Evaluation of gamma irradiation impact on 3D-printed multimaterial polymer

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INTRODUCTION: Multimaterial additive manufacturing may offer new possibilities for design of medical devices thanks to the freedom of shape and material. Rigid and flexible biocompatible materials are now available so polymer devices could benefit from the materials and the novel production process [1-2]. To this purpose, we investigate the impact on mechanical performance of γ-irradiation, a standard sterilization process, to polymer parts.

METHODS: Polyjet technology (Stratasys Ltd, USA) is being studied with a Connex 350 system processing UV-curing resins. A rigid material, commercialized as *Verowhite Plus*, and a flexible one, *TangoBlack Plus*, are assessed. Mechanical performance is tested using tensile tests according to ISO 527-1 for the rigid material, with type 1A specimen. For the flexible material, a sample is designed to have a length of reduced section of 25 mm, and a cross section of 4*4 mm^2. Five specimens of rigid materials and one of flexible material are tested, before and after irradiation at 34 kGy. In addition, an assembly of 3D-printed parts of both materials to build a pneumatic medical actuator [3] is tested in terms of biopsy-needle positioning velocity before and after irradiation.

RESULTS: The stress-strain curves of the rigid material are shown in Fig. 1. The Young's modulus (mean±std) of the unexposed and the γ-exposed specimens are equal to 1830±38 MPa and 2810±37 MPa, respectively. γ-irradiation has a significant stiffening effect. It is also to be noted that 2 out of 5 specimens show a rupture before 4.5 % of strain. The other 3 specimens present a stress increase in the plastic domain that was not observed before irradiation. No significant impact is noted for the flexible material. The pneumatic actuator (Fig. 2) is still functional after irradiation despite the Young's modulus increase of rigid material, with no significant variation of velocity.

DISCUSSION & CONCLUSIONS: The 53 % increase of the Young's modulus and the stress-strain relationship of the rigid material could be explained by a reticulation of the polymer structure under gamma exposition. This work allows the designer to compensate the stiffening effect during design for additive manufacturing process. The insignificant impact on flexible material and the satisfying behaviour of pneumatic actuators are encouraging to further test the materials and perform microbiological testing of γ-exposed materials.

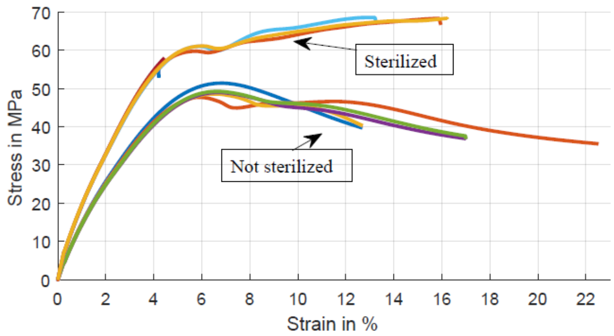

Fig. 1: Stress-strain curve of the rigid polymer specimens, before and after γ-sterilization.

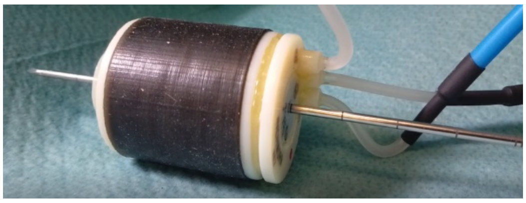

Fig. 2: 3D printed multimaterial pneumatic medical biopsy actuator after gamma irradiation.

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