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Stability Optimization of $NABH_4$ via PH and $H_2O:NABH_4$ 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 $NaBH_4$ > 30:1, without any acidic catalysts. Here we highlight the importance of pH and H_2O: $NaBH_4$ 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 pH>10 (e.g., pH = 10, 11 and 12), the H_2O: $NaBH_4$ ratio does not have the expected linear dependence with stability. On the contrary, high stability was observed at the ratio of 10:1 H_2O: $NaBH_4$ across all pH>10. When the H_2O: $NaBH_4$ 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 pH 11 and $NaBH_4$: H_2O 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 $NaBH_4$: H_2O ratio.

Keywords : hydrogen, sodium borohydride, stability optimization, $H_2O:NaBH_4$ ratio
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