

Stability Optimization of NaBH_4 via pH and $\text{H}_2\text{O}:\text{NaBH}_4$ Ratios for Large Scale Hydrogen Production

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Abstract : There is an increasing need for alternative clean fuels, and hydrogen (H_2) has long been considered a promising solution with a high calorific value (142MJ/kg). However, the storage of H_2 and expensive processes for its generation have hindered its usage. Sodium borohydride (NaBH_4) can potentially be used as an economically viable means of H_2 storage. Thus far, there have been attempts to optimize the life of NaBH_4 (half-life) in aqueous media by stabilizing it with sodium hydroxide (NaOH) for various pH values. Other reports have shown that H_2 yield and reaction kinetics remained constant for all ratios of H_2O to $\text{NaBH}_4 > 30:1$, without any acidic catalysts. Here we highlight the importance of pH and $\text{H}_2\text{O}:\text{NaBH}_4$ ratio (80:1, 40:1, 20:1 and 10:1 by weight), for NaBH_4 stabilization (half-life reaction time at room temperature) and corrosion minimization of H_2 reactor components. It is interesting to observe that at any particular $\text{pH} > 10$ (e.g., $\text{pH} = 10, 11$ and 12), the $\text{H}_2\text{O}:\text{NaBH}_4$ ratio does not have the expected linear dependence with stability. On the contrary, high stability was observed at the ratio of 10:1 $\text{H}_2\text{O}:\text{NaBH}_4$ across all $\text{pH} > 10$. When the $\text{H}_2\text{O}:\text{NaBH}_4$ ratio is increased from 10:1 to 20:1 and beyond (till 80:1), constant stability (% degradation) is observed with respect to time. For practical usage (consumption within 6 hours of making NaBH_4 solution), 15% degradation at $\text{pH} 11$ and $\text{NaBH}_4:\text{H}_2\text{O}$ ratio of 10:1 is recommended. Increasing this ratio demands higher NaOH concentration at the same pH, thus requiring a higher concentration or volume of acid (e.g., HCl) for H_2 generation. The reactions are done with tap water to render the results useful from an industrial standpoint. The observed stability regimes are rationalized based on complexes associated with NaBH_4 when solvated in water, which depend sensitively on both pH and $\text{NaBH}_4:\text{H}_2\text{O}$ ratio.

Keywords : hydrogen, sodium borohydride, stability optimization, $\text{H}_2\text{O}:\text{NaBH}_4$ ratio

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