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Treatment of Polymeric Wastewater by Advanced Oxidation Process

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Outline

- ❑ Introduction
- ❑ Motivations and Objectives
- ❑ Experimental Setups and Procedures
- ❑ Results and Discussion
- ❑ Conclusions

Introduction

Water-Soluble Polymers: PVA, PAA, PEG, PAM,….

Synthetic polymers that can dissolve, disperse or swell in water.

➢ Large scale production (over 3,700,000 ton/year)

➢Wide spectrum of applications

Introduction

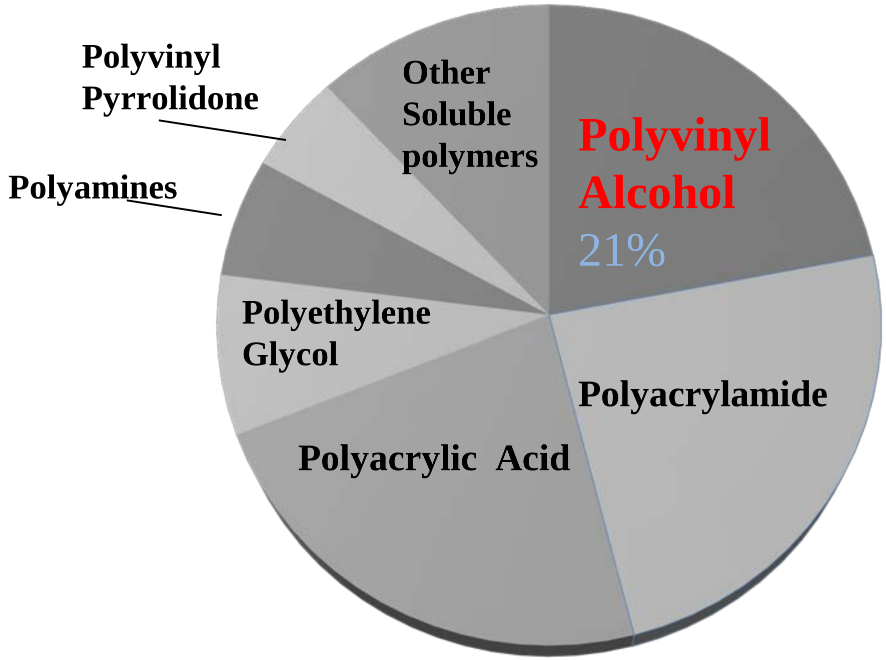


Fig. 1. World Consumption of Water-Soluble Polymers

Table 1. Applications of Water-Soluble Polymers

Polymer MW (g/mol)	Applications
< 10,000	Detergents, pigment dispersants and emulsifiers
10,000 - 100,000	Dissolvable Laundry packages
100,000 - 1,000,000	Thickeners, flocculants, sizing agent
> 1,000,000	Superabsorbent, liquid crystal displays (LCDs

PVA:
Global production of 775,000 tons/year

Problem Definition

- Generation of considerable amounts of PVA-containing wastewater: production, use, and disposal
- Released into the aqueous environment
- Hard to recover for recycle (low concentration) ➔ Degradation
- Non-biodegradable PVA polymer ➔ resistance to biological treatment processes.

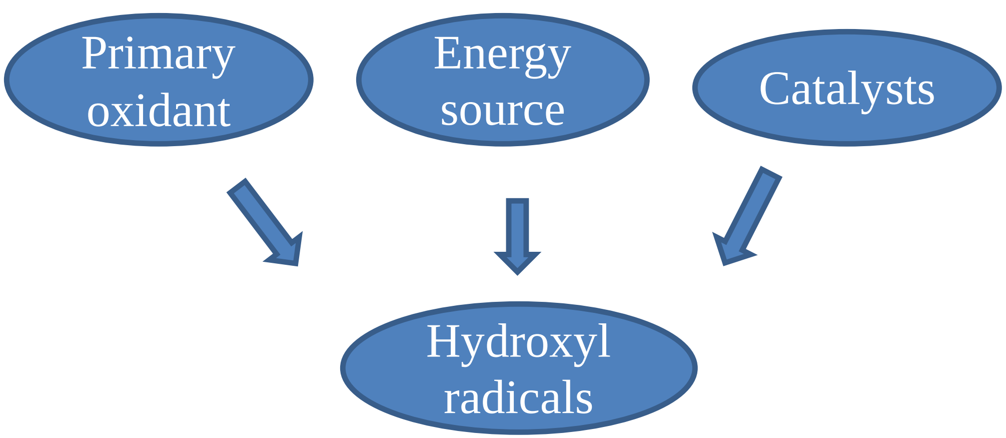
PVA is a non-toxic compound

- Negative influence on micro-organisms
- Support foam formation
- Decrease the transport of oxygen into water

Advanced Oxidation Process (AOPs)

Powerful technologies to transform organic contaminants into water and carbon dioxide

- ❑ Formation of hydroxyl radicals (strong oxidants)
- ❑ Reaction of these radicals with polymers soluble in water



Research Motivations

- The impact of non-sustainable wastewater treatment will extend beyond its immediate operational vicinity and even into future generations.

- The H_2O_2 residuals are found to be toxic to microorganisms. Therefore, there is an urgent need to control the H_2O_2 concentration in the effluent.

- Expert knowledge is required to establish the relationships between the process conditions and treated effluent solution.

Research Objectives

1. Design a sustainable AOP treatment process that encourage "zero-discharge".
2. Investigate the performance of photoreactors to determine feasibility and limitations of the existing UV/H_2O_2 process.
3. Design MPC controller for PVA degradation process.
4. Assess the behavior of the process when dealing with process uncertainty such as set-point changes and disturbances.
5. Improve the effluent quality by maintaining the TOC and the residual H_2O_2 below the defined limits.

Laboratory View of the Experimental Setup

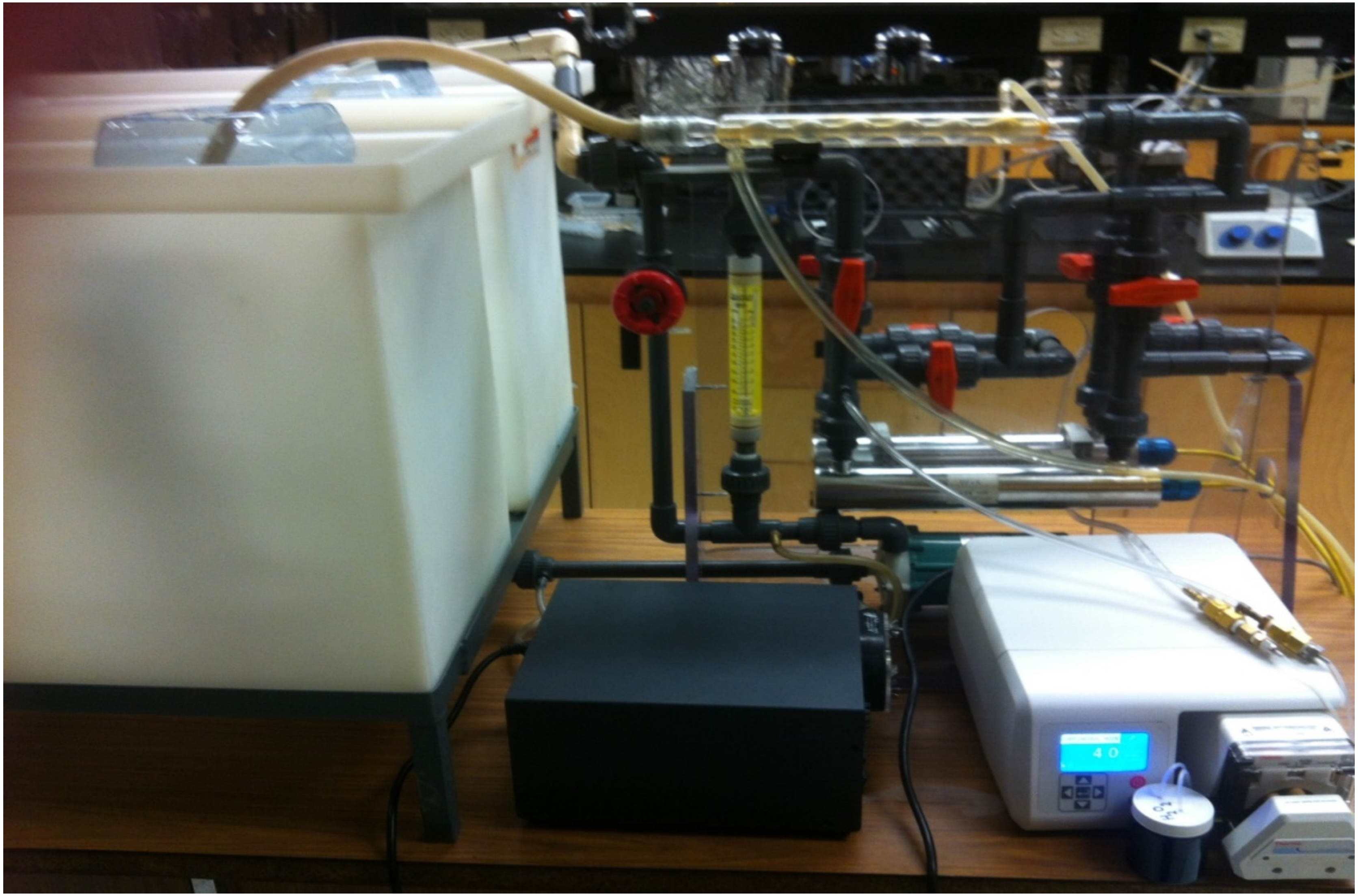


Fig. 2. Laboratory View of the Experimental Setup

UV/H_2O_2 Process Control Overview

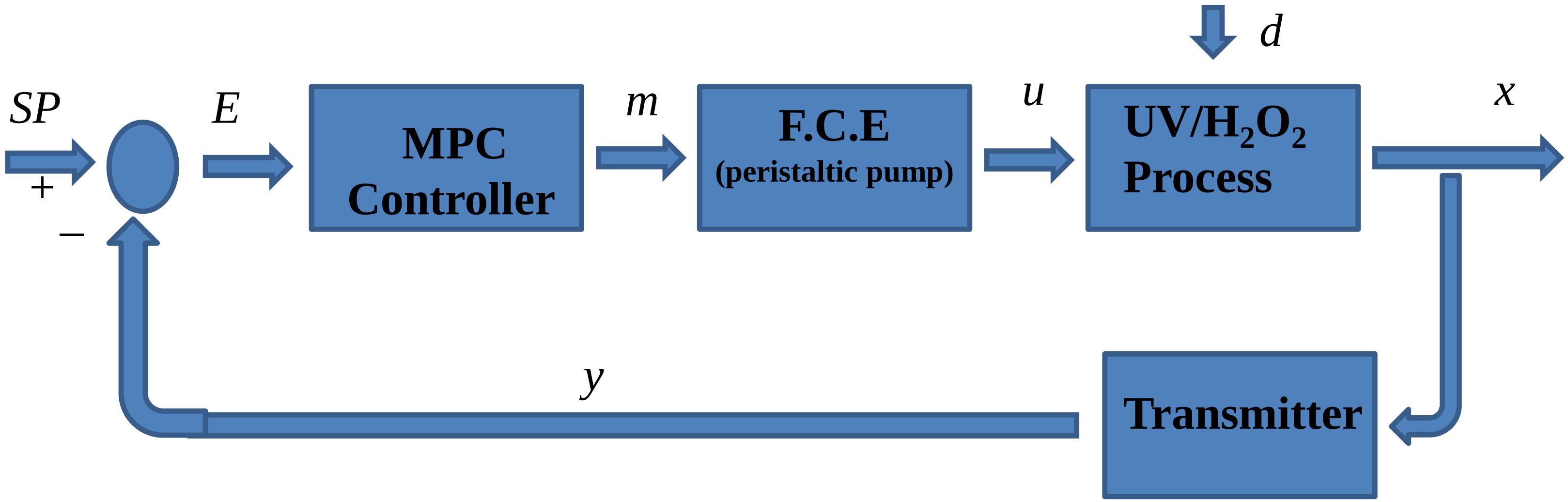
- ❑ AOP is a MIMO system - multivariable process with several inputs and outputs
- ❑ Noisy measurements
- ❑ Highly unpredictable process disturbances
- ❑ Variability of the influent
- ❑ Pairing each input to output constitute a configuration of a control loop
- ❑ Interaction is a major challenge for designing a control system

Dynamic Photreactor Model

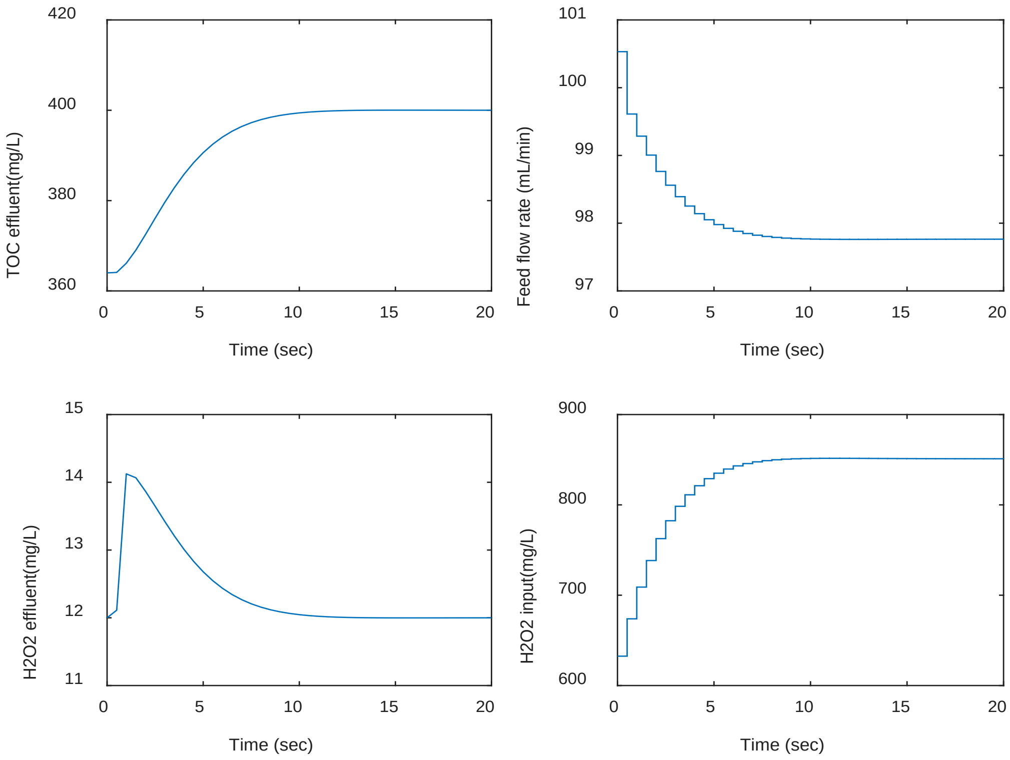
$$\begin{bmatrix} y_1 \\ y_2 \end{bmatrix} = \begin{bmatrix} \dfrac{0.436e^{-0.5s}}{0.733s+1} & \dfrac{0.139e^{-0.5s}}{1.433s+1} \\ \dfrac{7.02e^{-0.5s}}{1.117s+1} & \dfrac{0.059e^{-0.5s}}{1.367s+1} \end{bmatrix} \cdot \begin{bmatrix} u_1 \\ u_2 \end{bmatrix} + \begin{bmatrix} \dfrac{0.417e^{-0.5s}}{0.95s+1} \\ \dfrac{-0.585}{0.7833s+1} \end{bmatrix} u_3$$

Closed Loop UV/ H_2O_2 System

Adjustment of the manipulated variable - process variable is maintained at a desired value (set point) in spite of unpredicted disturbances.



Model predictive control loop of a photoreactor



Process response to a 10% set point change in **TOC effluent** (+36mg/L). Unconstrained control Weighted uwt=[0.1 0.5]

Concluding Remarks

- UV/H_2O_2 process is experimentally proven to be a powerful technique for treatment of polymeric wastewater.
- MPC multivariable controller is able to handle process interactions and produced good performance for tracking set point changes.
- AOP process has potential in contributing to sustainability as they rely on less-energy and consume less chemicals.

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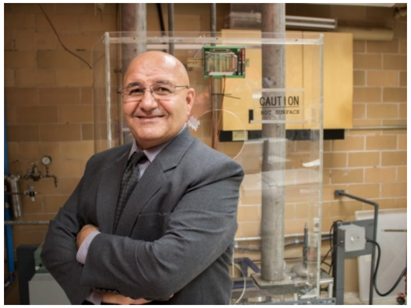
Professor, Chemical Engineering



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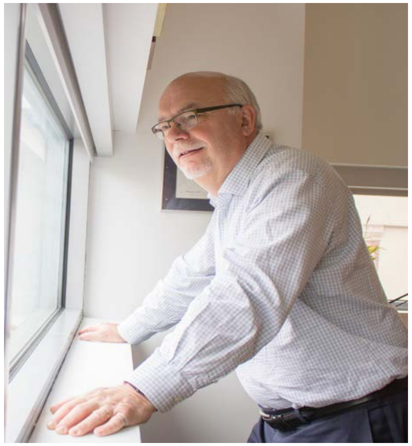

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Thank You.