A STUDY OF AIR POLLUTION BY LIQUID ENTRAINMENT IN PROCESSES INVOLVING GAS-LIQUID CONTACT

N.S. Mahmoud and S.A. El-Messih
Mathematics & Physics Engineering Department, Faculty of Engineering,
Alexandria University, Alexandria, Egypt.

ABSTRACT

In an increasingly technological world, there is a growing awareness of air pollution problems and concern about their control and abatement. In order to control pollution, we need to assess the relationship between man's activities and the levels of pollutant in the environment. So the object of this work is to study the effect of the rate of flow of air; the concentration of the surfactant and the surface tension on the air pollution in industrial atmospheres where processes involving gas-liquid contact are present. Air with different rate is passed through 0.1 N. NaOH solution containing surfactant with different concentration. The variables studied were the flowrate of air and content ration of the surfactant while the time is constant. It was found that by increasing the air flowrate the rate of pollution increases, by increasing the surfactant concentration the rate of pollution also increases and increasing surface tension the rate of pollution decreases.

1. INTRODUCTION

The problem of air pollution of industrial atmospheres has received a great interest in view of its negative impact on public health. Previous studies have concentrated on air pollution resulting from fuel combustion in motor cars and thermal power stations [1]. Air pollution resulting from liquid entrainment by gases in processes involving liquid-gas operations has received little interest despite its importance. In these processes gas bubbles leaving the solution entrain some liquid with them thus leading to air pollution. Liquid gas operations are encountered widely in chemical industry, pharmaceutical industry and food technology [2]. As an example, air sparking is used widely in fermentors used in drug industry, food technology and biological water pollution control to provide bacteria with the needed Oxygen. Also air sparking is used in bubble column reactors to enhance the rate of heat transfer. The problem of air pollution by entrainment is encountered also in boiling solutions where steam bubbles escaping from the boiling solution to the atmosphere carry with them some solution which pollute's the atmosphere [3-7]. Electrochemical industries where H_2 and O_2 gases evolve simultaneously with metal deposition as in the case of electroplating and production of metals by electrolysis also suffer from the problem of air pollution by entrainment.

The object of the present work is to study some of the factors affecting air pollution by entrainment such as gas flow rate and surface tension of the solution. Solution surface tension was changed by adding different concentrations of triton (a surfactant). Triton was chosen because of its stability in the test solution NaOH solution was used in the present work [8,9]. Triton has been used frequently by different authors as a surfactant to reduce surface tension of aqueous solution [8-12]. The ability of triton to reduce surface tension of aqueous solution is attributed to its structure which contain a polar group and a non polar hydrocarbon chain. Triton reduces water/air surface tension by attaching its polar group to water while the nonpolar tail is directed to air, the theory underlying the detailed mechanism of action of surfactants such as triton is discussed elsewhere [13].

2. EXPERIMENT TECHNIQUE

Figure (1) shows the experimental apparatus, it consists of : an air compressor, a Hoffman bottle filled with distilled water to saturate air with humidity, a U tube calibrated manometer, a 500 cm flask containing 250 cm 0.1 N NaOH solution and finally a conical flask containing 25 cm distilled water. Air was allowed to flow through the system for 20 minutes. NaOH droplets entrained by air during the experiment were caught by water in the conical flask. At the end of the experiment the 25 cm solution in the conical were diluted to 500 cm. 25 cm were taken from the 500 cm and titrated against 0.001 N HCl using methyl orange as indicator. The volume of HCl consumed was taken as a measure for the degree of entrainment or the rate of air pollution with NaOH. During each run air flow rate was determined by measuring the pressure drop across the U tube manometer. Surface tension of sodium hydroxide solutions containing triton was measured by Jaeger's method. Air flow rates ranged from 40 to 80 ml/sec while surface tension ranged from .02 to 0.07 N/m.

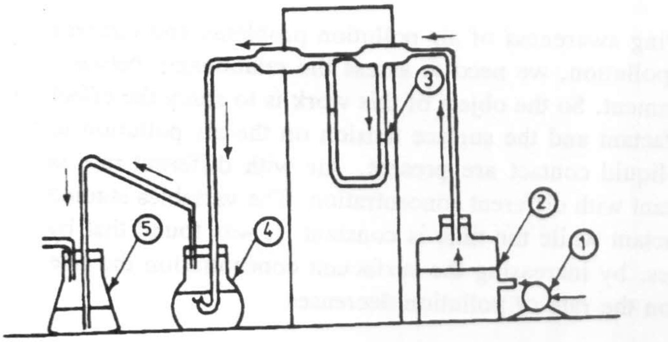

Figure 1. Experimental apparatus 1- air compressor; 2- hoffman bottle containing distilled water; 3- U tube manometer; 4- 5000 cm^3 flask; 5- conical flask.

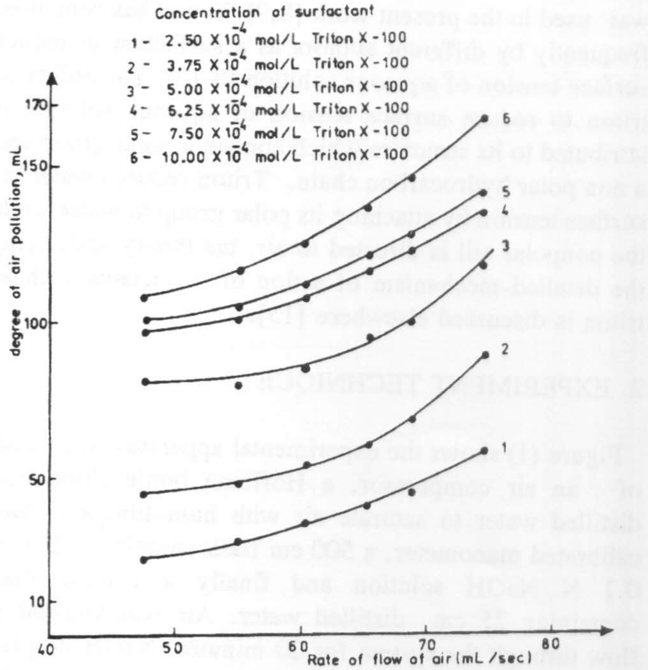

Figure 2. Effect of rate of flow on the rate of air pollution.

3. RESULTS AND DISCUSSIONS

Figure (2) shows the effect of air flow rate on the degree of air pollution by sodium hydroxide solution entrained with air bubbles at different triton concentration, the degree of air pollution increases with increasing air flow rate and surfactant (triton) concentration i.e. the degree of air pollution by liquid entrainment decreases with increasing surface tension of the solution as shown in Figure (3). The increase in the degree of air pollution with increasing air flow rate may be attributed to the increase in the number of air bubbles passing through the solution per second; with increasing the number of air bubbles the contact area between air and sodium hydroxide solution increases with a consequent increase in the amount of solution entrained by air bubbles.

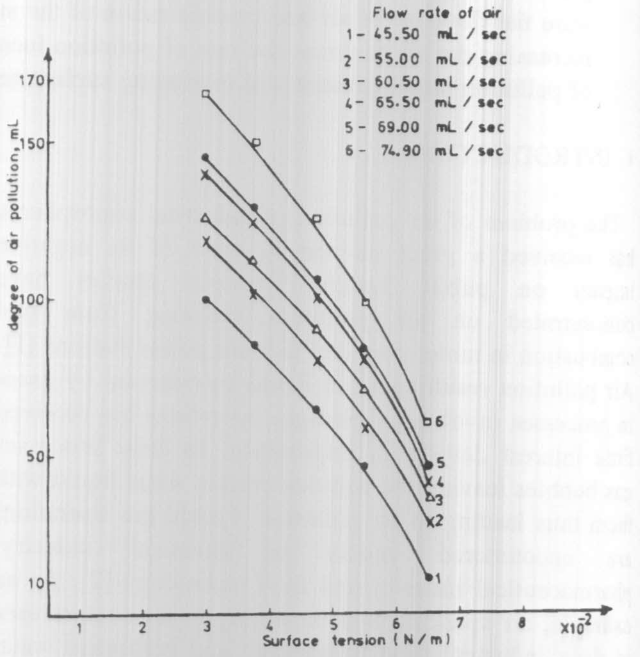

Figure 3. Effect of surface tension on rate of air pollution.

The increase in the degree of air pollution with increasing surfactant concentration may be attributed to the following.

(i) Surfactant addition reduces solution surface tension with a consequent decrease in bubble diameter according to the equation [4].

$$\sigma \pi d = \frac{1}{6} \pi d^3 (\rho_L - \rho_g)\, g$$

where $\sigma \pi d$ is the surface tension force at the nozzle generating air bubbles while the right hand term is the

buoyancy force acting on the bubble.
where: σ is the surface tension, d is bubble diameter
ρ_L is density of liquid ρ_g is density of gas
As a result of the decrease in bubble diameter, the number of bubbles increase for a given air flow rate with a consequent increase in the contact area between the bubbles and the solution, accordingly the amount of liquid entrained with air bubbles increases.

(ii) Surfactant molecules adsorb on the bubble surface leading to the formation of rigid noncoalescant bubbles of low rise velocity. The absence of bubble coalescence keeps the number of bubbles at a high value during the rise of these bubbles through the solution i.e. the contact area between bubbles and solution remains high and accordingly the amount of entrained liquid remains also high.

Figure (4) shows that the degree of pollution reaches a limiting value at a surfactant concentration of 7.5×10^{-4} M01/L, beyond this value the degree of air pollution remains almost constant with further increase in surfactant concentration. This may be attributed to the fact that at a surfactant concentration of 7.5×10^{-4} mol/L the critical micelle concentration is reached, increasing surfactant concentration beyond this value has no effect on the surface tension.

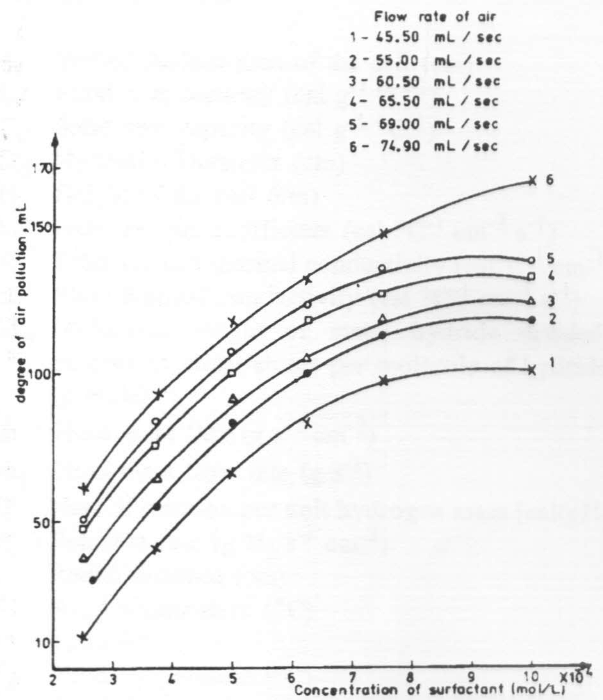

Figure 4. Effect of concentration of surfactant on the rate of air pollution.

4. CONCLUSIONS

The present study shows that for the system air 0.1 N NaOH solution increasing air flow rate increases the rate of air pollution.Increasing surfactant concentration increases the rate of air pollution, i.e. increasing surface tension decrease the rate of air pollution.

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