Title Utilization of chlorine dioxide gas in food packaging application

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Abstract

Chlorine dioxide (ClO_2) in its gaseous form has been used in numerous studies for vapor-phase decontamination, both in treating produce before packaging, and decontaminating the products inside their packages. Yet, very little is known about its compatibilities with packaging materials or its performance as affected by food packaging systems. The overall goal of this dissertation was to evaluate potential use of ClO_2 gas as an antimicrobial agent for food packaging applications.

In the first study, mass transfer profiles (permeability, solubility and diffusion coefficients) of ClO_2 for 10 types of polymeric packaging materials were determined by an isostatic method using a continuous system for measuring ClO_2 concentration with an electrochemical sensor as a detector. Overall, PET, PLA, BOPP, nylon, and multilayer of EVA/EVOH/EVA had high ClO_2 barrier, while PS, LLDPE, LDPE, HDPE, and PVC provided low barrier to ClO_2. Effects of gaseous ClO_2 on physical, mechanical, chemical, and barrier properties of polymeric packaging materials were then studied by exposing selected materials to ClO_2 gas. After 14 days of exposure, significant changes, such as increases in barriers to O_2 and CO_2 of nylon, changes in permselectivity (P_{CO2}/P_{O2}) ratio of up to 46.8% in treated PE, PS, PET, and nylon films, and changes in FT-IR spectra of PET, PLA, and EVA/EVOH/EVA, indicate possible changes in chemical profiles and performance of the materials.

Study on influences of packaging design on antimicrobial effect of ClO_2 gas, on shredded Romaine lettuce, indicated that minimizing the distance between gas releasing location and target surfaces, as well as, maximizing the area of gas release could significantly improve antimicrobial activity of ClO_2 gas in particular packaging system. Once the interior of the package was optimized, it was observed that the amount of ClO_2 used per package could be reduced to half of its original concentration (from 8 to 4 mgClO_2 /kg lettuce per day), while still achieving the same level of $\log_{10}$ CFU reduction of *Escherichia coli* O157:H7 in packaged shredded lettuce.

When in contact with food, ClO_2 gas will decontaminate the surfaces, as well as being absorbed by the product. The latter amount could not be accounted for its antimicrobial capacity. Study on absorption behavior of Romaine lettuce showed that increasing ClO_2 level and/or time of exposure

increased residual ClO_2 and chlorite (ClO_2^-) recovered from Romaine lettuce sample. The presence of cuts significantly increased the amount of ClO_2 consumed, while exceed water did not increase ClO_2 absorption by lettuce.

This research approach could be of great importance when considering antimicrobial packaging with ClO_2 gas as a safety measure. Information generated could also be used to generate parameters for computational modeling of packaging systems.