2019「中技社科技獎學金」

2019 CTCI Foundation Science and Technology Scholarship

境外生生活助學金

Living Grant for International Graduate Students

Highly efficient isopropyl alcohol removal by microwave-induced catalytic oxidation process

Tran Thi Phuong Quynh and Hsin-Hsin Tung*

Graduate Institute of Environmental Engineering, National Taiwan University, Taipei, Taiwan

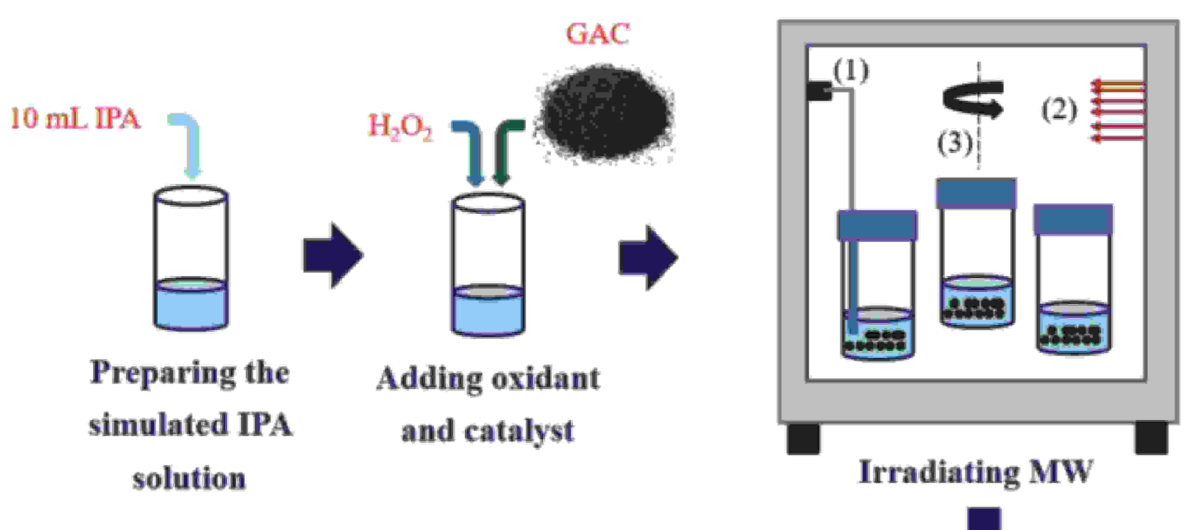
*Corresponding author. E-mail address: htung@ntu.edu.tw

ABSTRACT

Isopropyl alcohol (IPA) is a common waste solvent from semiconductor and optoelectronic manufacturing industries. The current study assesses the feasibility of microwave-induced catalytic oxidation process for synthetic IPA wastewater. The effect of three independent variables, including oxidant (hydrogen peroxide), initial IPA concentration, and dosage of catalyst (granular activated carbon, GAC) on the IPA removal efficiency, were investigated and optimized by response surface methodology (RSM) based on central composite design (CCD). The estimated optimal working conditions were as follows: $[H_2O_2] < 0.132$ M, GAC dosage = 108–123 g/L, and initial [IPA] = 0.038–0.10 M. The findings indicated that the dosage of GAC and the initial IPA concentration strongly affected the overall IPA removal. The values of $R^2 = 0.9948$ and adjusted $R^2 = 0.9901$ demonstrated that the response variability could be explained by the model expressing a satisfactory quadratic fit. Finally, the H_2O_2/GAC/MW process showed a faster and higher IPA removal rate than other processes tested.

MATERIALS AND METHODS

a) Experimental procedure



Note: (1) direct sensor for temperature and pressure
(2) MW generator
(3) high pressure rotor

b) Experimental range and levels of independent variables

Independent variables	Code	Real values of the coded levels				
		−1.682	−1	0	+1	+1.682
Concentration of H_2O_2 (M)	X_1	0.132	0.2	0.3	0.4	0.468
Dosage of GAC (g/L)	X_2	39.54	60	90	120	140.46
Concentration of IPA (M)	X_3	0.038	0.18	0.39	0.60	0.743

RESULTS

1) RSM model construction

Table 1. Design matrix by CCD, and the actual and predicted percentage TOC degradation for response surface quadratic model

Run number	Actual levels			TOC removal (%)	
	$[H_2O_2]_0$ (M)	GAC dosage (g/L)	$[IPA]_0$ (M)	Observed	Predicted
1	0.2	60	0.18	63.18	64.69
2	0.4	60	0.18	58.74	61.14
3	0.2	120	0.18	84.83	90.29
4	0.2	60	0.60	45.69	46.15
5	0.4	120	0.18	81.16	86.87
6	0.4	60	0.60	41.57	42.28
7	0.2	120	0.60	62.87	66.64
8	0.4	120	0.60	58.24	62.90
9	0.132	90	0.39	65.34	69.60
10	0.468	90	0.39	60.55	63.47
11	0.3	39.54	0.39	39.39	39.91
12	0.3	140.46	0.39	70.18	78.77
13	0.3	90	0.038	85.17	87.14
14	0.3	90	0.743	46.29	51.49
15	0.3	90	0.39	61.54	64.43
16	0.3	90	0.39	60.89	64.43
17	0.3	90	0.39	61.34	64.43
18	0.3	90	0.39	61.58	64.43
19	0.3	90	0.39	62.11	64.43
20	0.3	90	0.39	60.75	64.43

Second-order polynomial equation:

$$Y\% = 44.213 - 62.407X_1 + 0.821X_2 - 62.001X_3 + 0.011X_1X_2 - 3.810X_1X_3 - 0.203X_2X_3 + 74.439X_1^2 - 0.002X_2^2 + 39.495X_3^2$$

2) Influences of the selected variables and their interactions

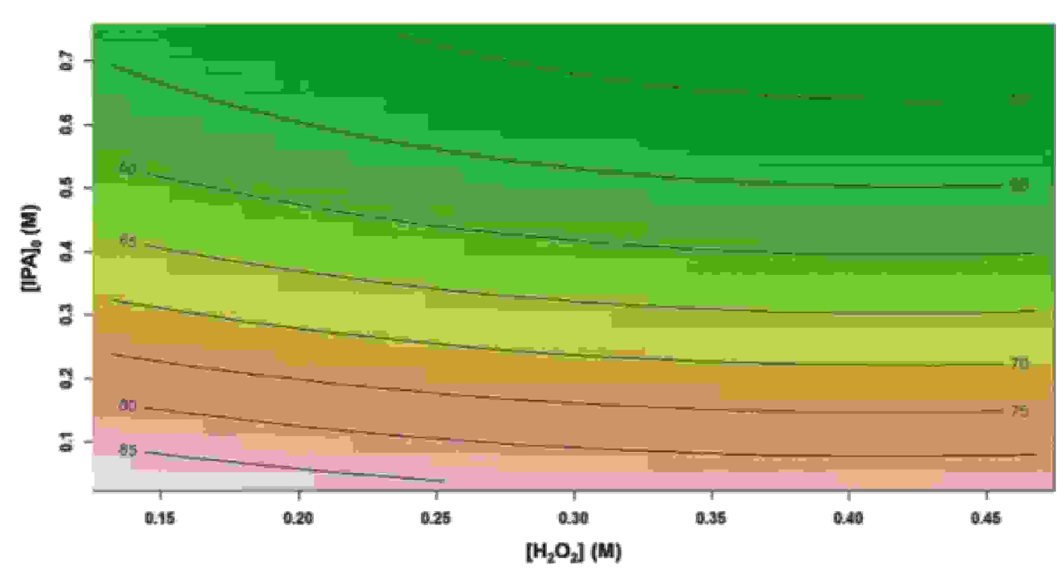


Figure 1. Influence of H_2O_2 and initial IPA concentration on TOC removal. The dosage of GAC was kept at 90 g/L

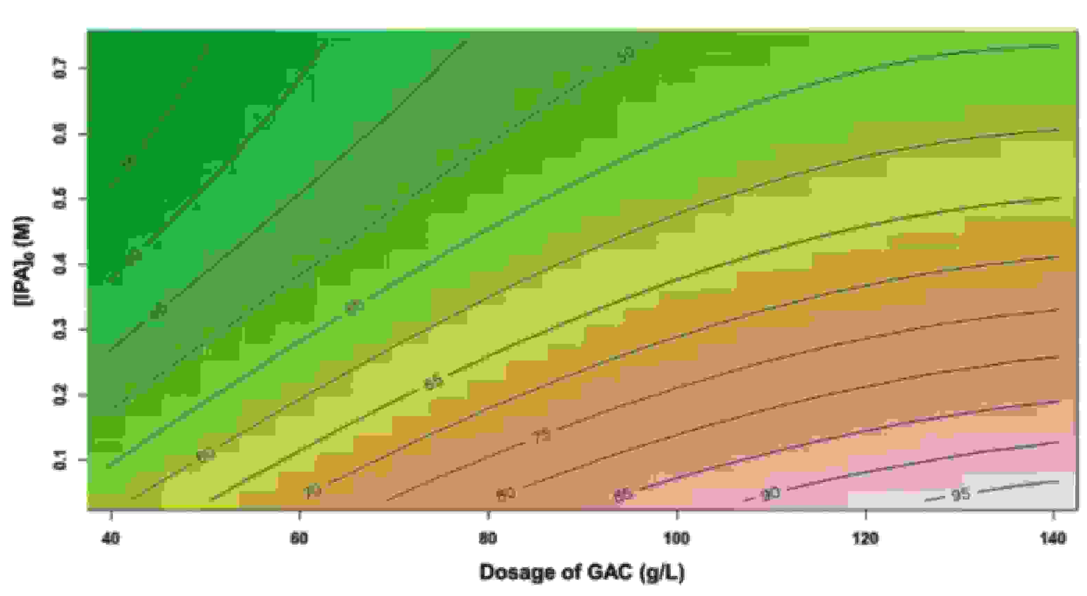


Figure 2. Influence of GAC dosage and initial IPA concentration on TOC removal. The concentration of H_2O_2 was kept at 0.3 M

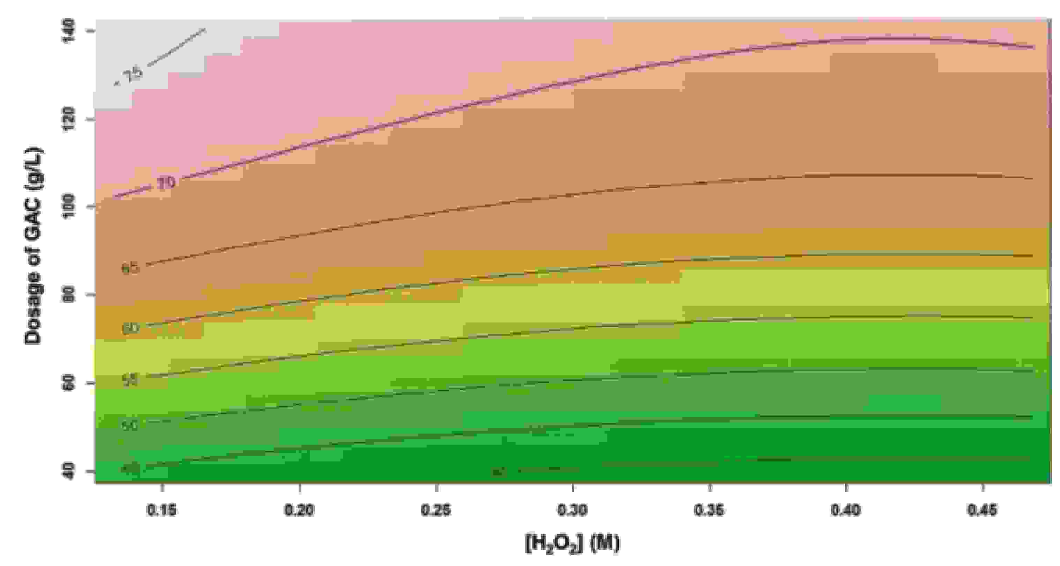


Figure 3. Influence of H_2O_2 concentration and GAC dosage on TOC removal. Initial concentration of IPA was kept at 0.39 M

3) Comparison of different treatment processes on TOC removal

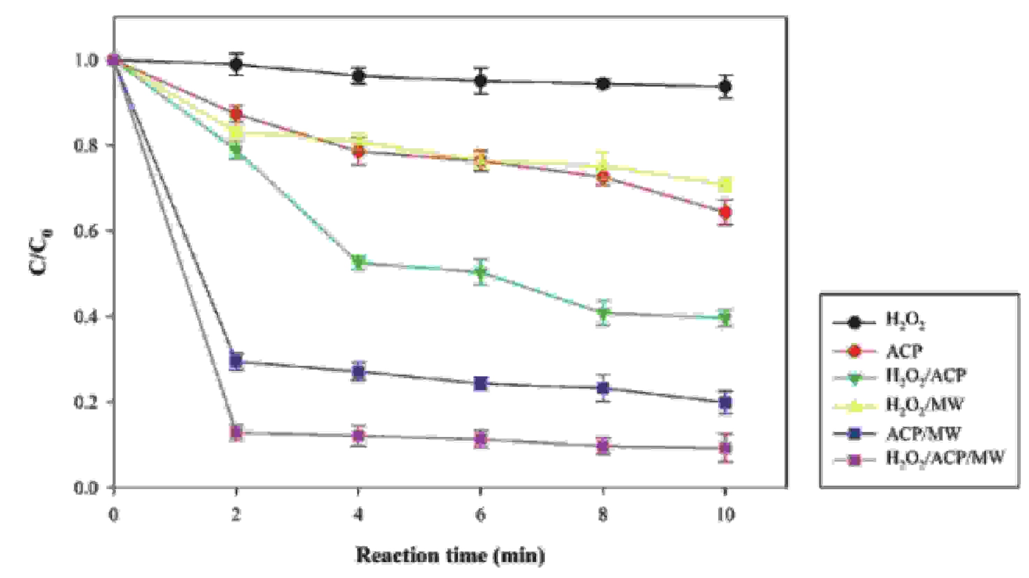


Figure 4. TOC removal by different treatment processes. Operational conditions: $[IPA]_0 = 0.038$ M, $[H_2O_2] = 0.132$ M, $Q_{GAC} = 108$ g/L

3) Mechanism of IPA degradation

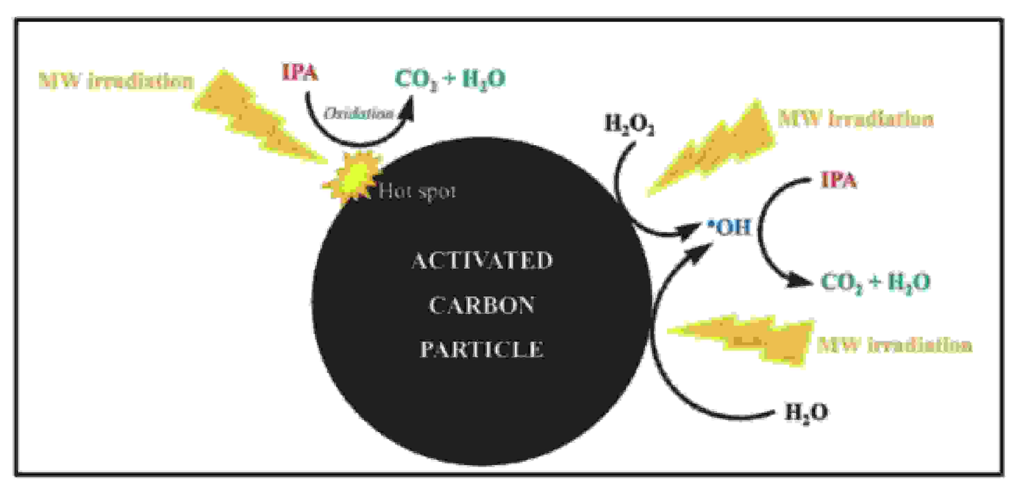


Figure 5. A proposed mechanism of IPA degradation in H_2O_2/GAC/MW combined process

CONCLUSIONS

- TOC removal rate ↑ as the dosage of GAC ↑ and $[IPA]_0$ ↓. In addition, an excess of H_2O_2 has a negative effect on TOC removal.
- The TOC removal efficiency reached 84.9% under optimal conditions with GAC dosage of 120 g/L, H_2O_2 dosage of 0.3 M, and initial IPA concentration of 0.13 M.

財團法人中技社

CTCI FOUNDATION