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PTFE Expansion at Ablative Temperatures of an Uncooled Coaxial Monopole Antenna

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Microwave (MW) tumour ablation is a percutaneous cancer treatment where a needle-like applicator that incorporates an MW antenna delivers MW energy to the targeted region. The interaction of MW energy with water molecules causes a sharp rise in temperature to over 100 ℃, resulting in immediate cellular death. The antenna's performance depends on the surrounding tissues' material properties, predominately on the dielectric permittivity and effective conductivity, which are both temperature- and frequency-dependent [1, 2].
Recently, there has been an emerging interest in uncooled applicators with simpler designs. However, the high temperatures generated during ablation, cause antenna performance degradation. This can be attributed to changes in the surrounding tissue material properties, predominately the dielectric permittivity and effective conductivity, and structural changes in the antenna. Although various studies exist on antenna performance, limited literature differentiates between the effect on the antenna performance degradation due to the antenna's structural changes and changing tissue material properties.
A series of experiments were conducted to investigate how the elevated ablation temperatures adversely impact the structure and, consequently, the performance of the coaxial-based uncooled antenna. Prototype antennas made from an RG405 coaxial cable were immersed in peanut oil and heated until 140 ℃ while recording the cable's Polytetrafluoroethylene (PTFE) dielectric expansion through image processing. Figure 1 shows the change in length experienced by the PTFE at different temperatures; during the heating and cooling cycles, before and after the experiment demonstrating permanent deformation (utilising a toolmakers microscope) and analytically using the PTFE's linear coefficient of thermal expansion.

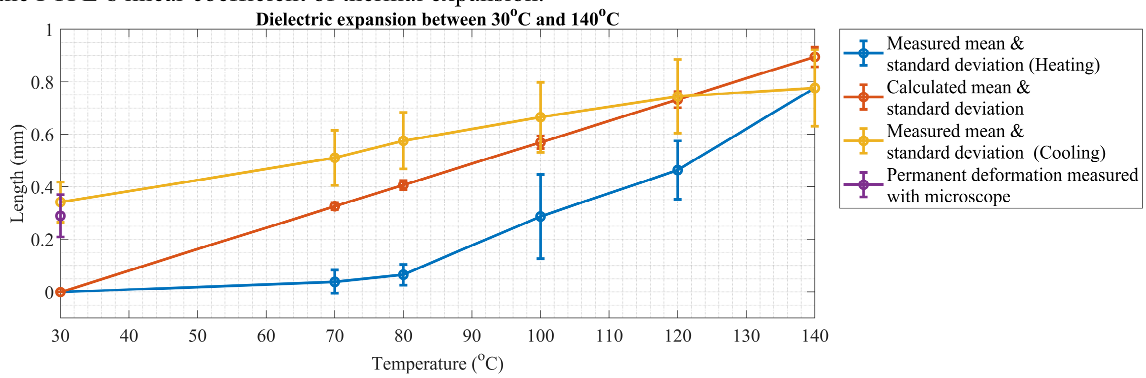

Figure 1. shows the PTFE dielectric expansion achieved experimentally and analytically.

In conclusion, this investigation suggests an adequate ablation temperature operating region where the uncooled antenna structural changes will marginally affect its performance. The obtained results suggest that if the ablation temperature is maintained between 60 ℃ and 80 ℃ (effective ablation temperatures), the expansion of the PTFE is relatively restrained and may be considered inconsequential to any decrease in the return loss monitored during ablation procedures. This will help to determine the decrease in return loss that can be exclusively attributed to the denaturalisation of the liver, hence shedding light on the specimens' dielectric changes experienced during ablation.

References

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