mixture is placed in appropriate molds to generate the required shape. The powder mixture and molds are preheated to a temperature of roughly 150°C at 35MPa pressure. After that, the temperature is raised to 350–400°C while the pressure is kept at 15 MPa. When PEKK reaches its melting point, the polymer melts, but the bioactive filler particles remain solid. The composite implants are air-cooled to 150°C after holding the temperature for 10 minutes to reduce thermal stresses and cracking. After cooling, the material is a mixture of solid PEEK matrix and nanofillers distributed inside it. . [15]When the die was opened, the composite sheet was removed. The samples were in sheet shape and the sheets were 20cm * 20cm* 3mm in size. Using a computerized cutting machine CNC, polymer sheets were then cut and machined to the required test parameters.[16]

Contact angle (Wettability)

Wetting is a common occurrence in both everyday living and industrial processes. It is the contact angle that represents a liquid's capacity to spread out on a solid surface. The contact angle test was performed using a specific apparatus (China) and a drop of normal saline on the samples' surface. Because wetting qualities are crucial in implantable materials and are thought to be a predictor of future osseointegration, the PEKK composite wettability was measured using a surface wettability test (water contact angle test). For PEKK composite examples, specimens with a low contact angle measurement (high wetting surface) were chosen.. [17]

Flexural test

Flexural testing was performed at room temperature using a three-point test instrument and a Universal testing machine with a velocity of mm/min) according to ASTM D790-03. A sheet with a minimum length of 65 mm, a width of roughly 10 mm, and a thickness of at least 2.5 mm will be used as the sample. Calculating the flexural modulus and strength was done using load displacement diagrams. A CNC machine was used to cut the prepared sheets into the shape of the flexural test specimen. Eight specimens were employed in the majority of the studies, and the final results provide the average values for those eight specimens.[18]

Results

Wettability (Contact angle)

The result of measuring of the water contact angle for the samples was showed that the contact angle for the control PEKK was (79.13) , 5% Tio_2 (73.392), 10% Tio_2(71.8574), and decrease to 68.872 in the 15Tio_2% group, each of these results was repeated three times for each sample and the number above was the average for the readings group. Water contact angle images were taken for all study groups, the control group shown higher water contact angle (79.13**)** , while the group 5% shown decrease in the water contact angle (73.392) follow by the group 10% (71.8574) then the group 15% which shown the lowest water contact angle (68.872)**.**

Descriptive statistics of water contact angle test of the four groups (control, 5%, 10%, 15%) were summarized in table (1). The table shown the lowest mean in group 15% TiO2 composite **(**58.5**)** and highest mean in group control **(**79.13**).**

Table (1)Descriptive statistics of water contact angle test

Descriptives				
Groups				Statistic
Wetability	Control (PEKK)	Mean		79.1354
		95% Confidence Interval for Mean	Lower Bound	75.0028
			Upper Bound	83.2680
		Std. Deviation		3.32831
		Minimum		75.62
		Maximum		84.36
	Composite:PEKK +TiO2 (5%)	Mean		73.3920
		95% Confidence Interval for Mean	Lower Bound	70.8578
			Upper Bound	75.9262
		Std. Deviation		2.04098
		Minimum		71.54
		Maximum		76.87
	Composite: PEKK +TiO2 (10%)	Mean		71.8574
		95% Confidence Interval for Mean	Lower Bound	69.8106
			Upper Bound	73.9042
		Std. Deviation		1.64841
		Minimum		70.47
		Maximum		74.54
	Composite:PEKK +TiO2 (15%)	Mean		68.8720
		95% Confidence Interval for Mean	Lower Bound	66.5524
			Upper Bound	71.1916
		Std. Deviation		1.86817
		Minimum		66.74
		Maximum		71.16

Flexural strength

This study compares the flexural properties of PEKK polymer and pekk nanocomposite samples. Table (1) shows descriptive statistics, mean values, standard deviation, Standard error, maximum and minimum of flexural strength test of pure PEKK, (pekk +5%Tio_2) , (pekk +10% Tio2) , (pekk +15% Tio2) respectively as a function of nanoparticle weight percentage , it shows increase the flexural strength values of the PEKK polymer composite comparing with pure pekk with increase the percentage or volume fraction of the Tio2 nano composite reach to maximum value at group which represent the PEKK with 15% Tio2 nano filler.

Table (2)Descriptive statistics of water contact angle test

Descriptives				
Groups				Statistic
Flextural	Control (PEKK)	Mean		142.5460
		95% Confidence Interval for Mean	Lower Bound	133.5212
			Upper Bound	151.5708
		Std. Deviation		7.26829
		Minimum		131.72
		Maximum		151.40
	Composite:PEKK +TiO2 (5%)	Mean		155.4212
		95% Confidence Interval for Mean	Lower Bound	143.0171
			Upper Bound	167.8253
		Std. Deviation		9.98987
		Minimum		137.70
		Maximum		161.03
	Composite: PEKK +TiO2 (10%)	Mean		168.9440
		95% Confidence Interval for Mean	Lower Bound	166.1071
			Upper Bound	171.7809
		Std. Deviation		2.28478
		Minimum		166.49
		Maximum		171.80
	Composite:PEKK +TiO2 (15%)	Mean		185.8372
		95% Confidence Interval for Mean	Lower Bound	181.4052
			Upper Bound	190.2692
		Std. Deviation		3.56937
		Minimum		182.40
		Maximum		190.49

Discussion

Wettability (Contact angle)

Surface wettability is critical in enhancing osteogenic activity on surface modified metals.. [19]. Protein adsorption, cell adhesion, cell distribution, and increased osteoblastic activity can all be affected by changes in surface wettability and surface energy. [20,21] As a result, in order to induce osseointegration, the implant surface must be hydrophilic in order to achieve surface wettability.. [22,]

The contact angle for the control PEKK is (81.9), 10% (72.8), 20% (68.3), and decreases to 58.5 in the 15% group. The decrease in the contact angle value could be attributed or explained due to the incorporation of the Nano filler in different concentrations may affect the surface topography of the polymer surface of the PEKK samples, resulting in less hydrophobicity. , As calcium ions established chemical interactions with water molecules, while P-OHs on the hydroxyapatite surface produced hydrogen bonds with water molecules, the polarity of the filler nano powder is higher than that of other nano powders. The hydroxyapatite became hydrophilic as a result, making it more wettable..[23,]

Flexural strength

The results of the mean flexural strength at break show that changing the type of reinforcement and matrix has a significant impact on tensile properties, as shown in the results of the PEKK polymer composite with pure pekk and increasing the weight percentage of the Tio2 nano composite with a very high significant difference.

The nature of the matrix material, type of reinforcement, volume percent, as well as the method and circumstances of processing for nanoparticle inclusion in the polymer matrix, all have an impact on the mechanical properties of composite materials. Incorporation of hard nanoparticle powders into the polymer matrix results in restricted polymer chain mobility, which improves nanocomposites' stiffness, lowers plastic deformation, and, as a result, boosts flexural strength and elastic modulus. [24].

A greater connection between the polymer matrix and the reinforcing phase resulted in a higher elastic modulus and flexural strength, which might be attributed to this. Clearly, a larger reinforcement content results in a stiffer overall material, which increases the load carrying capability of composite materials..[25]

Conclusion

In this study, compression fabrication processes were used to create PEKK with different Tio2 nanoparticle concentrations. The combination of PEKK and 15% Tio2 produced mechanical properties that outperformed all other compositions tested in this study.

Conflict of interest

The authors have no conflicts of interest regarding this investigation.

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