

## IMPROVED ANTIBACTERIAL ACTIVITY OF 3D PRINTED PEEK/ZnO-m PROTOTYPES BY PLASMA SURFACE TREATMENT

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Additive manufacturing (AM) facilitates the fabrication of patient-specific, complex geometries for biomedical applications. Poly(etheretherketone) (PEEK) demonstrates similar mechanical properties of trabecular bone and possesses biocompatibility, making it suitable for implantation. However, its inherent bioinertness and susceptibility to microbial colonization necessitate surface modifications. This study investigates the synergistic effect of incorporating zinc oxide microparticles (ZnO-m) into PEEK filaments and subsequent argon plasma treatment on the antibacterial properties and surface morphology of 3D printed PEEK prototypes. PEEK filaments with varying ZnO-m concentrations (1, 3, 5% wt.%) were fabricated via melt extrusion. Prototypes were then 3D printed via fused deposition modeling using the formulated filaments. Argon plasma treatment was applied to modify the surface properties, hypothesizing that plasma etching would expose ZnO-m particles, thereby enhancing antimicrobial efficacy. Antibacterial efficacy was assessed against *Staphylococcus aureus*, a common pathogen associated with implant-related infections. Surface morphology and ZnO-m distribution were analyzed using scanning electron microscopy. Results revealed that all plasma-treated PEEK/ZnO-m prototypes exhibited superior antibacterial performance compared to untreated PEEK. The 1% ZnO-m prototype with plasma treatment demonstrated over 99% growth inhibition and a bactericidal activity (R) value exceeding 2, indicating a substantial reduction in bacterial viability. SEM analysis confirmed that plasma treatment etched the PEEK matrix, exposing ZnO-m particles on the surface. This enhanced efficacy is attributed to the synergistic action of increased ZnO-m surface exposure, which generates reactive oxygen species (ROS) and releases antimicrobial Zn<sup>2+</sup>, and argon plasma-induced surface modifications, which increase surface hydrophilicity and roughness. These findings underscore the potential of incorporating ZnO-m into PEEK combined with argon plasma treatment of the printed prototypes to impart robust antibacterial properties, thereby mitigating the risk of implant-associated infections. This approach, leveraging plasma etching to optimize ZnO-m exposure, holds promise for the development of next-generation biomedical devices with enhanced biocompatibility, surface functionality, and infection resistance.

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