Biodegradable Polyesters Derived from Citric Acid and Polyols as Versatile Biomaterials for Tissue Engineering

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Abstract

Biodegradable polymers play an essential role in tissue engineering as they provide temporary structural support while gradually resorb in the body, offering an advantage over non-degradable systems. Polyesters are attractive due to hydrolytically cleavable ester bonds, but conventional lactone or lactide thermoplastics often have rigid structures that limit tailoring their overall performance. In contrast, citric acid–based thermosets have gained attention for their low-cost synthesis and structural adaptability. They form multifunctional networks rich in reactive groups, enabling control over degradation as well as mechanical and biological properties. Early generations of polyol–citrates, such as poly(octanediol–citrate) and poly(glycerol–citrate; GCA), have been extensively studied for biomedicine. These materials have been further refined to improve physicochemical and biological properties, resulting in polyesters with enhanced network architecture and broader functionality. Here, we provide an overview of biodegradable polyesters relevant to tissue engineering, focusing on polyol–citrate systems. Recent progress in polyol–citrate design is discussed, highlighting how network modification influences material properties. GCA polyesters are flexible, but still less studied formulations that form hydrophilic networks suitable for further modification. In our study, GCAs were modified via dual crosslinking with tannic acid (TA) and boric acid (B) to evaluate changes in degradation, mechanical performance, and bioresponse. Analytical characterization by spectroscopy, thermal analysis, and mechanical testing indicates that TA and B incorporation alters crosslink density, improves mechanical resilience, and modulates hydrolytic stability. These findings demonstrate the potential of modified citric acid–polyol polyesters as adaptable biomaterials used in tissue engineering applications for drug delivery systems and hybrid polymer/bioceramic bone substitute composites.

Index Terms

Citrate Polyesters, Tissue Engineering, Biodegradation, Mechanical Properties, Antibacterial Activity

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