DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

PhD Public Defence

Title: Photocatalytic Degradation of Plant-Generated Ethylene over Titanium Dioxide Thin Films: Kinetic Modelling and Photoreactor Design

Location: Online defence – see link on event page

Time: Monday 4 May 2020 at 13.00

PhD defendant: Rodica Elisabeta Stroe

Supervisor: Professor Lasse Rosendahl

Moderator: Professor Søren Knudsen Kær

Opponents: Associate Professor Thomas Condra, Dept. of Energy Technology, Aalborg University (Chairman)
Professor Bengt Andersson, Chalmers University of Technology, Sweden
Professor Dr.ir. Philippe Heynderickx, Ghent University, Incheon Global Campus, Korea

All are welcome. The defence will be in English.

DUE TO THE CURRENT CIRCUMSTANCE, THE DEFENCE WILL BE CARRIED OUT ONLINE.

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Abstract:

This thesis addressed the possibility of employing the UV-A-mediated oxidation of volatile organic compounds (VOCs) over titanium dioxide (TiO2) thin films for controlling the levels of ethylene (C2H4) in the postharvest industry. An intrinsic hormone of fruits, vegetables and flowers, C2H4 can quickly shift to being a pollutant, as its presence in concentrations above a certain threshold accelerates their degradation. Thus, it possesses the ability of minimizing their shelf life and substantially contributing to food loss and waste. The photocatalytic degradation of C2H4 over TiO2 thin films has been kinetically studied and a photoreactor has been designed and investigated for oxidizing low levels of C2H4.

The postharvest industry being the main target, case studies have been set up in the form of measurement campaigns conducted in both a typical Danish storage facility and a transportation truck, where fresh produce were stored and transported, respectively. Data collected showed that C2H4 concentrations range from 0.5 to 1.5 ppm, values dictated by types of stored commodities, working shifts and amount of produce. Research studies have shown that C2H4 sensitivity levels, although commodity-specific, are high for the majority of perishables, resulting in degradation signs even at C2H4 levels as low as 0.01 ppm. Thus, it can be concluded, based on the measurement campaigns, that controlling C2H4 in the final stages of the cold chain can prolong the shelf life of fresh produce and flowers. In addition, these campaigns set a good baseline for subsequent kinetic studies and photoreactor design.

Several substrate candidates with different TiO2 coating thicknesses were evaluated in terms of photocatalytic activity, while observing the resulted morphological structure, with the purpose of selecting the appropriate catalyst for oxidizing C2H4. A kinetic analysis was carried out experimentally in a batch reactor, deriving kinetic parameters, which enabled the implementation of the reaction in a Computational Fluid Dynamics (CFD) simulation. Moreover, it was desired to couple the kinetics to the species and radiation transport. Therefore, the reaction was monitored under varying conditions of C2H4 concentration and incident surface radiation.

Reactor design options were discussed and design criteria were decided upon, focusing on enhancing the conversion through maximizing radiation distribution and the contact of pollutant species with active surfaces via turbulent mixing. A full-scale 3D CAD model is presented. This was employed for two purposes: manufacturing the prototype of the reactor and conducting parametric studies through CFD. A comprehensive model was set up, including fluid flow under turbulent regime, species transport with surface reaction and radiation transport. The simulation case studies were compared in terms of turbulent mixing, radiation distribution, residence time and conversion.