Structural, mechanical, and dielectric properties of polydimethylsiloxane and silicone elastomer for the fabrication of clinical-grade kidney phantom

ABSTRACT

This study aimed to introduce an alternative, inexpensive, and straightforward polymer with specific mechanical and dielectric properties suitable for the fabrication of a clinical-grade kidney phantom. Two polymer-based phantom materials, polydimethylsiloxane (PDMS) and silicone elastomer (SE), were investigated for their capability to meet the requirements. The concentration ratios of base to curing agent (B/C) were 9.5/1.5, 19/3, 10/1, 20/2, 10.5/0.5, and 21/1 for PDMS and 4.5/5.5, 10/12, 5/5, 11/11, 5.5/4.5, and 12/10 for SE. All samples were mixed, degassed, and poured into Petri dishes and small beakers. The polymer was cured under room temperature for 2 h and then demolded from the hard mold. The air bubbles produced were removed using a vacuum desiccator for 30 min. All samples underwent mechanical testing (tensile strength and elastic modulus), and their dielectric properties were measured using a dielectric probe kit equipped with 85071E materials measurement software. The radiation attenuation properties were also measured using PhyX-Zetra for PDMS phantoms with the chemical formula C2H6OSi. Small changes in base and cross-linker play an essential role in modifying the elastic modulus and tensile strength. The effective atomic number of PDMS showed a similar pattern with human kidney tissue at the intermediate energy level of 1.50 × 10−1 to 1 MeV. Therefore, PDMS can potentially be used to mimic the human kidney in terms of tensile strength, flexibility, the acceptable real part of the complex dielectric constant ε′r, and conductivity, which allows it to be used as a stable kidney phantom for medical imaging purposes.

Keyword: Mechanical; Dielectric; Effective atomic number; PDMS; Silicone elastomer; Kidney phantom