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Biopolymer Multilayer Structure as a Barrier System for Packaging Paper

The transition to sustainable food packaging has accelerated the development of PFAS-free paper barrier coatings as safer alternatives to fluorinated compounds. However, the influence of multilayer architecture on barrier performance remains poorly understood. This study investigates chitosan–starch–zein multilayer coatings to improve the oil barrier properties of paper. The optimum formulation with 20wt% zein achieved Kit ratings of 6 (C-S-Z20) and 9 (S-C-Z20), dynamic contact angles of $\sim 50^\circ$, and Cobb₆₀ values of 15.20 and 14.70 g/m², respectively. SEM revealed dense, homogeneous multilayer structures, while FTIR showed that enhanced performance resulted from hydrogen-bond interactions. Higher zein contents reduced barrier performance, and increasing coating layers alone did not consistently improve barrier properties, highlighting the importance of optimized composition and microstructural integrity for effective PFAS-free paper barriers.

Keywords: paper coating, biopolymer, chitosan, starch, zein, barrier properties

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1. Introduction

Paper-based materials have attracted increasing attention for food packaging because they are renewable, recyclable, biodegradable, lightweight, and derived from abundant cellulose resources, making them promising alternatives to petroleum-based plastics. However, the inherently hydrophilic and porous structure of cellulose fibres results in poor resistance to water, grease, and gases, limiting the direct use of paper for packaging fatty and high-moisture foods. To overcome these limitations, extensive research conducted focused on developing functional barrier coatings using both synthetic and bio-based materials. Conventional coating systems, including polyethylene, polypropylene, acrylic polymers, waxes, and fluorinated compounds such as per- and polyfluoroalkyl substances (PFAS), have been widely employed because of their excellent water- and grease-barrier properties [1]. Nevertheless, increasing