Seminar

Institute for Plasma Research

Title: Plasma Surface Modification of Polyethylene Blend to Control Bacterial Adhesion for Biomedical and Food Packaging Applications

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Abstract

Polyethylene (PE) is one of the most widely used polymeric materials in biomedical devices and food packaging applications due to its chemical stability, flexibility, low cost, and ease of processing [1]. However, its inherently hydrophobic and chemically inert surface promotes bacterial adhesion and subsequent biofilm formation, which can compromise product safety, reduce shelf life, and increase the risk of infections [2].

This study investigates the effects of low-pressure, mid-frequency (40 kHz) capacitively coupled air plasma (CCP) treatment on polyethylene (PE) blends, focusing on plasma-induced physicochemical modifications and its implications on antibacterial performance. Plasma was generated at 3 kV and 0.02 mbar with inter-electrode gaps of 30 mm and 80 mm, plasma exposure times ranging from 1 to 60 minutes. Plasma parameters were estimated using Langmuir probe method and influence of plasma dwell (cooling) time was examined to understand post-treatment surface relaxation. Plasma treatment significantly improved surface wettability, reducing the water contact angle from 100° to 57°. Surface energy modifications were associated with molecular rearrangement during the plasma-off period. FTIR analysis indicated changes in chain branching and LLDPE/LDPE composition, while XRD and DSC confirmed variations in crystallinity, lattice strain, and crystallite size. AFM and FESEM revealed pronounced morphological evolution, including changes in surface roughness and formation of lamellar textures. Importantly, bacterial adhesion decreased by up to 42% after 30 minutes of plasma treatment.

Overall, the results demonstrate a strong correlation between plasma process parameters, surface physicochemical properties, and antibacterial performance, highlighting mid-frequency air plasma as an eco-friendly and cost-effective approach for modifying PE packaging films.

References:

1. Paxton NC, Allenby MC, Lewis PM, Woodruff MA (2019) Biomedical applications of polyethylene. Eur Polym J 118:412–428. https://doi.org/10.1016/j.eurpolymj.2019.05.037

2. Shineh G, Mobaraki M, Perves Bappy MJ, Mills DK (2023) Biofilm Formation, and Related Impacts on Healthcare, Food Processing and Packaging, Industrial Manufacturing, Marine Industries, and Sanitation–A Review. Appl Microbiol 3:629–665. https://doi.org/10.3390/applmicrobiol3030044