Research Article

Analysis of surface topography of dental implants coated with sulfonated poly ether ether ketone

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ABSTRACT

Osseointegration in patients with deficient bone quality is a challenge, especially in dental implants. Coating of the implants with a suitable material is considered as a method to enhance osseointegration. In this study, titanium implants were coated with sulfonated poly ether ether ketone (SPEEK) and their surface roughness was evaluated. Fourier-transform infrared and scanning electron microscope images confirmed the coating of the implant with SPEEK. The higher surface roughness observed in SPEEK-coated implants could be useful for favorable bone cell attachment over the implant surface.

KEY WORDS: Coating, Dental, Implant, Sulfonated poly ether ether ketone, Surfaces

INTRODUCTION

In patients with challenging bone conditions, titanium implants are more prone to failure.[1] Consequently, installation of dental and orthopedic implants may not be an optimal approach for patients suffering from diseases that affect the bone metabolism. For example, osteoporosis is one of the most frequently occurring bone disorders and characterized by low bone mineral density.[2] Both animal experimental and clinical data confirmed that osteoporosis negatively influences the healing process of a bone wound.[3] However, a non-disturbed bone healing process is essential to achieve optimal integration of a dental or orthopedic implant into bone. Therefore, a systemic condition that adversely interferes with bone healing may decrease the potential for the successful integration of implants within the native bone tissue and contribute to implant failure.[4]

The current trend is to modify implant surfaces to improve cell-surface interaction, which leads to an increase in local bone density and acceleration of healing time even in the elderly or pathologic bone. "Osseointegration" is a pivotal point for the survival of implants, and it has been demonstrated that the biological fixation is strictly related to the surface characteristics of the implant. Pure titanium appears to be well integrated; however, surface modifications are widely investigated to enhance the bond of host tissue to the implant through either precipitation of bone mineral or protein deposition or direct cell stimulation.[5-7] Therefore, different materials, coatings, and surface treatments have been proposed to enhance biomechanical properties of the interface area sulfonated poly ether ether ketone (SPEEK) which has been demonstrated to be biocompatible, bioactive, and hydrophilic. No studies have been reported on surface coating of dental implants with SPEEK.

Aim and Objectives

The aim of the study was to analyze SPEEK and coat it over Ti dental implants. In addition, the surface roughness of the SPEEK-coated titanium dental implants was also evaluated.

MATERIALS AND METHODS

Polyether ether ketone (PEEK) (M. Wt. 100 KDa) was procured from Victrex, India, while nano-hydroxyapatite (nHA) was purchased from Sigma-Aldrich, India. The solvents dimethylformamide and N-methyl pyrrolidone (NMP) were purchased from Sisco Research Laboratories Pvt., Ltd., Mumbai, India. The nanohydroxyapatite powder used as received and had a particle size of <200 nm. The TEM image of the commercial nHA used in the present study was reported in our earlier paper.[8]

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Sulfonation of PEEK

The initial step toward the fabrication of SPEEK-based composites was the sulfonation of the commercially procured PEEK using sulfuric acid according to the procedure described elsewhere.[9] In brief, about 10 g of PEEK powder was taken in a three-necked round bottom flask to which a calculated quantity of sulfuric acid was added. Sulfonation of PEEK was achieved by stirring the contents of the flask at room temperature under nitrogen atmosphere for a prescribed duration of time. Subsequently, the contents of the flask were poured slowly onto a large excess of crushed ice in a glass container. The SPEEK present in the sulfuric acid solution immediately precipitated as soft fibres and was recovered by filtration. Thus, obtained SPEEK precipitates were washed several times with deionized water until the pH of the washwater reached neutrality. To ensure the complete removal of any residual sulfuric acid, the SPEEK precipitates were further kept in boiling water for 1 h. They were then filtered and dried in an oven at 90°C for about 10 h. The schematic representation of conversion of PEEK to SPEEK is given in Figure 1.

Speek Coating Over Dental Implants

Initially, 2 g of SPEEK was dissolved in 15 ml of NMP in a magnetic stirrer. 5 ortho mini implants were dipped into the solution for 2 min. The retrieved implants were then washed with deionized water, dried, and then analyzed under scanning electron microscope (SEM) and surface roughness was studied.

Evaluating Surface Roughness

Surface roughness was evaluated using non-contact profilometer.

RESULTS

Fourier-transform infrared (FTIR) spectrum of SPEEK is depicted in Figure 2. The peak at 3400/cm relates to O-H stretch, while the peaks at 1256 and 1020/cm correlate to O=S=O stretch and S=O stretch, respectively. The peak at 3100/cm corresponds to aromatic stretching. This confirmed the sulfonation of PEEK.[10]

SPEEK-coated Implants

The photograph of titanium implants and Ti-coated implants is shown in Figure 3a and b, respectively. The SPEEK coating can be seen as whitish coating over the implant. The SEM image of the uncoated and coated implants is seen in Figure 3c and d. From the figure, the coatings can be seen as rough irregular mass with pores.

Surface Roughness

The results of the profilometer studies are shown in Figure 4 and tabulated in Table 1.

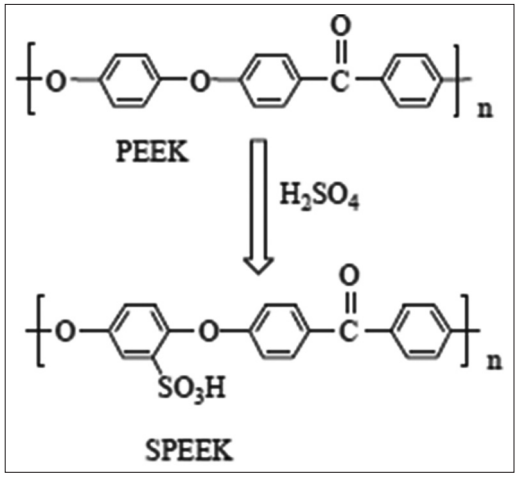

Figure 1: Conversion of polyether ether ketone to sulfonated poly ether ether ketone

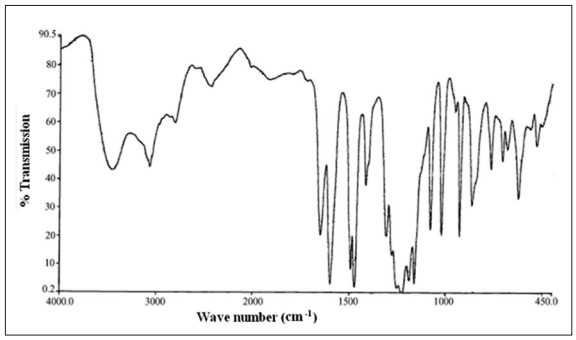

Figure 2: FITR spectrum of sulfonated poly ether ether ketone

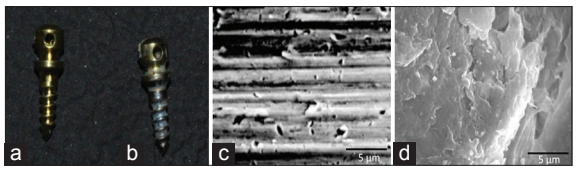

Figure 3: Photograph of (a) Ti implant; (b) sulfonated poly ether ether ketone (SPEEK)-coated Ti implant; scanning electron microscope image of (c) Ti implant; (d) SPEEK-coated Ti implant

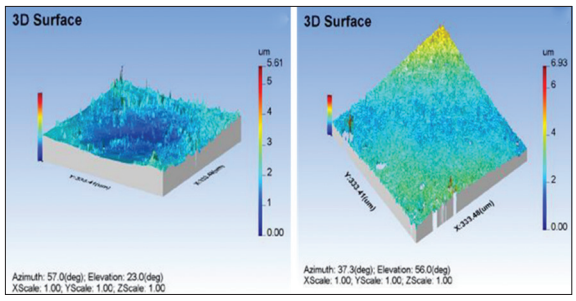

Figure 4: Surface roughness

From Table 1, it is evident that the surface roughness of the SPEEK-coated implant is much higher than the uncoated ones. Increase in surface roughness was attributed to the formation of SPEEK layer over the implant surface.

Table 1: Surface roughness values of non-coated and coated implants

Sample	Ra value (μm)
Non-coated implant	0.027±0.019
SPEEK-coated implant	0.112±0.098

SPEEK: Sulfonated poly ether ether ketone

DISCUSSION

The main route adopted by research and industry to enhance osseointegration has traditionally entailed roughening techniques, with good outcomes in terms of bone to implant interlock. Hydrophilic surfaces have very low contact angle values, whereas hydrophobic ones reveal a contact angle of >90°. Surface energy and wettability play an important role on the interaction with the proteins on the implant surface and influence strongly cell adhesion. A further biofunctionalization method implies the direct integration of molecules into the coating material, which acts as a carrier system. Carriers currently in use are polylactide, polyglycolic acid, hydrogels, polypyrrole, and calcium phosphate/HA coating. In the present study, the sulfonation of PEEK was confirmed using FTIR study. The SEM image clearly showed the presence of a polymer coating on the surface of Ti implant.[11] The surface roughness studies also revealed that coating of the implant with SPEEK increased its surface roughness. The greater the surface roughness, the greater would be the surface area. This would lead to greater cell-implant interaction. Hence, better host-biomaterial interaction could be expected.

CONCLUSION

PEEK was successfully sulfonated and coated onto the surface of Ti implants. SPEEK being hydrophilic, this technique opens the avenue for biofunctionalization of the implant. In addition, since the surface roughness is also increased on coating, it would be reasonable to expect favorable ossteointegration of the implant *in vivo*.

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