Area: FIS

Bactericidal Plasma-Functionalized Chitosan Films for Seed Storage in Uncontrolled Conditions

Francisco Alfaro (PQ)[1]*, Claudia Marques da Silva (TC)[1], Cecilia Zorzi Bueno (PQ)[1], Helton José Wiggers (PQ)[1], Diego Mantovani (PQ)[2]

francisco.alfaro@biopark.edu.br; diego.mantovani@ulaval.ca

[1]Laboratory for Biomaterials and Bioengineering (LBB-BPK), Associação de Ensino, Pesquisa e Extensão – Biopark, Toledo, PR, Brazil; [2]Laboratory for Biomaterials and Bioengineering (LBB-ULaval), Division of Regenerative Medicine, Laval University, Quebec, Canada

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Highlights

Plasma functionalization modifies the surface chemistry and performance of chitosan films; Ar+O_2 boosts polarity and bactericidal effect, while N_2 raises nitrogen but favors bacterial survival.

Abstract

Chitosan is a natural polymer whose surface properties can be tailored by plasma treatment to improve antimicrobial performance [1, 2]. In this work, chitosan films were functionalized with argon/oxygen (Ar+O_2) and nitrogen (N_2) plasmas under controlled low-pressure RF conditions. The Ar+O_2 treatment involved sequential exposure to Ar (15 sccm, 42 mTorr, 2 min, 30 W) and O_2 (15 sccm, 40 mTorr, 2 min, 30 W) plasmas, while the N_2 treatment was performed at 45 sccm, 64 mTorr, 4 min, 50 W. The samples were characterized by water contact angle (WCA), scanning electron microscopy (SEM), X-ray photoelectron spectroscopy (XPS), optical emission spectroscopy (OES), and antibacterial assays against seed-associated microorganisms (S. aureus). The results (Table 1) demonstrated that Ar+O_2 plasma increased surface polarity and generated oxygen-rich functionalities, leading to bactericidal effects with up to ~49% reduction compared to untreated controls. In contrast, N_2 plasma increased nitrogen incorporation on the surface but unexpectedly promoted bacterial survival, reaching ~139% higher colony counts than controls.

Table 1. Key physicochemical and biological changes in chitosan films after plasma functionalization.

Samples	WCA (°)	Surface Chemistry (XPS)	Antibacterial Effect
Control	Hydrophobic	Reference	Baseline (0%)
Ar+O_2 Plasma	≈ 37± 6	↑ O-rich groups	≈49% reduction
N_2 Plasma	≈ 42 ± 4	↑ N incorporation	≈139% increase

These findings suggest that polarity and oxidative groups are stronger determinants of bactericidal performance than nitrogen incorporation alone. This study highlights plasma functionalization of chitosan as a promising strategy to engineer biodegradable films for seed storage in uncontrolled conditions, potentially extending shelf-life and reducing microbial contamination.

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