

## BUFFERING EFFECT OF SODIUM HYPOPHOSPHITE AQUEOUS SOLUTIONS

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**Abstract:** *Phosphatation is one of the primary methods for surface treatment and primer coating deposition. Besides, phosphorus can exhibit oxidation states of -3, +3, and +5, providing a variety of compounds potentially suitable for this purpose. Particularly, in sodium hypophosphite, the phosphorus exists in the +1-oxidation state. Consequently, this study investigates whether sodium hypophosphite ( $\text{NaH}_2\text{PO}_2$ ) solutions are acidic or alkaline and examines their pH stability. In this sense, this brief report provides data addressing these questions.*

**Keywords:** *Sodium Hypophosphite, pH ranges, Titration, Buffering Properties.*

### INTRODUCTION

The successful electrochemical formation of Ni-Co-P layers on copper in presence of  $\text{NaH}_2\text{PO}_2$  (Ignatova *et al.*, 2016) has drawn attention to this compound. In turn, various phosphorus-containing acids and salts have been tested for phosphatation of zinc (Fachikova *et al.*, 2023), aluminium (Ilieva *et al.*, 2021) and steel (Ivanova, 2019; Konovalova & Rumyantseva, 2022). Moreover, phosphatation has recently gained interest as a sealing method for cerium conversion coatings (Kozhukharov *et al.*, 2024; Andreeva *et al.*, 2024).

On the other hand, previous research (Atanasova, 2015) has demonstrated that some salt solutions possess buffering properties. Hence, the present study aims to determine the initial pH and the potential buffering properties of aqueous sodium hypophosphite solutions.

### EXPOSITION

#### Materials and equipment

All titrations were conducted using a HI 255 precision combined meter by Hanna Instruments, equipped with an HI 1131 universal glass electrode. The solutions were prepared using the precursors listed in Table 1.

Table. 1. Description of the used Precursors

Precursor	Formula	Purity	Origin
Oxalic acid dihydrate	$\text{C}_2\text{H}_2\text{O}_4 \cdot 2\text{H}_2\text{O}$	99.5 %	Chimspecter Ltd.
Sodium hydroxide	$\text{NaOH}$	99.5 %	Valerus Ltd.
Hydrochloric acid	$\text{HCl}$	37 %	Merck (Germany)
Sodium hypophosphite monohydrate	$\text{NaH}_2\text{PO}_2 \cdot \text{H}_2\text{O}$	99.0 %	Valerus Ltd.

#### Initial solution preparations

Prior to the actual test procedures, NaOH and HCl solutions were prepared with estimated concentrations and standardized by means of titration with oxalic acid solution, as a primary standard. A solution of oxalic acid (6.3379 g dissolved in 1000 ml of distilled water) was prepared in a volumetric flask, with a calculated concentration of  $0.05027 \text{ mol dm}^{-3}$ . It was used to standardize the sodium hydroxide solution, which was prepared by dissolving 4.0202 g of 99.5% NaOH in distilled water in a 2000 ml volumetric flask in order to obtain approximately  $0.05025 \text{ mol.dm}^{-3}$  of NaOH. Seven titrations determined its concentration to be  $0.044 \pm 0.001 \text{ mol dm}^{-3}$ .

This NaOH solution was then used to titrate the diluted HCl solution, which was prepared by dissolving 8.3 ml of concentrated hydrochloric acid in distilled water using a 2000 ml volumetric flask. After titrations with the NaOH solution, its concentration was determined to be  $0.0474 \pm 0.001 \text{ mol dm}^{-3}$ , based on the average value of the NaOH concentration, given above.

The sodium hypophosphite solution (5.3539 g  $\text{NaH}_2\text{PO}_2 \cdot \text{H}_2\text{O}$  dissolved in 1000 ml of distilled water) had an approximate concentration of  $0.05102 \text{ mol dm}^{-3}$ , considering the precursor's 99% purity.

## EXPERIMENTAL PROCEDURES

The standardized NaOH and HCl solutions were used to assess the potential buffering properties of the sodium hypophosphite solution. Each titration involved altering the pH by one unit, following already established protocols (Kozhukharov *et al.*, 2024; Atanasova *et al.*, 2015).

The further experiments used 25 ml of the sodium hypophosphite solution each. Titrations with NaOH and HCl were performed seven times for accuracy, with a 15-minute wait before measuring pH to ensure stability. The obtained results are summarized in Tables 2 and 3.

Table 2. Titration results: Sodium hypophosphite solution with NaOH

Measurement	I	II	III	IV	V	VI	VII
V [ml]	0.15	0.05	0.10	0.10	0.10	0.10	0.10
Initial pH	6.235	6.327	6.218	6.312	6.310	6.302	6.243
Final pH	7.640	7.171	7.383	7.398	7.567	7.572	7.940

The results in the Table 2 reveal that even insignificant quantities of the used alkaline solution (in the range of 0.05 – 0.15 ml.) caused drastic pH changes in the 25 ml hypophosphite probe solutions. Summarizing the data in Table 2, it could be inferred that on average, adding  $0.100 \pm 0.03 \text{ ml}$  of  $0.044 \text{ M}$  of NaOH resulted in a pH shift from an initial value of  $6.28 \pm 0.04$  to  $\text{pH} = 7.9 \pm 0.9$ .

Table 3. Titration results: Sodium hypophosphite solution with HCl

Measurement	I	II	III	IV	V	VI	VII
V [ml]	0.10	0.10	0.05	0.10	0.10	0.05	0.10
Initial pH	6.136	6.172	6.102	6.093	6.075	6.077	6.077
Final pH	4.009	3.826	4.447	4.082	3.982	4.447	3.996

The data in Table 3 confirm these observations. The pH values of the seven  $0.05102 \text{ mol dm}^{-3}$   $\text{NaH}_2\text{PO}_2 \cdot \text{H}_2\text{O}$  probe solutions underwent drastic changes as well. Adding just  $0.09 \pm 0.02 \text{ ml}$  of  $0.0474 \text{ M}$  HCl to the probe solutions shifted the initial pH ( $6.10 \pm 0.04$ ) to a final pH of  $4.1 \pm 0.2$ .

As noted, a 15-minute wait was necessary before recording the pH values. Immediately after titrant addition, pH values displayed greater fluctuations and instability. This instability suggests that under conventional conditions, constructing titration curves is difficult, if not impossible.

## CONCLUSION

Attempts to titrate 0.05 M aqueous sodium hypophosphite solutions were done. For this purpose, 0.05 M secondary standard NaOH and HCl solutions were prepared by means of titration with a primary standard solution of oxalic acid.

No buffering properties were observed, instead hypophosphite anions decomposed, resulting in sharp and immediate pH shifts.

This behaviour hinders the construction of titration curves under conventional conditions.

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