

THE INFLUENCE OF TEMPERATURE AND ORGANIC MATTER ON THE DECOMPOSITION KINETICS OF PERACETIC ACID IN AQUEOUS SOLUTIONS

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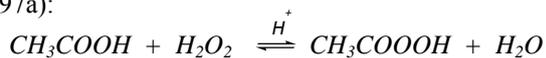
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Abstract—Peracetic acid (PAA) is a powerful sanitizer used by food industries all over the world. The main disadvantage of PAA is its decomposition rate. The main purpose of this paper is to study the decomposition of PAA between 20 and 40 °C with 0.0, 2.5 or 5.0 g·L⁻¹ of beer, milk or tomato juice in its solutions. The observed decomposition of PAA is a first-order reaction for solutions free of organic matter with observed rate constants from 1.24·10⁻³ to 5.59·10⁻³·h⁻¹ and an activation energy (E_a) of 62.11 kJ·mol⁻¹. However a pseudo first-order reaction was observed in the presence of organic matter and the rate constants between 1.13·10⁻³ and 2.18·10⁻² h⁻¹. The E_a calculated by the observed decomposition rate constants are 42.3 and 61.2 kJ·mol⁻¹ when there was 2.5 and 5.0 g/L beer in solution, respectively. PAA solutions contaminated with 2.5 and 5.0 g·L⁻¹ milk have showed E_a values between 9.7 and 55.3 kJ·mol⁻¹, respectively. For tomato juice solutions, the Arrhenius equation slope was not constant. The different E_a obtained indicate that different mechanisms are taking place at the various tested operating conditions. This work also proposes a mathematical equation to estimate the PAA concentration for solutions free of organic matter.

Keywords—peracetic acid, decomposition kinetics, beer, milk, tomato juice.

I. INTRODUCTION

PAA is a powerful sanitizer with a reduction potential of 1.06V that has been introduced in the Brazilian food industry in the 90's. Commercial formulations of this sanitizer contain mixtures of acetic acid, hydrogen peroxide (PH), water and PAA as shown by the following chemical equation (Zhao *et al.*, 2008b, Musante *et al.*, 2000, Kunigk *et al.*, 2001; and Yuan and Heiningen, 1997a):



PAA has many advantages when compared to sodium hypochlorite, the most commonly used sanitizer in Brazil (Kunigk *et al.*, 2001). One of the many advantages of PAA is that its decomposition produces nothing else than acetic acid and oxygen which are non-toxic compounds and therefore affect neither the final product nor the industry biological waste treatment process. It was reported that PAA in solution may be consumed by hydrolysis, spontaneous decomposition or decomposition catalyzed by transition metal ions (Yuan and Heiningen,

1997b, Kitis, 2003, Veschetti, *et al.*, 2003 and Zhao, *et al.*, 2008a).

Spontaneous decomposition of PAA occurred at a pH range of 5.9-10.2 (Koubek *et al.*, 1963 *apud* Zhao *et al.*, 2008a). Zhao *et al.* (2008a) reported that in an acid condition and at a temperature range of 55 to 95°C the spontaneous decomposition of PAA is a second-order reaction with respect to PAA concentration. However at a temperature below 55 °C the spontaneous decomposition of PAA is so insignificant that it could be negligible and hydrolysis became the predominant consumption factor for PAA. Zhao *et al.* (2007) reported that the hydrolysis of PAA in an acidic environment is first order with respect to PAA concentration, water and H⁺ concentration.

Rucker and Cates (1988) reported that the decomposition of peracetic acid is affected by the solution's pH and the observed decomposition rate of peracetic acid at 30 °C increases with pH ranging from 0.921·10⁻³ h⁻¹ at 5.34 to 15.5·10⁻³ h⁻¹ at 8.90.

Temperature also affects the decomposition of PAA. Greenspan and MacKellar (1948) observed that at room temperature, diluted solutions of PAA (10 g/L), lost half of their sanitation power within 6 days. Kunigk *et al.* (2001) have shown that increasing the temperature, a more rapid decomposition occurred. At 45 °C the concentration was halved in 72 hours, but at 25 °C the loss in 240 hours was only 33%. They concluded that temperature has an important role in the shelf life of PAA solutions.

No information was found on the decomposition kinetics of PAA solutions contaminated with organic matter usually present in the food industry. The main purpose of this paper is to present the results obtained in experiments carried out to study how organic matter affects the reduction of PAA concentration during its storage when their aqueous solutions are contaminated with 0.00, 2.5 or 5.0 g·L⁻¹ beer, milk or tomato juice at 20, 30, 35 and 40 °C, rather than to make a rigorous study of its decomposition kinetic. This study is aimed at showing that organic matter reduces the PAA shelf-life and this must be taken in consideration for equipment sanitation operations. It is also important to note that the concentrations of organic matter that have been chosen for the simulation of contamination of PAA solutions are several decimals above the values which may be expected in the food industry but can illustrate what could happen.