

# Influence of Chlorine Concentration on the Effectiveness of Cleaning-in-Place Agents

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## INTRODUCTION

- Fouling is unwanted deposit that causes inefficiencies in heat transfer, hydraulics, food safety and quality.
- Cleaning-in-place (CIP) systems are used for cleaning food equipment without dismantling the equipment. They are favored because of their reliability and repeatability.
- Sodium hydroxide (NaOH) is mainly used for removing organic matter.
- Sodium hypochlorite (NaClO) is commonly added to alkali cleaning solutions because it is believed to improve cleaning efficiency.
- Efficiency in cleaning can be represented in rate constant of first-order kinetic model.

$$\frac{dm}{dt} = km \quad \ln \frac{m}{m_0} = -kt$$

- NaClO concentration allowed for cleaning and sanitation is below 200 ppm (Timmerman, 2011).

## AIM

- To investigate the influence of sodium hydroxide concentration on the effectiveness of removing product residues from food-contact surfaces during CIP.
- To determine the contribution of sodium hypochlorite concentration on the effectiveness of sodium hydroxide in removal of product residues during CIP.
- To develop recommendations on the optimum concentration of cleaning agents for effective removal of product residues during CIP.

## METHODS

### Fouling preparation

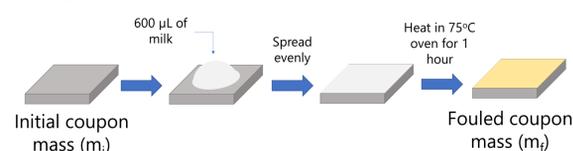


Figure 1. Step by step of deposit preparation.

### Cleaning solution preparation

Table 1. Concentration of NaOH and NaClO

[NaOH] kg/m <sup>3</sup>	0	0.5	5	7.5	15
[NaClO] ppm	0	50	100	150	200

## METHODS (continued)

### Cleaning solution preparation

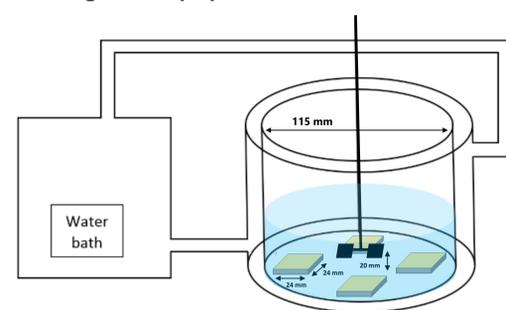


Figure 2. Bench-top cleaning experiment set up.

### Evaluation of cleaning efficiency

$$\Delta \text{ dry mass} = \frac{\text{mass of fouling residue}}{\text{mass of initial fouling}}$$

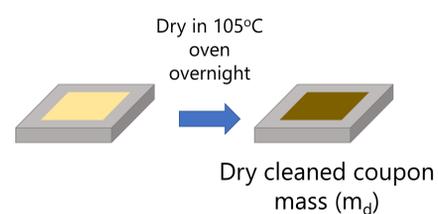


Figure 3. Analyzing the cleaned coupon.

## RESULTS

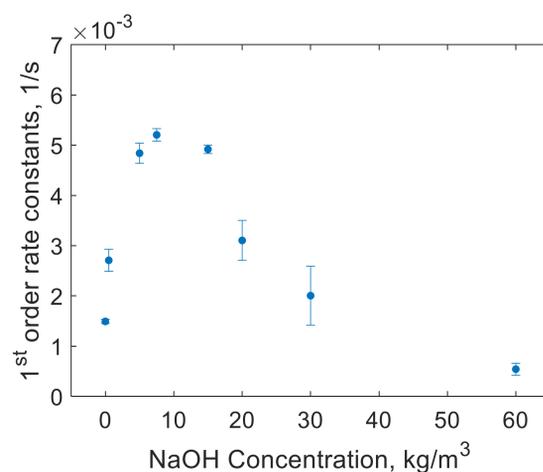


Figure 4. Effect of NaOH concentration on cleaning rate.

## RESULTS (continued)

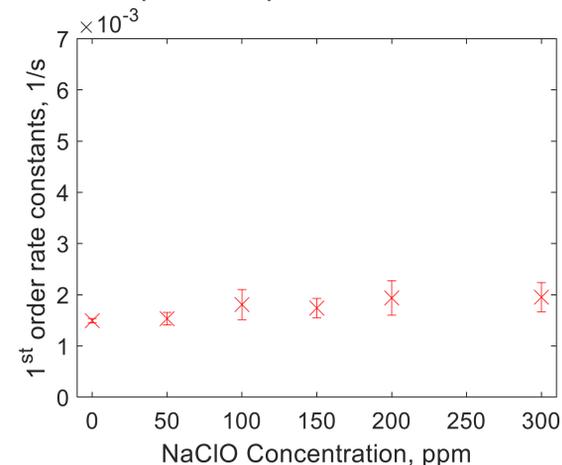


Figure 5. Effect of NaClO concentration on cleaning rate.

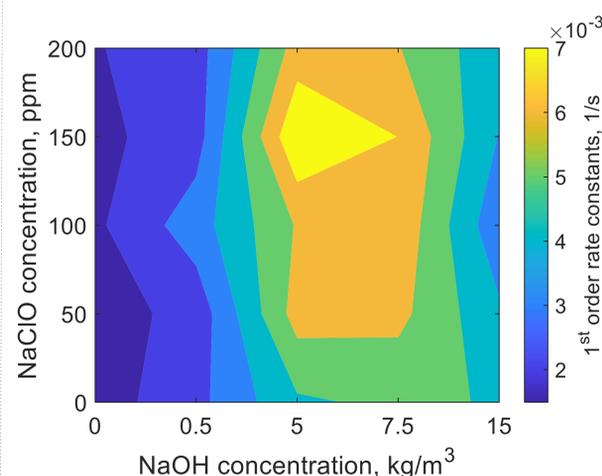


Figure 6. Effect of combination of NaOH and NaClO on cleaning rate.

## CONCLUSIONS

- Increasing NaOH concentration would significantly affect cleaning ( $p < 0.05$ ). The local maxima was found at the NaOH concentration of 7.5 kg/m<sup>3</sup>.
- Increasing NaClO concentration by itself does not result in a significant difference when compared to cleaning with water ( $p > 0.05$ ).
- Cleaning agents with mixture of NaOH and NaClO were shown to be the most effective at 5-7.5 kg/m<sup>3</sup> of NaOH and 150 ppm of NaClO. However, interaction between NaOH and NaClO was not shown to be significant ( $p > 0.05$ ).

## IMPLICATIONS

- Optimization of NaOH concentration is important – higher concentration will lead to inefficiency and higher waste load.
- Further usage of NaClO as additive in cleaning agents should be avoided as it does not significantly improve cleaning.
- The presence of NaClO in the groundwater and soil can form Trihalomethanes (THM), such as chloroform. THM can create short-term skin and health problems. It is also considered carcinogenic (Jackmand and Hughes, 2911).

## FUTURE WORK

- Introduce higher temperature to the cleaning system to find any interaction between NaOH concentration, NaClO concentration, and temperature.
- Study the effect of chlorinated alkali in biofilm or microbiological deposit removal as NaClO is frequently considered as sanitizer.
- Investigate the impact of different types of food deposits on the efficiency of both NaOH and NaClO.
- Upscale the study to the pilot-level to closely mimic the condition in manufacturing plants.

## BIBLIOGRAPHY

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