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DILUTION OF SODIUM HYPOCHLORITE SOLUTIONS (NaOCl) (May 16, 2003)

Note: It is also necessary to obtain CI Pamphlet # 96, Edition 2, *The Sodium Hypochlorite Manual*, and CI Pamphlet #65, Edition 4, *Personal Protective Equipment for Chlor-Alkali Chemicals.* You must review them before attempting to establish your procedures for diluting NaOCl. (Order from CI's website @ www.CL2.com)

Reasons for Diluting Sodium Hypochlorite Solutions

Reasons to dilute sodium hypochlorite solutions include:

- To meet specific process or product requirements.
- Enhanced accuracy in hypochlorite feed/metering systems. (CI Pamphlet #96, Section 6.4)
- Enhanced product stability. Sodium hypochlorite (NaOCl) continually decomposes on standing after it is produced. If the solution is diluted to 50% of its initial concentration, the rate of decomposition will be about 25% of the pre-dilution rate if all other conditions are kept basically the same. Since preserving the strength of the product is important, dilution is a simple way to help decrease decomposition. (CI Pamphlet #96, Section 3.3)

Dilution Water Quality Considerations

It is important that dilution water be of suitable quality to prevent precipitants from forming and to protect against the addition of ionic species that can promote product decomposition. (See CI Pamphlet #96, Section 3) Soft water (well or tap) should be used which can be generated using an ion exchange softening unit that uses salt (sodium chloride) as the regenerate. These units are commercially available in a wide range of sizes.

Adjusting the pH/Excess Caustic of the Diluted Bleach Solution

When diluting solutions of sodium hypochlorite it is important to also consider adjusting the pH (level of excess alkalinity or caustic soda) of the diluted solution to ensure the final solution remains stable. Section 3.7 of CI Pamphlet #96, describes the effect of pH on the stability of a bleach solution.

Check the diluted bleach solution with a pH meter (using high alkalinity pH electrodes) or titrate as indicated in CI Pamphlet #96, Section 10 to be certain the solution contains adequate excess alkalinity. Do not use litmus papers to check this pH; experience has shown they do not work. If the pH is below 11.9 consider adding additional sodium hydroxide to the solution. The amount of caustic soda to be added can be estimated using a small volume of the diluted sodium hypochlorite solution. Collect about 500 ml of bleach solution in a beaker and add a dilute solution of caustic soda drop wise from a calibrated burette while monitoring the pH. The amount of caustic soda needed to adjust the pH of the bulk bleach solution can now be calculated.

While the effect of the dilution on the level of excess alkalinity in the bleach is typically not significant, the need to add additional alkali to the diluted solution will depend on the pH (excess caustic level) of the initial bleach solution and how far the solution is diluted. As a rule of thumb, the closer the pH of the initial solution is to 11.9 pH or the more it is diluted, the more likely it will be necessary to increase the pH of the diluted solution.

Precautions When Adding Caustic Soda to Sodium Hypochlorite Solutions

Care must be taken when adding sodium hydroxide (caustic soda) to bleach solutions as this involves an exothermic reaction that will cause the bleach solution to heat up. How hot the bleach solution gets will depend on the strength of the caustic solution used and how much is added. In extreme cases this could result in an unsafe situation due to splattering/splashing of the solution. For this reason it is generally better to use a dilute solution of caustic soda and add it slowly to a well agitated sodium hypochlorite solution. It may be necessary to cool the solution during the pH adjustment.

The quality of the caustic soda used must also be considered. Some of the contaminants (trace metals, sodium chloride, etc.) typically found in sodium hydroxide can affect the stability/shelf life, color and/or the overall quality of the sodium hypochlorite solution. It is generally better to use a high purity caustic to adjust the pH of a bleach solution. See section 4.3.4.2 of CI Pamphlet #96, for additional information.

Temperature Considerations When Diluting Sodium Hypochlorite Solutions

The dilution (addition of water) of sodium hypochlorite is not exothermic (release of heat), therefore, cooling equipment is not necessary. NOTE: Dilution with water is different than the addition of sodium hydroxide to meet a product specification or for pH adjustment. When sodium hydroxide is added to sodium hypochlorite, cooling or extensive mixing may be necessary due to the exothermic reaction that occurs (see Precautions When Adding Caustic Soda section above).

Equipment Recommendations for Diluting Sodium Hypochlorite Solutions

The dilution of sodium hypochlorite is a relative simple matter. Small batch operations can be designed by utilizing a storage tank and adding the known amount of sodium hypochlorite and then adding the calculated amount of soft water. Automatic dilution systems are available to dilute higher concentration solutions down to a lower concentration with great accuracy and speed. All equipment that may come into contact with the sodium hypochlorite must be made of compatible materials. Section 6 of CI Pamphlet #96 should be referenced when choosing equipment for the dilution process.

Calculations for Diluting Sodium Hypochlorite Solutions

This can be done with the following information:

A= weight percent of initial (strong) sodium hypochlorite.
B= weight percent of desired final (diluted) sodium hypochlorite.
X= gallons of initial (strong) sodium hypochlorite
H= specific gravity of initial (strong) sodium hypochlorite
V= volume of water in gallons needed to be added for dilution per gallon of initial sodium hypochlorite solution.

$$V = X \times H \times \frac{(A - B)}{B}$$

Gallons (V) of water needed per gallon of initial NaOCl solution for dilution = gallons (X) of initial (strong) bleach x sp. gr. (H) of initial (strong) bleach x [(A - B) divided by B].

For example: To dilute one gallon of 10% to 5% sodium hypochlorite by weight.

Gallons of water = (1 gal.) x 1.154 x (10-5) / 5 = 1.154 gallons added per initial one gallon of NaOCl. (For ten gallons of initial strength NaOCl, 10 x 1.154 = 11.54 gal. of water to be added to the ten gallons of initial strength solution).

Care must be taken to obtain an accurate reading of the concentration (weight percent) and specific gravity of the strong solution. If these two factors are wrong the concentration of the diluted solution will be off.

Analytical Procedures

Appropriate analytical procedures can be found in Section 10 of the CI Pamphlet #96.

Personal Protective Equipment (PPE)

The level of PPE needed for diluting sodium hypochlorite solutions is highly dependent on the task or tasks involved in your operation. If lines or connections are disconnected or there is a chance for NaOCl to leave a closed system, then recommended PPE levels are higher. Splash goggles and a face shield along with protective gloves are virtually always recommended. Chemical suits, hats or hoods, boots and respiratory protection are recommended for certain operations. CI Pamphlet #65 on PPE for sodium hypochlorite solutions covers this subject in Section 7.

Chlorine Institute Publications

CI offers many publications and videos on its six mission statement chemicals. These can be reviewed and ordered from our website at www.CL2.com. Some documents like Pamphlet #96, The Sodium Hypochlorite Manual, Ed. 2, can be downloaded from the website for a small fee. You should also consider ordering the video on the safe handling of sodium hypochlorite and Pamphlet #65 on PPE. This information can be very helpful in developing your procedures for handling and diluting sodium hypochlorite.

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