Dynamic Modeling by Identification Technique of PVA Solution Degradation in a Tubular Photochemical Reactor

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INTRODUCTION

- Many polymeric compounds that are found in wastewater effluents are toxic for the environment and the aquatic life's.
- New compounds are being introduced to the environment, as a result of new advancements and new manufacturing technologies.
- Polymers with a molecular weight higher than 100.0 Kg/mol are not biodegradable.
- The challenges in depolymerisation of wastewater are summarized in two points:-

1- The level of conversion that the process would achieve (% TOC removal).
2- The economic feasibility to establish a large pilot scale that efficiently treat the wastewater that possess polymers, pharmaceuticals and other toxic compounds.

WATER SOLUBLE-POLYMERS

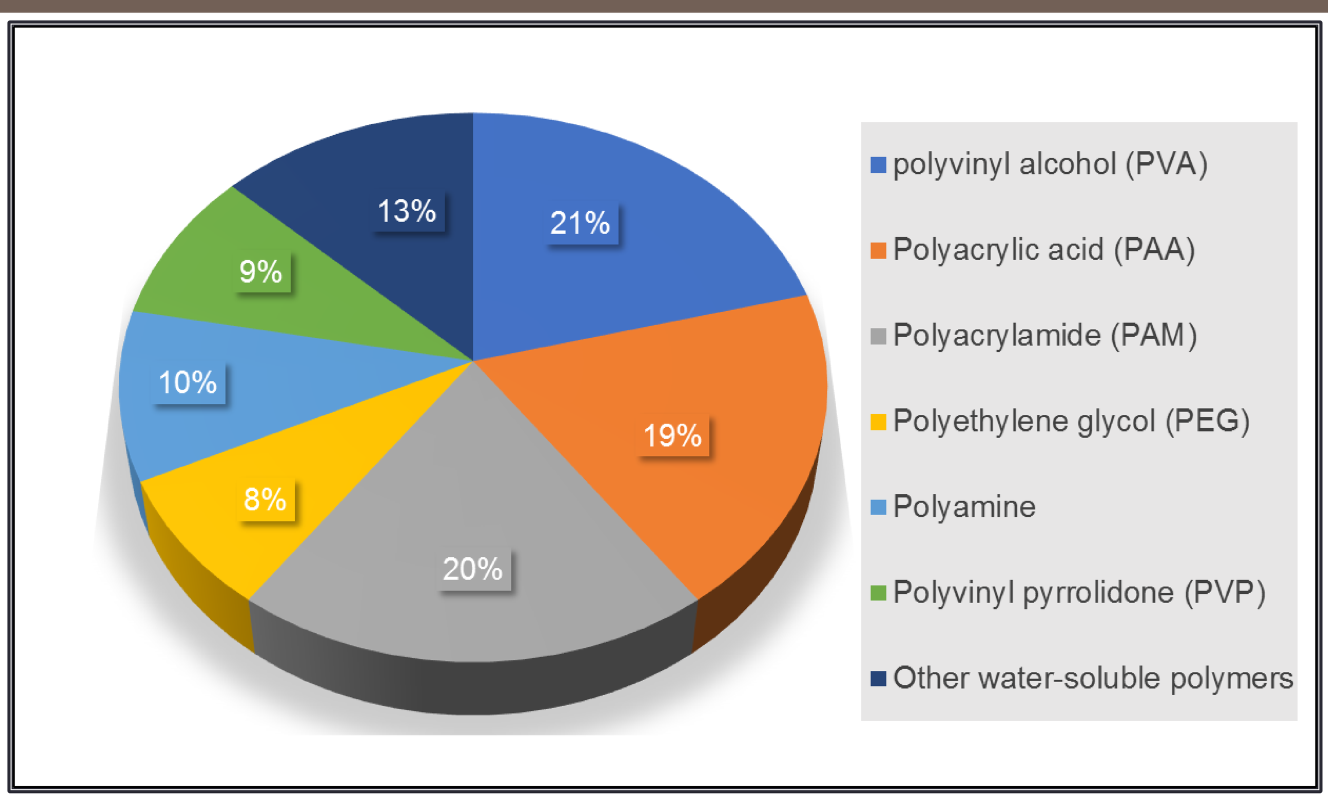


Figure (1) : Water soluble-polymers

PVA DEGRADATION PROCESS

- The hydroxyl radicals produced from the following equation:

$$H_2O_2 \xrightarrow{\text{UV light}} 2OH^{\blacksquare}$$

- The hydroxyl radicals, attacks the PVA bonds and break the polymer into smaller chunks of molecules with lower molecular weights.

$$PVA + H_2O_2 + UV\ light \rightarrow H_2O + CO_2$$

- The hydrogen peroxide is pumped through a rubber tubing towards the entrance of the photochemical tubular reactor where it mixes with the incoming PVA polymeric solution.
- The UV light 252 nm wave length with a 14 W input power, brakes down the hydrogen peroxide oxidizer to hydroxyl radicals.

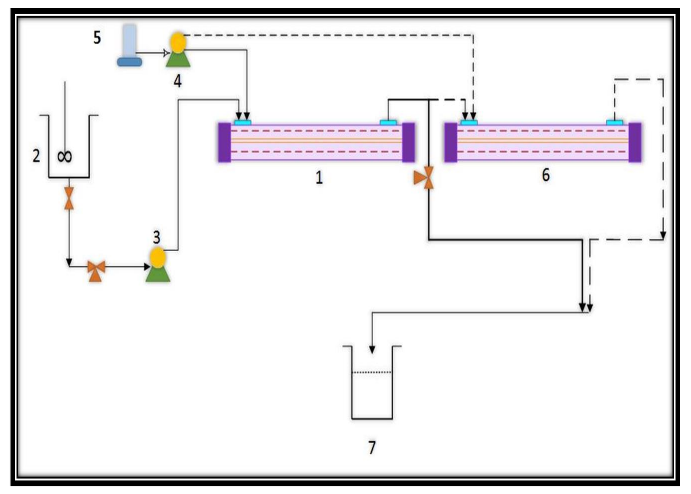
REFERENCES

1. Hamad, D. (2015). Experimental Investigation of Polyvinyl Alcohol Degradation in UV/H2O2 Photochemical Reactors Using Different Hydrogen Peroxide Feeding Strategies. 210. Toronto, Canada.

2. Hamad, D., Dhib, R., & Mehrvar, M. (2016). Photochemical Degradation of Aqueous Polyvinyl Alcohol in a Continuous UV/H2O2 Process : Experimental and Statistical Analysis. J Polym Environ, 24, 72-83.

4. Munter, R. (n.d.). Industrial Waste Water Treatment.

REACTOR SETUP



1. Photochemical reactor #1.
2. PVA solution Polymeric wastewater influent tank.
3. PVA low volumetric flow rate pump
4. H_2O_2 pump.
5. H_2O_2 Jar
6. Photochemical reactor # 2.
7. Effluent tank.

Figure (2): UV/H_2O_2 polymeric (PVA), wastewater experimental setup.

PROJECT OBJECTIVES

1- Dynamically model the UV/H_2O_2 , photochemical reactor degrading PVA, using step-change testing.

2- Cover all the possible non-linear regions of the process, and find the corresponding transfer functions of each nonlinear block.

3- Design a controller to monitor the effluent pH.

4- Control variable to be the H_2O_2 flow rate into the photochemical reactor.

EXPERIMENTAL METHOD

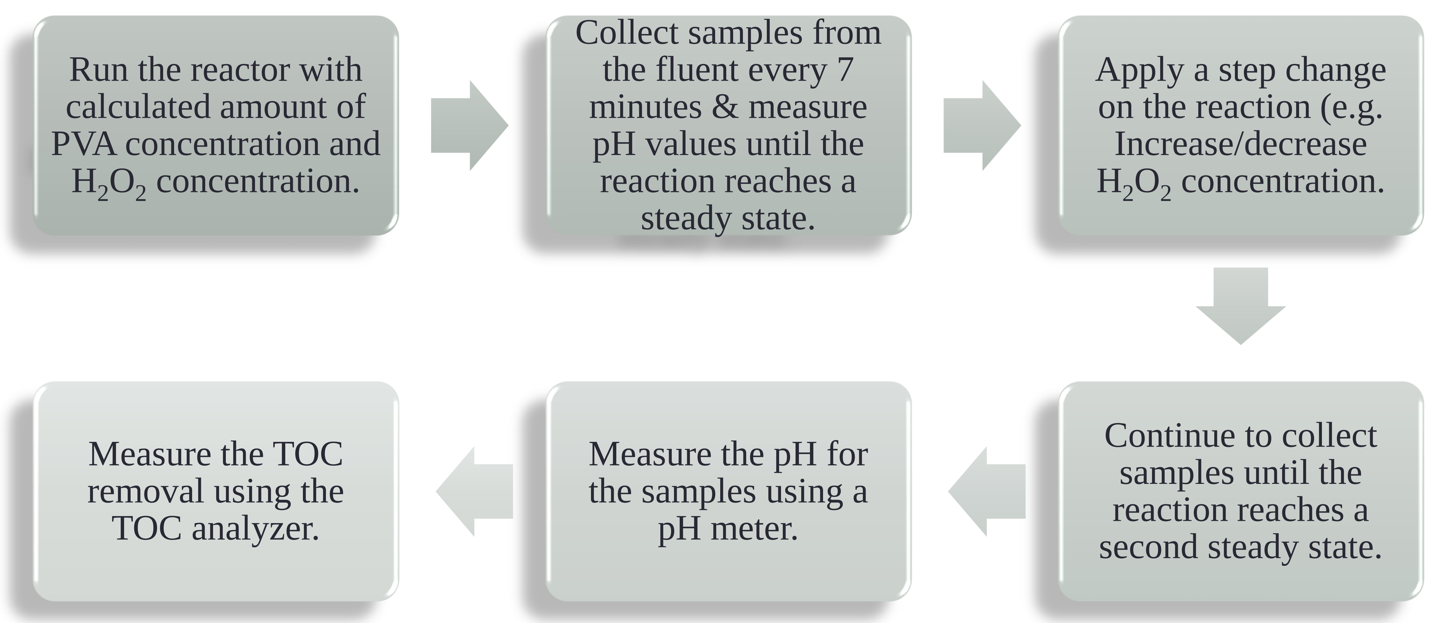


Figure (3) : Overview of procedure

ACKNOWLEDGEMENT

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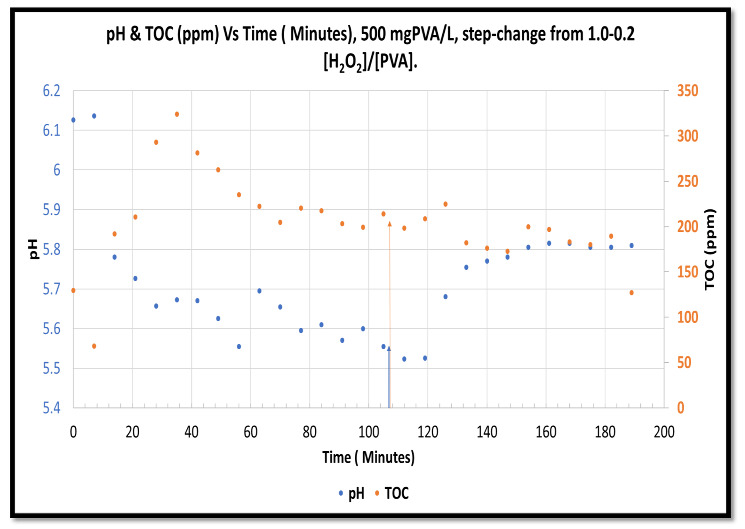
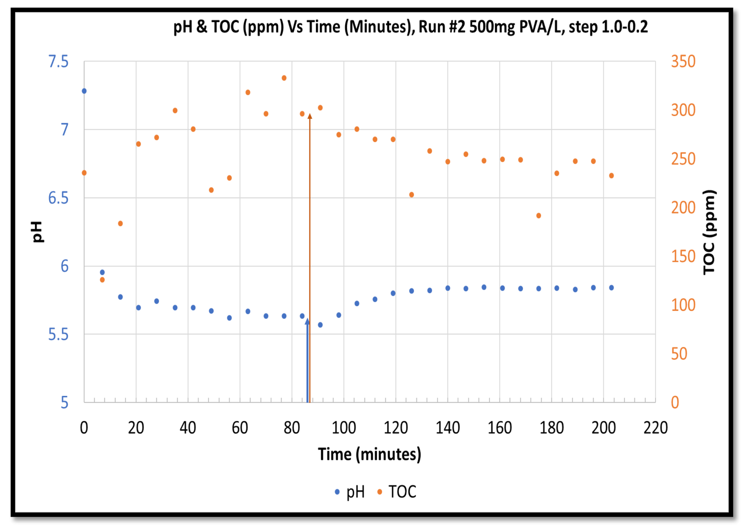
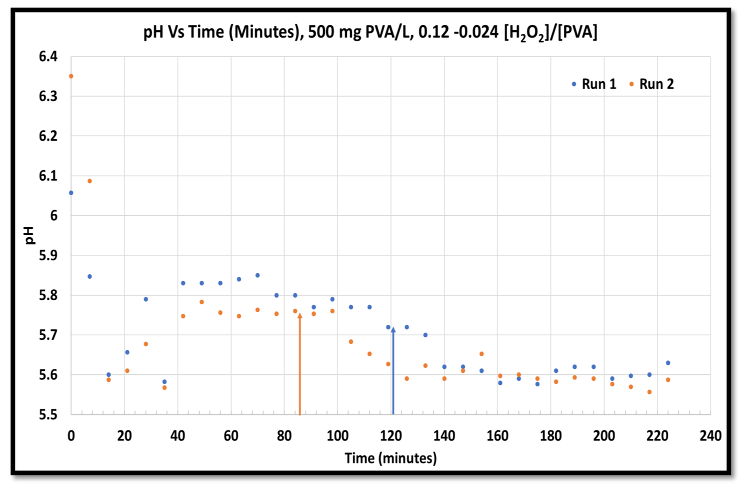
RESULTS



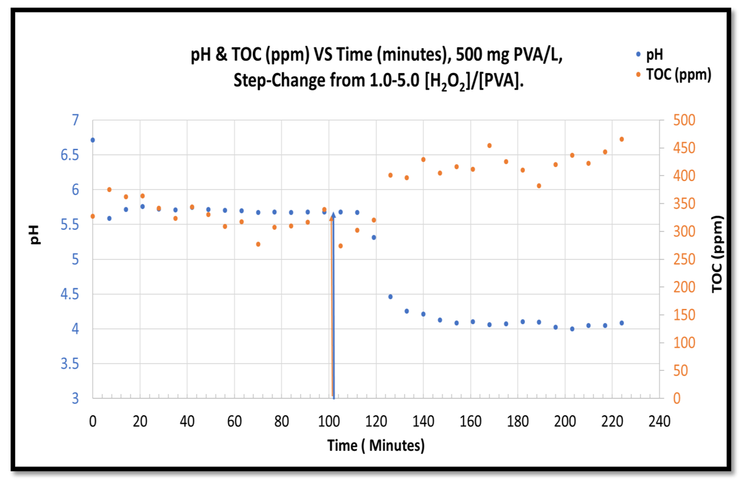
Plot (1) : Run (1), pH and TOC (ppm) Vs Time (Minutes). Step change from 1.0 to 0.2 [H_2O_2]/[PVA] for 500 mg PVA/L



Plot (2) : Run (2), pH and TOC (ppm) Vs Time (Minutes). Step change from 1.0 to 0.2 [H_2O_2]/[PVA] for 500 mg PVA/L



Plot (3) : Run (1) & (2), pH Vs Time (Minutes). Step change from 0.12 to 0.024 [H_2O_2]/[PVA] for 500 mg PVA/L.



Plot (4) : pH and TOC (ppm) Vs Time (Minutes). Step change from 1.0 to 5.0 [H_2O_2]/[PVA] for 500 mg PVA/L

- It is apparent, from the data collected in plot (1) and (2),, that a relationship between effluent pH of the PVA treated solution and measured TOC exists.
- As effluent pH approaches neutral value, 7.0, the highest TOC removal is achieved.
- Step-change was done on the system, at minutes 107 in run (1) corresponding to plot (1), and minute 86.0 in run (2) corresponding to plot(2).
- In plot (1) and (2), Step change from 1.0 to 0.2 [H_2O_2]/[PVA], 500 mg PVA/L, results in an increase in pH of the effluent approaching neutral pH value of 7.0 and an increase in the TOC removal of the process, on the other hand a step change of 0.12 to 0.024 [H_2O_2]/[PVA], results in a decrease in the pH effluent an a probable decrease in the TOC removal as it is apparent in plot (4).
- The scavenging affect of hydrogen peroxide in the reaction is apparent in plot (4), as the concentration of H_2O_2 is increased by a factor of 5, the TOC removal decreases and the pH values of the effluent samples decreases towards a pH value of 4.0

CONCLUSION

1- To properly control a UV/H_2O_2 depolymerization process, a thorough understanding of all possible transfer functions of process is required.

2- A dynamic experimental modeling of a the photochemical process, is an efficient tool to control an advanced oxidation process.

3- Once a process is dynamically modeled, a proper PID, PI or other suitable controllers may be designed to achieve high PVA degradation, high TOC removal and neutral effluent pH.