A Novel Poly(L-Lactic Acid) and Polycaprolactone Composite With Bismuth Oxide Nanoparticles for a Biodegradable, Radiopaque Stent Material

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Angioplasty procedures rely on stents to keep arteries open, but traditional metal stents remain permanently in the body and can lead to long-term complications. Biodegradable stents offer a promising alternative but lack sufficient mechanical performance and are not easily visible under imaging. This study investigates whether the incorporation of polycaprolactone (PCL) and bismuth oxide (Bi2O3) nanoparticles into poly(L-lactic acid) (PLLA) can create a biodegradable, radiopaque material suitable for stent applications. Polymer films were fabricated using a solvent casting method with dichloromethane (DCM). PLLA and PCL were blended at an 80:20 weight ratio, and bismuth oxide nanoparticles were added at 5 wt%. Nanoparticles were dispersed using bath sonication, and films were dried for 48 hours. Mechanical properties were evaluated using tensile strength testing, while chemical structure and radiopacity were analyzed using Fourier transform infrared spectroscopy (FTIR) and X-ray imaging. Results showed that blending PLLA with PCL reduced the Young's Modulus (from 4.69 GPa to 2.53 GPa), indicating improved flexibility, which is desirable for stents, but also decreased tensile strength (from 28.9 MPa to 12.0 MPa), consistent with the inherent mechanical properties of PCL. Correlation analysis of FTIR spectra showed a high coefficient (r = 0.9905) between the blend and nanocomposite, and characteristic ester stretches resonated at high intensities. X-ray imaging confirmed distinct radiopacity in bismuth-loaded samples compared to the polymer-only groups. The PLLA-PCL-Bi2O3 composite demonstrated tunable mechanical properties, maintained chemical integrity, and improved imaging visibility, confirming its potential use as a biodegradable polymer-based stent material.

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