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Investigation of Poly P-Dioxanone as Promising Biodegradable Polymer for Short-Term Medical Application

Authors : Stefanie Ficht, Lukas Schübel, Magdalena Kleybolte, Markus Eblenkamp, Jana Steger, Dirk Wilhelm, Petra Mela

Abstract : Although 3D printing as transformative technology has become of increasing interest in the medical field and the demand for biodegradable polymers has developed to a considerable extent, there are only a few additively manufactured, biodegradable implants on the market. Additionally, the sterilization of such implants and its side effects on degradation have still not been sufficiently studied. Within this work, thermosensitive poly p-dioxanone (PPDO) samples were printed with fused filament fabrication (FFF) and investigated. Subsequently, H_2O_2 plasma and gamma radiation were used as low-temperature sterilization techniques and compared among each other and the control group (no sterilization). In order to assess the effect of different sterilization on the degradation behavior of PPDO, the samples were immersed in phosphate-buffered solution (PBS) over 28 days, and surface morphology, thermal properties, molecular weight, inherent viscosity, and mechanical properties were examined at regular time intervals. The study demonstrates that PPDO was printed with great success and that thermal properties, molecular weight (Mw), and inherent viscosity (IV) were not significantly affected by the printing process itself. H_2O_2 plasma sterilization did not significantly harm the thermosensitive polymer, while gamma radiation lowered IV and Mw statistically significantly compared to the control group ($p < 0.001$). During immersion in PBS, a decrease in Mw and mechanical strength occurred for all samples. However, gamma sterilized samples were affected to a much higher extent compared to the two other sample groups both in final values and timeline. This was confirmed by scanning electron microscopy showing no changes of surface morphology of (non-sterilized) control samples, first microcracks appearing on plasma sterilized samples after two weeks while being present on gamma sterilized samples already immediately after radiation to then further deteriorate over immersion duration. To conclude, we demonstrated that FFF and H_2O_2 plasma sterilization are well suited for processing thermosensitive, biodegradable polymers used for the development of innovative short-term medical applications.

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