

**Testing of a Photo-electrochemical (PEC) Air Purifier for
Destruction of
Volatile Organic Compounds (VOCs)**

Final Report

Submitted to:

Lovely Goswami
Transformair, LLC
3802 Spectrum Blvd.
Suite 143
Tampa, FL 33612

Submitted by:

Bernard Olson, Ph. D.
Particle Calibration Laboratory Director
University of Minnesota
111 Church St. S.E.
Minneapolis, MN 55455

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INTRODUCTION

A Photo-electrochemical air purifier provided by Transformair was tested at the University of South Florida Clean Energy Research Center to determine its effectiveness of destroying volatile organic compounds (VOCs) in air. The experiment was carried out in a stainless steel chamber and toluene was used as the representative VOC. The photo-electrochemical air purifier was placed in the chamber where toluene was introduced as a contaminant and a circulating fan in the chamber kept the toluene gas uniformly mixed in the chamber. A gas chromatograph (GC) with a flame ionizer detector (FID) detector was used to monitor the concentration of toluene in the chamber. After measuring the initial concentration of toluene, the photo-electrochemical air purifier was turned on and the concentration was measured at predetermined intervals until the concentration decreased to undetectable levels. In addition to testing the photo-electrochemical air purifier, tests were performed with the chamber empty to determine the concentration of toluene gas as a function of time over the same test period, and with a HEPA filter operating in the chamber and tested under the same conditions to determine if it would remove any of the toluene gas over the same test period.

TEST EQUIPMENT AND MATERIALS

The following equipment and materials were used in the tests:

1. *Gas Chromatograph:* SRI Model 8610C
GC Column: DB-624 30 m 0.530 mm 3.00 micro
Oven temperature: 80°C
Detector: FID
Carrier gas: Helium (16psi)
Auxiliary gas: air (7psi), H₂ (25psi)
Syringe: Hamilton Samplelock Syringe 1ml
Software: Peaksimple 2000
Toluene retention time: 1.533 minutes

3. *Stainless Steel Chamber:* Volume: 604 liters (32 in. x 32 in. x 36 in.)
Circulating fan: 12 V, 2.2 W, 8 cm x 8 cm

4. *Toluene:* Brand: Sigma-Aldrich
Lot Number: SHBC1382V
1 ppmv concentration in chamber

TEST METHODS

The photo-electrochemical air purifier tested consists of six APR-3500 A° UV, 12 inches long lamps in series having an intensity of 100W/m² at the filter, a pleated fiber filter having a proprietary catalyst coating with a cross-sectional area of 13.5 in. x 9 in. and a blower. Air enters through the bottom of the purifier and flows around the lamps and through the filter mounted just downstream from the lamps. The assembly is mounted in sheet metal enclosure with a small blower attached on top to draw air through the system. The flow rate through the blower was estimated to be 60 cfm (1,700 lpm). Figures 1, 2 and 3 show the components of the photo-electrochemical air purifier.

To test the photo-electrochemical air purifier ability to destroy VOCs the test procedure consisted of first turning on the GC-FID and allowing it to warm up for 30 minutes followed by placing the photo-electrochemical air purifier within the chamber and connecting to power to ensure that all the UV lamps and the blower were working properly. The air purifier was then turned off and the air in the chamber was refreshed by leaving the door open and turning on the circulating fan in the chamber for 30 minutes. Photographs of the stainless steel chamber, GC-FID and test setup are shown in figures 4, 5 and 6, respectively. A 1.0 ml sample of the air in the chamber was then taken using the syringe and injected into the GC to provide a background air sample. For each GC-FID sample taken a screen shot of the software output was saved to a file and the data was recorded in a spreadsheet. The circulating fan was then turned off and 2.6 uL of liquid toluene was then dispensed under the circulating fan of the chamber to provide 1 ppmv of toluene/air gas under room temperature and the chamber door was closed and sealed immediately. The circulating fan was then turned on and a period of 20 minutes was allowed to completely evaporate and provide a homogeneous concentration of the toluene gas in the chamber. A 1.0 ml sample was then withdrawn from the sample port of the chamber using the syringe and analyzed using the GC-FID. The test was repeated twice and averaged for the initial toluene concentration. The photo-electrochemical air purifier blower and UV lamps were then turned on and the concentration of toluene inside the chamber was measured by the GC-FID at 15 minute intervals over a 90 minute duration. Two samples were taken at each interval and the average value was considered to be the concentration of toluene gas in the chamber. The test procedures were then repeated for an empty chamber used as a control and to determine if there was a decrease in toluene concentration over the same 90 minute duration, and a HEPA filter

operating at the same flow rate instead of the photo-electrochemical air purifier to see if it would remove any of the toluene gas.



Figure 1. Photograph of photo-electrochemical air purifier showing six UV lamps at the base of the system.

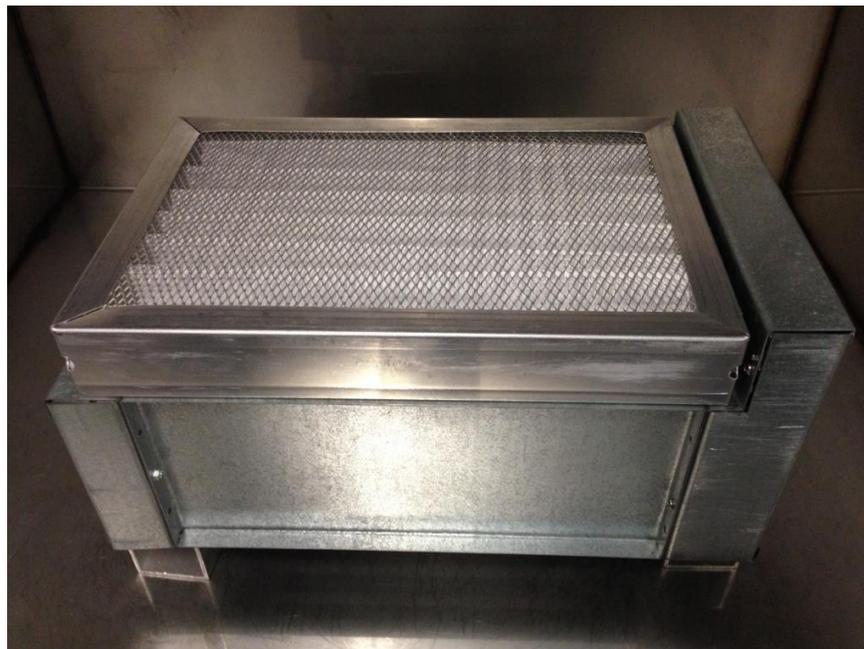


Figure 2. Photograph of photo-electrochemical air purifier showing the pleated filter placed directly above the UV lamps.



Figure 3. Photograph of photo-electrochemical air purifier assembly mounted in a sheet metal enclosure with a blower connected to the exhaust side of the system.



Figure 4. Photograph of stainless steel chamber having an internal volume of 604 liters.

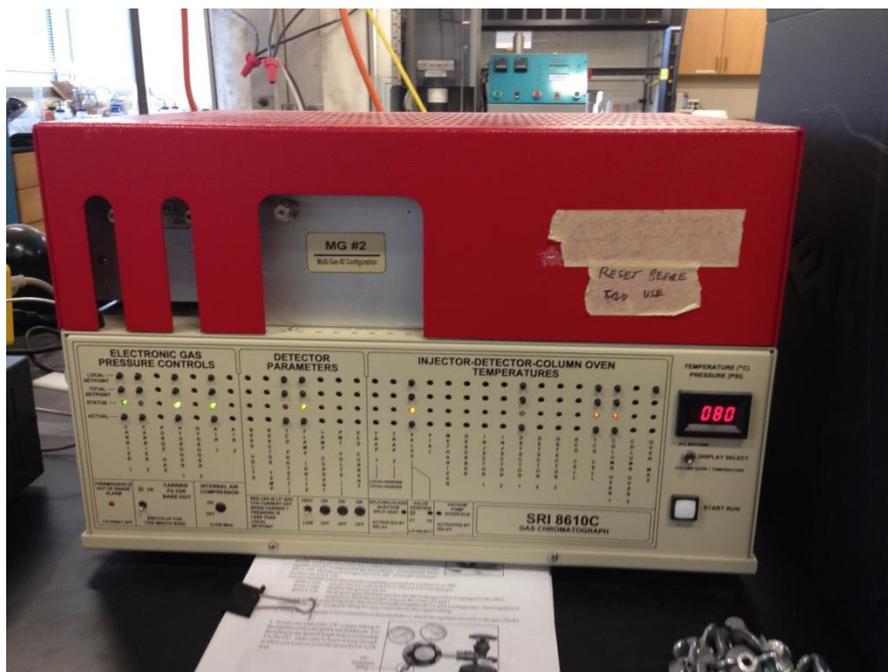


Figure 5. Photograph of SRI 8610 C gas chromatograph and flame ionizer detector.



Figure 6. Photograph of test setup showing stainless steel chamber with photo-electrochemical air purifier inside, GC-FID and computer.

RESULTS

Figure 7 shows the output of the GC-FID for the background air sample where there is a small background peak at the beginning and then a large peak shortly thereafter. These two peaks were consistent throughout all the samples collected. Figure 8 shows the output for the initial toluene concentration in the chamber. The retention times, areas and heights of the peaks are shown in the screen shot. There are now three peaks, the ones occurring at a retention time of 0.016 minutes and 0.333 minutes are from the air background while the peak occurring at a retention time of 1.533 minutes is from the toluene gas. The area under each of the curves is directly proportional to the concentration and is calculated by the software. The remaining screen shots images are provided in a separate document.

Figure 8 shows the concentration ratio of toluene with the original concentration (C_o) being 1.0 ppmv. Over the 90 minute test period samples were taken every 15 minutes for the photo-electrochemical air purifier HEPA filter tests and every 30 minutes for the empty chamber. The data plotted in Figure 8 are also provided in Tables 1, 2 and 3. Two samples were taken and averaged at the 15 minute intervals for the photo-electrochemical air purifier test while only one sample was taken at each time period for the empty chamber and HEPA filter tests.

The results given in Figure 9 show that the toluene gas was reduced to undetectable levels after 90 minutes when the photo-electrochemical air purifier was used, whereas for the empty chamber the concentration was still at 96.3% of its initial value. While it might be expected that the concentration would remain at 100% there is some uncertainty in the test method which would contribute to the variability in concentration from sample to sample. For the HEPA filter test, the results indicated that the concentration ratio was also somewhat variable being at a minimum of 95.4% at 45 minutes and 98.9% at the end of the 90 minute test period, which demonstrated that it did not remove the VOC to any significant level.

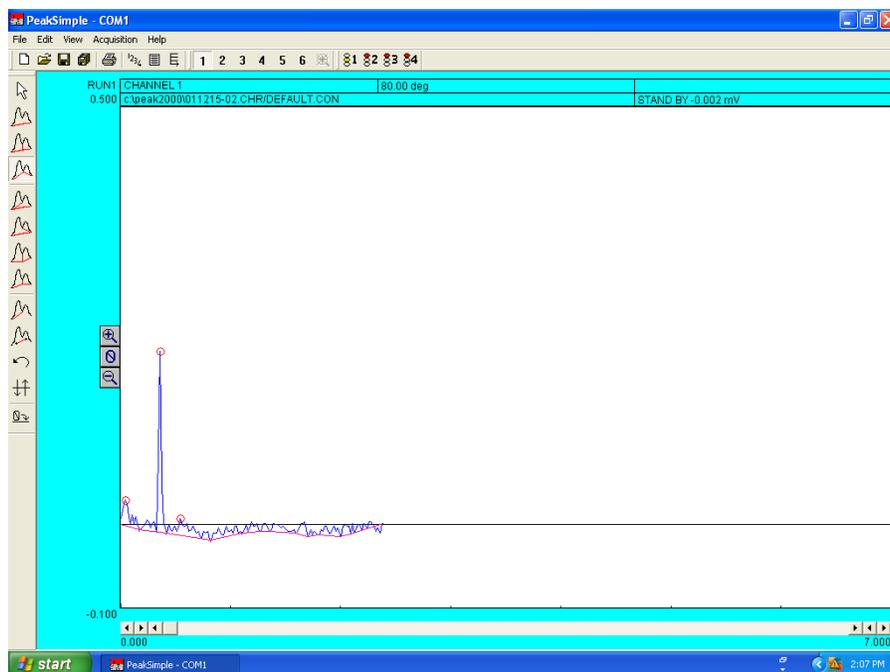


Figure 7. GC-FID output screen shot showing two air background peaks.

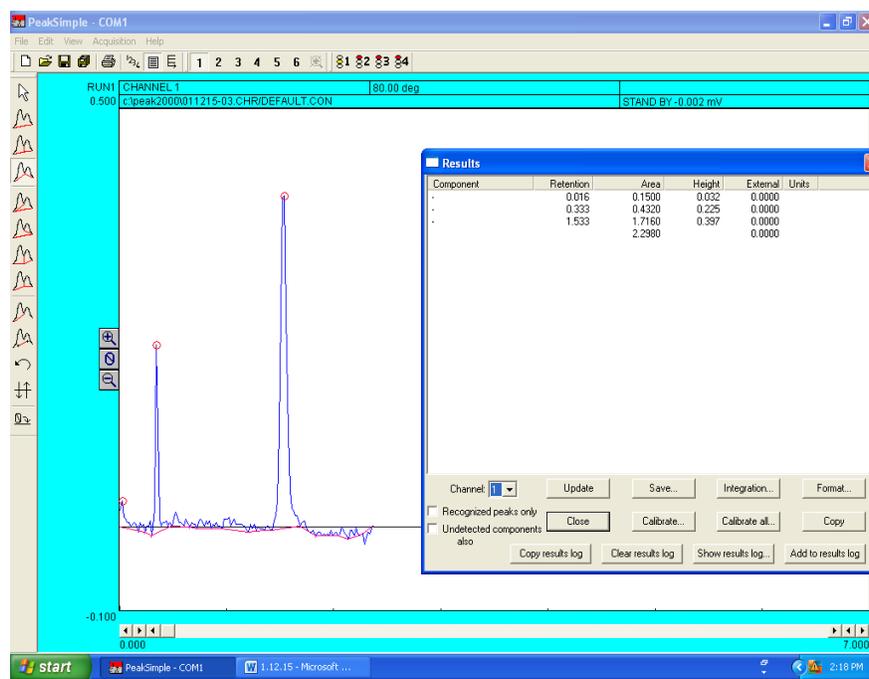


Figure 8. GC-FID output screen shot showing air background peaks occurring at retention times of 0.016 and 0.333 minutes and the toluene peak occurring at 1.533 seconds.

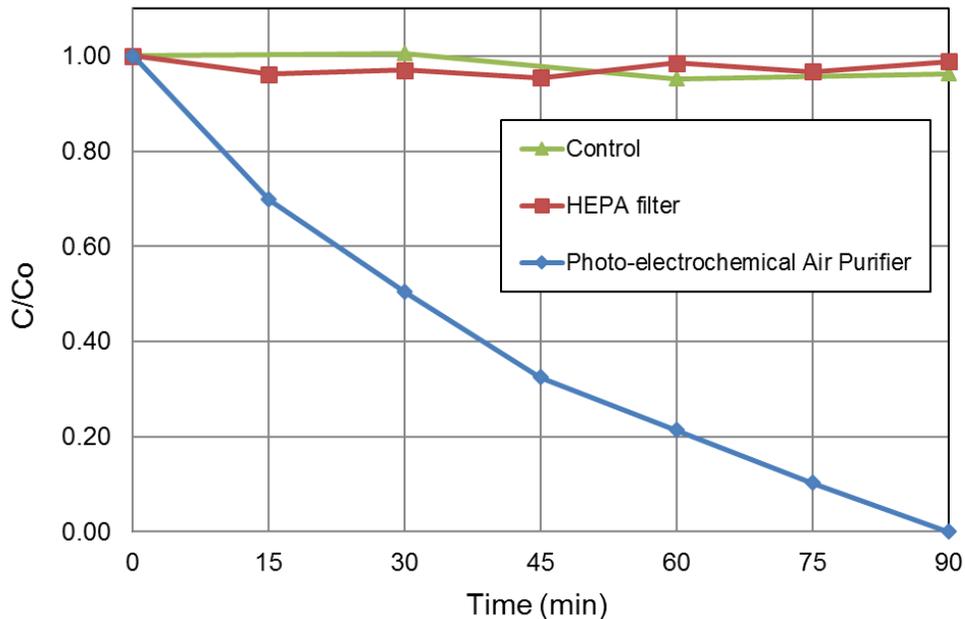


Figure 9. Concentration ratio of toluene vs. time for the photo-electrochemical air purifier, empty chamber and HEPA filter. The initial concentration of toluene for each test was 1 ppmv.

Table 1. Time vs. Toluene Gas Concentration Ratio for Photo-electrochemical Air Purifier.

| Time (min) | GC Area Sample 1 | GC Area Sample 2 | Avg. GC Area | C/Co |
|------------|------------------|------------------|--------------|-------|
| 0 | 1.713 | 1.713 | 1.713 | 1.000 |
| 15 | 1.197 | 1.196 | 1.197 | 0.698 |
| 30 | 0.896 | 0.832 | 0.864 | 0.504 |
| 45 | 0.638 | 0.476 | 0.557 | 0.325 |
| 60 | 0.325 | 0.406 | 0.366 | 0.213 |
| 75 | 0.192 | 0.162 | 0.177 | 0.103 |
| 90 | 0 | 0 | 0.000 | 0.000 |

Table 2. Time vs. Toluene Gas Concentration Ratio for Empty Chamber.

| Time (min) | GC Area | C/Co |
|------------|---------|-------|
| 0 | 1.57 | 1.000 |
| 30 | 1.578 | 1.005 |
| 60 | 1.494 | 0.952 |
| 90 | 1.512 | 0.963 |

Table 3. Time vs. Toluene Gas Concentration Ratio for HEPA Filter.

| Time (min) | GC Area | C/Co |
|-------------------|----------------|-------------|
| 0 | 1.689 | 1.000 |
| 15 | 1.624 | 0.962 |
| 30 | 1.639 | 0.970 |
| 45 | 1.612 | 0.954 |
| 60 | 1.664 | 0.985 |
| 75 | 1.634 | 0.967 |
| 90 | 1.67 | 0.989 |

CONCLUSIONS

The results show that the photo-electrochemical air purifier destroys toluene gas, used as a representative VOC, to undetectable levels within a 90 minute time period under the conditions tested. The toluene gas concentrations in the empty chamber was at 96.3% of its initial value after 90 minutes, and the concentration with the HEPA filter operating in the chamber was still at 98.9% its initial values after 90 minutes demonstrating that it does not remove the VOC from the airstream.