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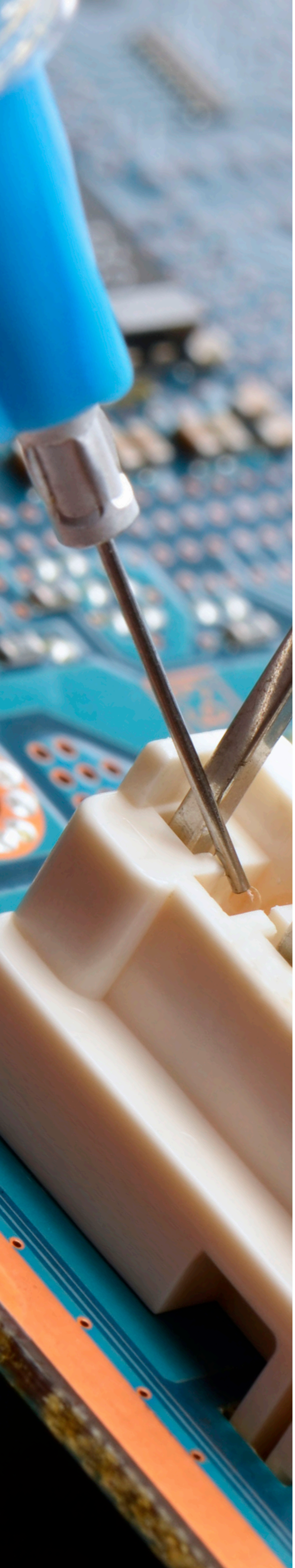
CASE STUDY



EP62-1LPSPMed: Used to Encapsulate Radioactive ^{125}I Seeds Within a 3D-printed Episcleral Plaque

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Overview of EP62-1LPSPMed

Master Bond EP62-1LPSPMed is an ultra-low-viscosity, two-part epoxy with a long working life that combines strong mechanical performance, broad substrate adhesion, and cryogenic stability. It also shows exceptional resistance to radiation and common medical sterilization methods, as well as biocompatibility, making it well-suited for the precision encapsulation of radioactive iodine-125 (^{125}I) in 3D-printed episcleral plaques.

Application

Episcleral plaque brachytherapy is a standard treatment for intraocular tumors where a device containing radioactive ^{125}I seeds is placed directly on the episclera. ^{125}I seeds then deliver continuous, low-dose radiation directly to tumors to kill cancer cells. Although this approach minimizes damage to surrounding tissues, conventional plaques still deliver unwanted radiation to healthy tissues and often cause retinopathy or cataracts.

Recent advances in 3D printing and radioactivity painting have made it possible to tailor the tumor dose coverage to reduce lateral radiation exposure. Researchers at Canada's Laboratoire de Biomatériaux pour l'Imagerie Médicale developed a 3D-printed plaque, where tungsten-loaded PEEK filament was used as a radiopaque polymer and shaped into an episcleral plaque with 16 cylindrical cavities (CCs) on its inner surface. These cavities acted as collimators that concentrated radioactivity from ^{125}I to attenuate lateral emission. The authors used Master Bond EP62-1LPSPMed as a biocompatible, ultra-low-viscosity epoxy to encapsulate radioactive ^{125}I within each cavity, ensuring stable source positioning and containment without altering the plaque geometry or radiopacity.

Key Parameters and Requirements

The 3D-printed plaque was first modeled based on the COMS (Collaborative Ocular Melanoma Study) geometry (without suture lugs) and then printed using a PEEK filament loaded with 10 vol% tungsten to achieve radiopacity (99% shielding from ^{125}I photons). Sixteen cylindrical cavities were arranged symmetrically on a concave surface, each of which was first loaded with silver paint, followed by sodium iodide (Na-^{125}I) solution using a 5 μL syringe. A drying time of 10 minutes was performed between each drop if multiple drops were added to the same cavity.

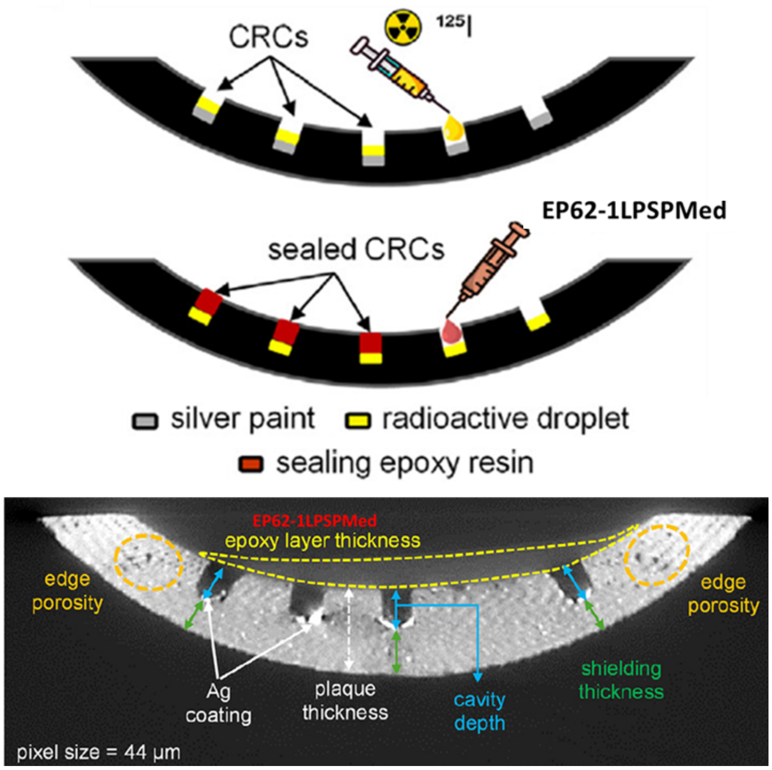

Figure 1. (top) Diagram illustrating the process used to encapsulate radioactive ^{125}I droplets within CRC EP cavities, followed by sealing with EP62-1LPSPMed. (bottom, yellow dotted outline) Cross-sectional µCT image showing the CRC EP's internal structures and EP62-1LPSPMed thickness.

After adding ^{125}I droplets into each cavity, which was then sealed using Master Bond EP62-1LPSPMed, whose ultra-low viscosity and long working life allowed it to be precisely dispensed into small cavities via syringe for encapsulation (***Figure 1***, top). EP62-1LPSPMed was drawn into a 1 mL syringe with a 20 G blunt needle and then dropped into each cylindrical radioactive cavity (CRC). EP62-1LPSPMed was also used as a protective layer on the surface of the plaque (***Figure 1***, bottom, yellow dotted outline) and then cured using an infrared lamp at 120°C for 1 hour. After curing, the thickness of the epoxy sealing was measured by **µCT**. Finally, each plaque was assessed for radioactivity leak tightness using ISO 9978:2020-based tests.

Results

The 3D-printed EP created in this study is thinner than those typically used, which may make it more comfortable for patients during treatment. Despite being thinner, it still provided EP back shielding and blocked approximately 99% of ^{125}I photons, ensuring a forward dose profile. The built-in CRCs created a collimating effect where their walls absorbed photons not projected in-line with the aperture of the cavities. Because EP62-1LPSPMed has low atomic number components, it did not introduce significant extra attenuation, so the heavy tungsten-PEEK walls provided the main dose profile shaping.

The authors performed leak-tightness tests using ISO 9978-compliant testing protocols, which included decontamination, wet wiping, and water immersion assessments. The **γ**-counter measurements averaged 3.68 ± 1.31 nCi, which is within established safety limits.

The assembled plaques with their EP62-1LPSPMed-sealed ^{125}I radioactive sources were imaged by **µCT** to verify geometry and cavity filling and then used to irradiate a MAGIC-pf dosimetric gel. Gel dosimetry via MRI mapping was used to measure the 3D dose profiles for two layouts (uniform and gradient), which were compared to those from standard COMS and SEP plaques.

For the CRC EP with a uniform ^{125}I loading, the lateral dose spread was limited to 7 mm at 100% isodose, and the gradient loading further confined the dose distribution, with the 100% isodose spread limited to 4.8 mm. This loading minimized the lateral dose at shallower depths, showing that the CRC EPs reduced lateral dose exposure compared to both COMS EPs and SEPPs (***Figure 2***), which can reduce radiation to surrounding healthy tissue, such as the retina and optic nerve.

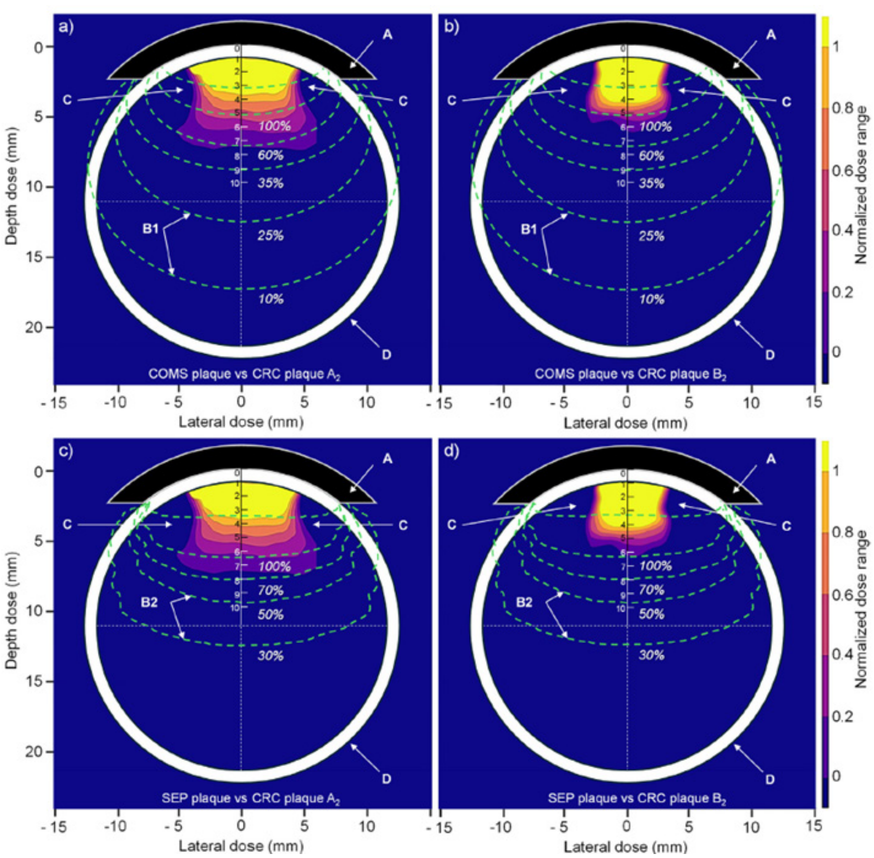

Figure 2. Comparison of the uniform (a,c) ^{125}I loading and (b,d) gradient ^{125}I loading. The green dotted lines show the isodose contours of COMS (a,b) or SEP (standard episcleral plaque) plaques (c,d).

Conclusions

The study introduced a 3D-printed plaque with two different cavity geometries, which were filled with ^{125}I (uniform and gradient) to obtain a more forward-projected dose. Both geometries resulted in a more precise and deeper dose than conventional COMS and SEP plaques, allowing them to target tumors while minimizing the radiation dose received by lateral healthy tissues.

^{125}I within the plaque cavities was encapsulated by EP62-1LPSPMed, whose ultra-low viscosity, biocompatibility, and radioactivity resistance made it ideal for encapsulating ^{125}I droplets in the tiny cavities of the plaque via a 20G syringe. Once cured, EP62-1LPSPMed provided a tight seal without attenuating forward-focused radiation, as confirmed by the dose profiles.

By securely containing the ^{125}I sources, EP62-1LPSPMed maintained dose integrity and prevented any radioisotope leakage, as confirmed by ISO 9978-compliant leak-tightness tests, which included decontamination, wet wipe, and water immersion. Combined with its biocompatibility, these results show that EP62-1LPSPMed is ideal for encapsulating and immobilizing radioactive ^{125}I seeds within episcleral plaques for treating eye tumors.

Reference

Zekraoui, Souheib, et al. 3D-Printed Radiopaque Episcleral Plaques with Radioactive Collimating Cavities for Enhanced Dose Delivery in Brachytherapy. *Brachytherapy*, 24, 2025, pp. 354–363, https://doi.org/10.1016/j.brachy.2024.12.001