Biological Analysis of Newly Fabricated Nano-Porous Network on PEEK Surface

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Statement of Purpose: Polyetheretherketone (PEEK) has been widely used in orthopaedic implantations due to its bone-like mechanical properties [1]. However, its bioinertness may lead to inferior bone-implant integration. Therefore, many efforts such as incorporation of hydroxyapatite (HA) to PEEK matrix and Ti or HA coating to PEEK surface have been considered to improve its bone-implant integration since last decade [2,3]. In spite of the improvement of bioactivity by using these methods, the mechanical properties of newly formed PEEK materials are not satisfactory owing to the poor physical bonding between PEEK substrate and these additional substances. Hence, a thought to establish porous network on PEEK surface for allowing bony in-growth seems to be an alternative. Technical challenge due to its advanced chemical resistance has to overcome during porous fabrication. However, so far the ideal porous pattern by surface modification for biomedical application is still lack of resolution. In this study, our team has succesfully made use of sulfonated treatment [4] to fabricate a uniform nano-porous network on PEEK surface namely "SPEEK". To determine their biocompatibility for tissue-engineering applications, we examined the biological behaviors of SPEEK and untreated materials with the use of mammalian cell culture.

Methods: Medical grade polyetheretherketone (PEEK) (Ketron LSG, Quadrant EPP, USA) was machined into disc of 5 mm diameter and 2 mm thickness. Sulfonation of PEEK were conducted in supersonically stirred sulfuric acid (95–98 wt%). After 5 minutes, the sulfonated PEEK was taken out and then put into supersonically stirred distilled water. The samples were further rinsed with acetone followed by distilled water cleaning. Biological assessments such as cell adhesion and proliferation by using MC3T3-E1 mouse osteoblasts were conducted. In cell adhesion assay, an aliquot contained with10000 cells were cultured on various sample surfaces for 4 hours. The cells were then fixed and stained with the Hoechst Staining Kit and the morphology was observed under fluorescence microscopy. Cell proliferation was measured by MTT assay on Day 2, 4 and 7 of cell culturing. At the prescribed time points, the specimens were gently rinsed three times with PBS and transferred to a new 96-well plate. The MTT solution was added and the specimens were incubated at 37℃ to form formazen, which was then dissolved using dimethyl sulfoxide (DMSO). The optical density (OD) was measured at 570 nm using a spectrophotometer (Biotek, USA).

Results and discussion: Sulfonated treatment produced a uniform nanoporous network layer at the PEEK surface (Fig.1a). This newly formed SPEEK layer was about 100 μm in thickness (Fig.1b). The cell adhesion and viability assay revealed that the PEEK materials after sulfonated treatment were found more cells as compared with the untreated control (Fig.2 and Fig.3). The bioactivity enhancements may attribute to the synergistic role played by the nanotopography and SO_3 group formation.

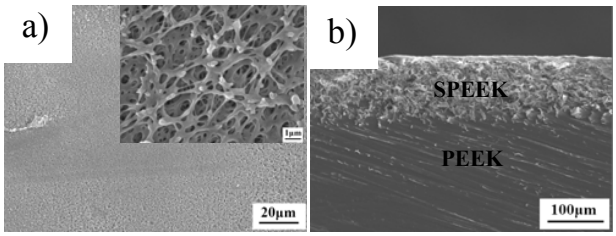

Fig.1 Scanning electron microscopic photographs acquired from (a) the surface of SPEEK, (b) the cross section of SPEEK

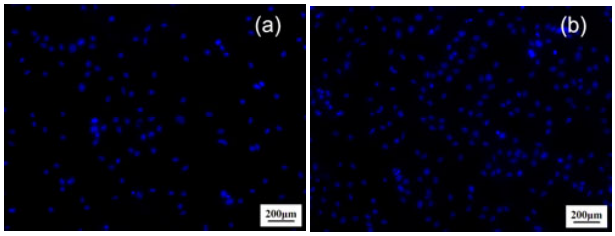

Fig.2 Morphology of osteoblast adhesion after 4 hours of incubation measured by cell counting (nuclei in blue) under fluorescence microscopy. (a) PEEK control, (b) SPEEK

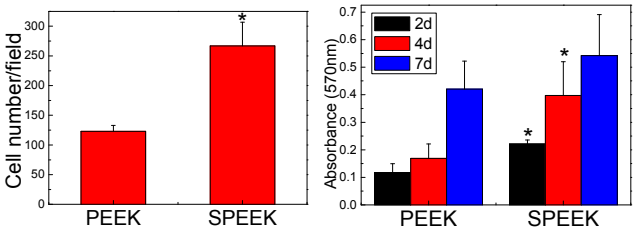

Fig.3 The results of cell adhesion and viability assay of MC3T3-E1 osteoblasts after cell culturing. Statistical significance indicated by *P < 0.05 compared with the PEEK control

Conclusions: Sulfonated treatment has sigificantly improved the bioactivity of PEEK materials by the synergistic role played by the nanotopography and surface chemistry. Our results suggest that superior bone-PEEK integration can be achieved by this novel and simple technique. *In-vivo* study will be considered prior to clinical use.

References:

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