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Release Kinetic Models of Vanillin and Physicomechanical Properties of Thermoplastic Starch and Chitosan Nanocomposite Films: Effects of Mixing Order

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Release Kinetic Models of Vanillin and Physicomechanical Properties of Thermoplastic Starch and Chitosan Nanocomposite

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Abstract

The effects of mixing sequence of starch–chitosan nanocomposite films on antimicrobial properties of vanillin, the release kinetics of vanillin, and physicomechanical changes of films have been reported. Four types of films were prepared based on the order of mixing. SC1: starch–glycerol–MMT–vanillin; SC2: starch–glycerol–chitosan–MMT–vanillin; SC3: starch–MMT–glycerol–vanillin–chitosan and SC4: starch–chitosan–glycerol–vanillin–MMT. All formulation exhibited high antimicrobial activity against E. coli, S. enterica, and Z. bailii, except P. aeruginosa, which showed lower sensitivity. Migration dynamics of vanillin from films into simulants showed high vanillin migrated into water and 10% ethanol at 25 and 40 °C as analyzed by high-performance liquid chromatography (HPLC). The diffusion coefficients of vanillin in water ranged between $0.38 \times 10{-}13m2\ s{-}1$ and $4.30 \times 10{-}13m2\ s{-}1$ and in 10% ethanol between $1.38 \times 10{-}13m2\ s{-}1$ and $5.16 \times 10{-}13m2\ s{-}1$ following the Fickian diffusion mechanism and first-order kinetics. The diffusion was temperature-dependent following the Arrhenius equation with high activation energies of 15.00–52.80 kJmol−1 in water and 35.80–56.50 kJ mol−1 in 10% ethanol. The plot of the mass fraction of $mt/m\infty$ against time for each sample shows the burst release of vanillin in between 30 min and 1 h and then attained the steady-state migration over 48 h. The plasticization effect of vanillin reduced the tensile strength and elastic modulus of films, while it increased the elongation at the break by 154% that was reversed after the addition of chitosan. These nanostructured starch films showed promising applications in the antimicrobial packaging industry

Keywords

Antimicrobial, Bioplastic, Food packaging, Migration, Montmorillonite, Nanostructured