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Sustainable Antimicrobial Biopolymeric Food & Biomedical Film Engineering Using Bioactive AMP-Ag+ Formulations

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Abstract : New antimicrobial interventions are urgently required to combat rising global health and medical infection challenges. Here, an innovative antimicrobial technology, providing price competitive alternatives to antibiotics and readily integratable with currently technological systems is presented. Two cutting edge antimicrobial materials, antimicrobial peptides (AMPs) and uncompromised sustained Ag+ action from triangular silver nanoplates (TSNPs) reservoirs, are merged for versatile effective antimicrobial action where current approaches fail. Antimicrobial peptides (AMPs) exist widely in nature and have recently been demonstrated for broad spectrum of activity against bacteria, viruses, and fungi. TSNP's are highly discrete, homogenous and readily functionisable Ag+ nanoreseviors that have a proven amenability for operation within in a wide range of bio-based settings. In a design for advanced antimicrobial sustainable plastics, antimicrobial TSNPs are formulated for processing within biodegradable biopolymers. Histone H5 AMP was selected for its reported strong antimicrobial action and functionalized with the TSNP (AMP-TSNP) in a similar fashion to previously reported TSNP biofunctionalisation methods. A synergy between the propensity of biopolymers for degradation and Ag+ release combined with AMP activity provides a novel mechanism for the sustained antimicrobial action of biopolymeric thin films. Nanoplates are transferred from aqueous phase to an organic solvent in order to facilitate integration within hydrophobic polymers. Extrusion is used in combination with calendering rolls to create thin polymerc film where the nanoplates are embedded onto the surface. The resultant antibacterial functional films are suitable to be adapted for food packing and biomedical applications. TSNP synthesis were synthesized by adapting a previously reported seed mediated approach. TSNP synthesis was scaled up for litre scale batch production and subsequently concentrated to 43 ppm using thermally controlled H2O removal. Nanoplates were transferred from aqueous phase to an organic solvent in order to facilitate integration within hydrophobic polymers. This was acomplised by functionalizing the TSNP with thiol terminated polyethylene glycol and using centrifugal force to transfer them to chloroform. Polycaprolactone (PCL) and Polylactic acid (PLA) were individually processed through extrusion, TSNP and AMP-TSNP solutions were sprayed onto the polymer immediately after exiting the dye. Calendering rolls were used to disperse and incorporate TSNP and TSNP-AMP onto the surface of the extruded films. Observation of the characteristic blue colour confirms the integrity of the TSNP within the films. Antimicrobial tests were performed by incubating Gram + and Gram – strains with treated and non-treated films, to evaluate if bacterial growth was reduced due to the presence of the TSNP. The resulting films successfully incorporated TSNP and AMP-TSNP. Reduced bacterial growth was observed for both Gram + and Gram – strains for both TSNP and AMP-TSNP compared with untreated films indicating antimicrobial action. The largest growth reduction was observed for AMP-TSNP treated films demonstrating the additional antimicrobial activity due to the presence of the AMPs. The potential of this technology to impede bacterial activity in food industry and medical surfaces will forge new confidence in the battle against antibiotic resistant bacteria, serving to greatly inhibit infections and facilitate patient recovery.

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