The Effects of pH Adjustment on Peracetic Acid Vapor Production

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Executive Summary

The purpose of this study is to evaluate the effects of adjusting the pH of peracetic acid (PAA) solutions and monitoring the resulting production of PAA vapor. This study used the ChemDAQ PAA vapor sensor which was validated and provides an accurate reading of PAA vapor concentration. The validation report of the ChemDAQ PAA vapor sensor is presented in a separate study[1]. The same testing methodology was used in this paper, to analyze and report the relative PAA vapor concentration (ppm). In this study the PAA vapor concentration was quantified at pH 4 (unadjusted pH), 6, 7, 8.5, and 9 at various PAA solution concentrations. Compared to pH 4, the PAA vapor production at pH 9 is reduced by >58%, which is a significant and meaningful difference that can help reduce worker exposure and improve worker safety.

Background

Peracetic acid (PAA) is a common antimicrobial food processing aid that is currently in use at hundreds of processing facilities throughout the U.S.A. All commercially available PAA products are an equilibrium mixture of peracetic acid, hydrogen peroxide, and acetic acid. While there are numerous advantages for using PAA over other common antimicrobials such as halogen-based products, quaternary ammonium compounds, and mineral or organic acids, one potential drawback may be the pungent vinegar odor associated with PAA products. In most facilities, PAA odor is not an issue but in certain industries such as poultry processing, large water reservoirs (poultry chillers) can exacerbate PAA odors. Although the breakdown products of PAA are non-hazardous and naturally occurring, certain individuals can display hypersensitivity to high PAA vapor concentrations, which mainly affects the respiratory tract as well as the ocular system.

It is incumbent for all industries that use chemicals to make the workplace as safe as possible for their workers. It is possible to make mechanical and physical changes in many locations within a facility to reduce the exposure to PAA vapor. For example, increasing ventilation in a plant would be an ideal approach to reducing exposure to PAA vapor, but may be difficult to achieve depending upon the processing plant design. On the other hand, in spray applications, reducing the tendency to volatilize PAA can be achieved by decreasing spray pressure and increasing droplet size. A third method is also available, pH adjusting the PAA at the point of use. In poultry processing facilities, poultry chillers represent one of the largest sources of fugitive PAA vapor. Typically, these poultry chillers are air agitated to enhance heat exchange to promote rapid cooling of the birds. This sparging can intensify volatilization of PAA. Installing an adequate ventilation system near poultry chillers to decrease PAA vapor exposure can be challenging due to

[1] www.Envirotech.com/ChemDAQValidation

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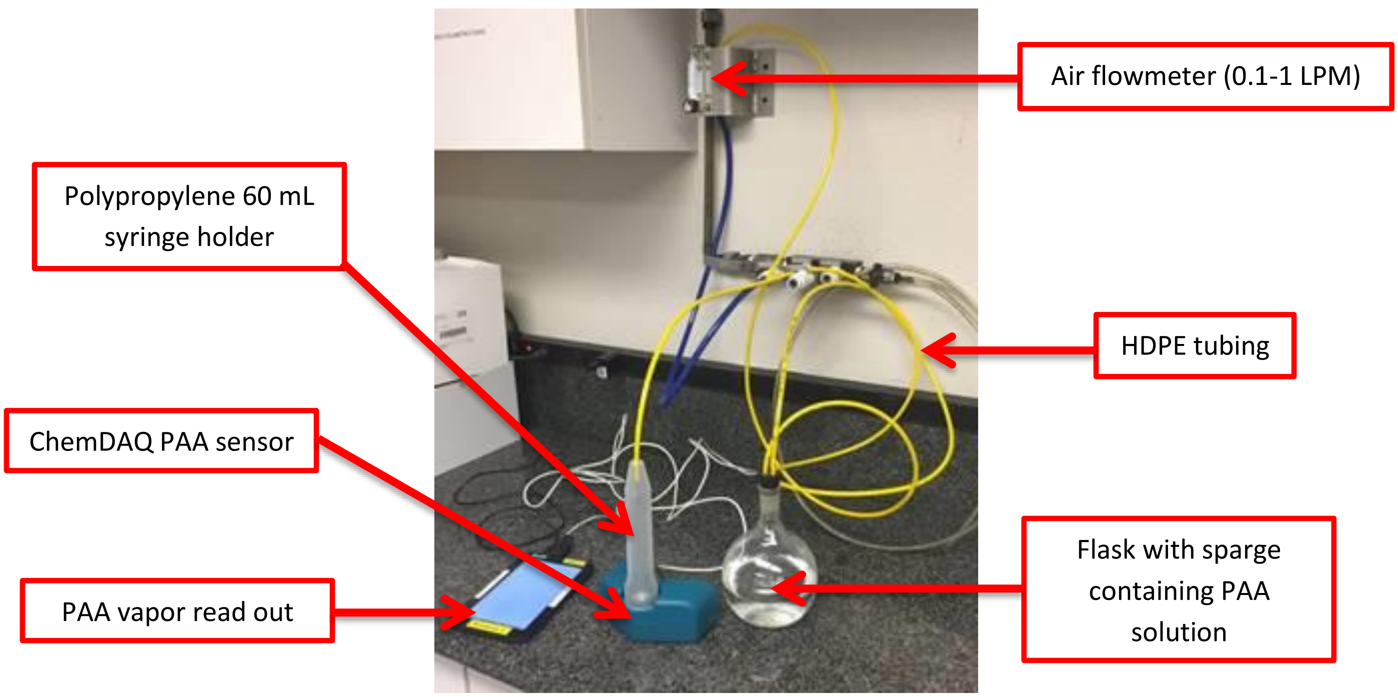
engineering design limitations and available space within a plant. Therefore, pH adjusting PAA in poultry chillers may be the best and least costly way to substantially decrease PAA vapor production to limit worker exposure to PAA vapor.

Materials and Methods

The measurements of PAA vapor were taken using ChemDAQ's peracetic acid air sensor which was validated in a previous study. The ChemDAQ PAA vapor sensor was connected to a Winbook model TW700, running Windows 8.1. The output from the sensors is a proprietary 485 signal, the sensor was connected to the tablet via a 485/USB converter. The data was collected using ChemDAQ's data log software and results were manually recorded.

Figure 1 shows the ChemDAQ PAA vapor sensor experimental design



Enviro Tech's Perasan MP-2C contains 22% PAA, 5% hydrogen peroxide, and 45% acetic acid and was used to make the PAA test solutions. Nominal aqueous solutions of PAA were made at 25, 50, 100, and 250 ppm. The solutions were divided into four separate 500 mL samples. Using 18M sodium hydroxide, one of the 500 mL samples at each concentration was pH adjusted to 6, 7, 8.5, and 9 ± 0.1. The unadjusted PAA solutions were at pH 4 ± 0.3. The concentrations of PAA were analyzed using the Modified Palin DPD methodology (Enviro Tech US Patent 7,651,860 B2) and verified to be within ± 3 ppm of the target concentration. Each solution (unadjusted pH and adjusted pH) was individually transferred to the 1000 mL round flask. The stopper was fitted to the round flask with the inlet tube being submerged 1 cm into the liquid so the air would sparge through the PAA solution. The air flow was sparged into the PAA solution and the flow rate adjusted to 1 LPM. The system was purged for 10 minutes to ensure vapor production equilibration. After the purge time, the 60 mL polypropylene syringe holder was fitted over the ChemDAQ PAA vapor sensor. The air containing PAA vapor was allowed to pass through the sensor for approximately two minutes until the concentration reading remained constant. The syringe holder was then removed from the sensor for approximately 5 minutes until the concentration reading returned to zero. This was repeated in triplicate at all concentrations and the results were averaged. The average temperatures of the PAA solutions were 22°C.

Results

Table 1 shows the average concentration of the PAA vapor produced from the unadjusted pH and pH adjusted PAA solutions.

PAA Solution Conc. (ppm)	Solution pH	PAA Vapor (ppm)	% Reduction	% Diff. pH 7 v. 9
25	4	0.37	-	-
25	6	0.28	24.32	-
25	7	0.25	32.43	-
25	8.5	0.16	56.76	-
25	9	0.14	62.16	47.7

PAA Solution Conc. (ppm)	pH	ppm PAA vapor	% Reduction	% Diff. pH 7 v. 9
50	4	0.72	-	-
50	6	0.58	19.44	-
50	7	0.45	37.50	-
50	8.5	0.35	51.39	-
50	9	0.30	58.33	35.3

PAA Solution Conc. (ppm)	pH	ppm PAA vapor	% Reduction	% Diff. pH 7 v. 9
100	4	1.22	-	-
100	6	0.95	22.13	-
100	7	0.72	40.98	-
100	8.5	0.58	52.46	-
100	9	0.47	61.48	33.3

PAA Solution Conc. (ppm)	pH	ppm PAA vapor	% Reduction	% Diff. pH 7 v. 9
250	4	2.91	-	-
250	6	2.35	19.24	-
250	7	1.95	32.99	-
250	8.5	1.33	54.30	-
250	9	1.22	58.08	43.1

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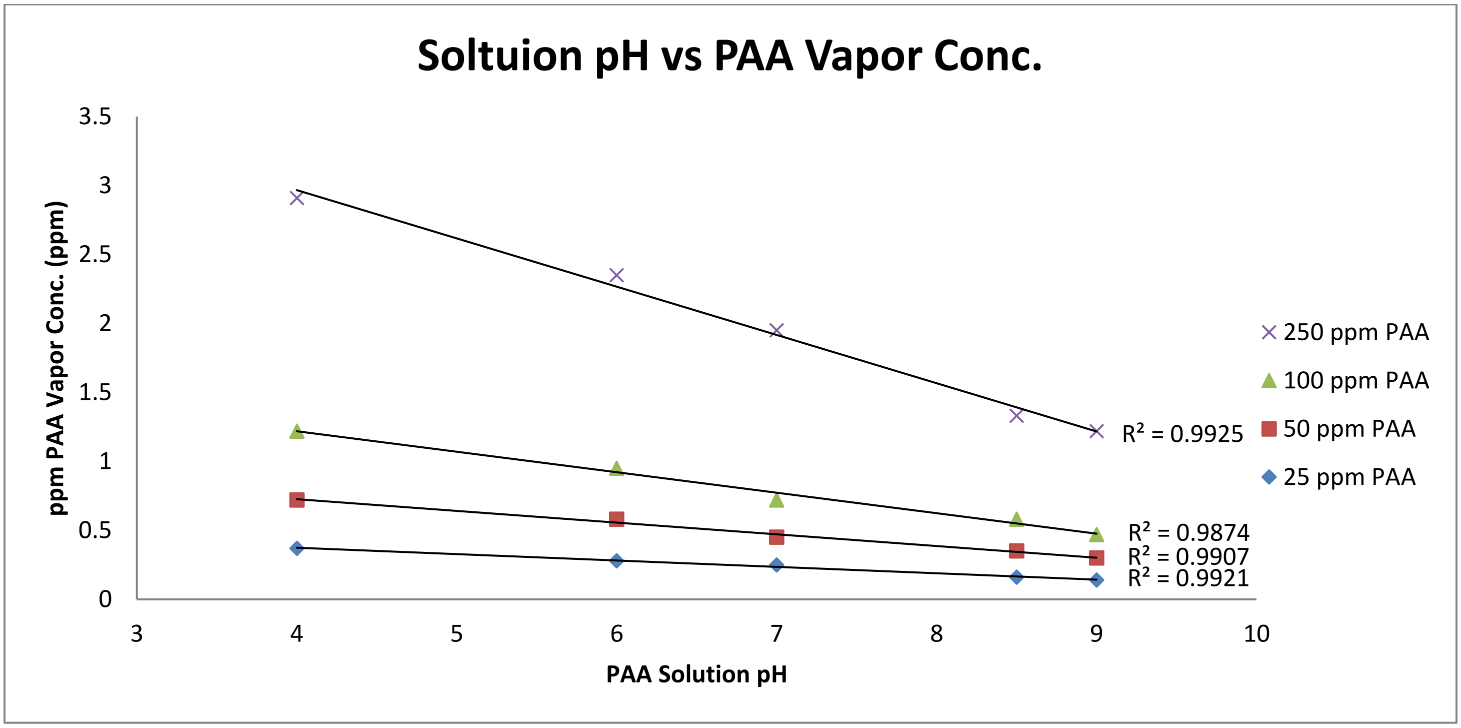
Figure 2 is the graphical representation showing the effects of pH adjusting a PAA solution on PAA vapor evolution



Conclusions

The results of this study shows that increasing the PAA solution concentration, regardless of the pH, increases overall PAA vapor production. Additionally, the PAA vapor production is proportional to the PAA solution concentration which showed excellent linearity across all PAA solution concentrations.

The primary findings of this study were that increasing the pH of a dilute PAA solution significantly reduces the PAA vapor evolution. While this theory has been hypothesized over the years, the results of this study prove that the pH of PAA is directly correlated with PAA vapor production. As previously stated, poultry reservoirs (poultry chillers) are one of the largest sources of PAA vapor emission which could potentially lead to unpleasant work environments. Based on the results of this study, simply increasing the pH of the poultry chiller from pH 4 to pH 9 can lead to a >58% decrease in PAA vapor production. It should be noted that a reduction of PAA vapor of 33-47% can be observed by raising the pH from pH 7 to pH 9. While pH adjusting PAA may not completely eliminate PAA odor, doing so will substantially decrease fugitive vapors which will lead to a safer work environment for all employees. One of the novel aspects of the pH adjusting method that was discovered by Enviro Tech is that efficacy against bacterial organisms such as *Salmonella* and *Campylobacter spp*. is not compromised, and in the case of *Salmonella*, equal or greater susceptibility is observed at an elevated pH (7.6-9.5) levels.

It is important to note that the results obtained in this study are based on laboratory parameters. In actual applications there are a multitude of variables that play a factor in PAA vapor evolution and vapor concentration. Common variables are atmospheric temperature and pressure, PAA solution temperature, volume of PAA solution, degree of agitation, ventilation, room size, and distance from solution.

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