Estimation of Hydrogen Gas Concentration in Aqueous Solutions via Oxidation-Reduction Potential Measurements as a Function of pH

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Introduction

The medicinal and therapeutic effects of hydrogen-rich water ingestion have caught the attention of hospitals, the health industry and even NASA.[1] Indeed drinking hydrogen-rich water is often more effective than inhalation;[2] however, hydrogen exhibits low solubility and readily escapes the solution to reach equilibrium. Therefore, it is important to estimate if the hydrogen gas concentration in solution is significant enough to exert its therapeutic effects. Unfortunately, the current methods of measuring hydrogen gas concentration are difficult and not practical in clinical or individual settings.

This work proposes a novel method of estimating hydrogen gas concentration in solution in terms of simple pH and oxidation-reduction potential (ORP) measurements.

Methods

- Samples (4) of tap water at pH 2, 7, 10 and 12 were prepared by the addition of HCl or NaOH as appropriate.
- Measurements were taken at a pressure of 0.83 atm and a temperature of 19°C.
- pH, dissolved oxygen, and ORP of each sample were initially measured as a control.
- Hydrogen gas was bubbled into the solutions and ORP was again measured.

Results

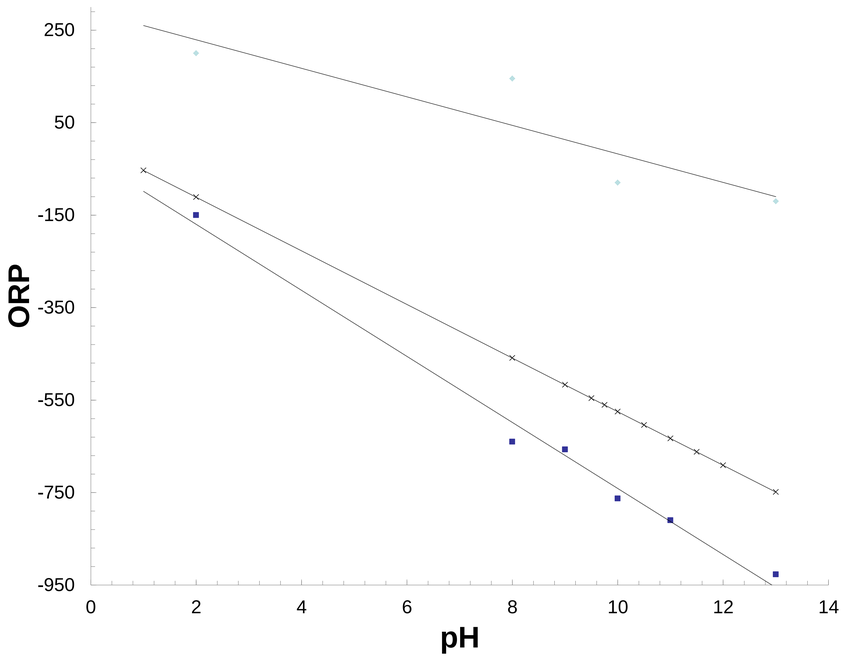

Figure 1. Relationship of ORP and pH when saturated with H_2 gas. Predicted relation as calculated by the Nernst equation ✕ Measured ORP when saturated with H_2 gas ◆ Measured ORP with no H_2 gas ■

- ORP decreased with increasing pH before addition of hydrogen gas (R^2=0.80).
- When hydrogen gas was bubbled into solution, the ORP decreased with increasing pH (R^2=0.99).
- The lowest ORP measurement (-927 mV) was obtained at the highest pH (13) with addition of hydrogen gas.
- The lowest measured ORP value is 178 mV more negative than what was predicted by the Nernst equation
- As the pH increased, there was a trend to greater deviations between the predicted and measured ORP values.

Discussion

- The measured linear relation between ORP and pH follows the trend predicted by the Nernst equation.
  - The higher the pH the more negative the ORP.
- The more negative measured ORP values compared to the predicted ORP values may be indicative of a supersaturated hydrogen gas solution.
  - Hydrogen was bubbled into water under high pressure.
- The greater deviation from the Nernst equation values compared to the observed values at higher pHs may suggest that a high pH facilitates hydrogen supersaturation.
  - Hydrogen-rich water produced via electrolysis has been shown to be supersaturated with nanosize hydrogen bubbles existing in negative colloidal forms around the hydroxides[3].

Conclusion

The ease of pH and ORP measurements may be a rapid and effective tool in the clinical and practical settings to estimate hydrogen gas concentration of hydrogen-rich water.

References

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