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Hydrogen production and storage from hydrolysis of sodium borohydride: study of the recyclability of the by-product of reaction

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Hydrogen is one of the most valuable alternatives to fossil fuels to produce energy. However, although it is abundant in the universe and has the highest gravimetric density, it is difficult to obtain and store in its molecular form and in safe conditions. One alternative to the conventional hydrogen storage is to use the high hydrogen content (10.66 wt. %) of sodium borohydride to, simultaneously, produce and store it [1]. Hydrogen can be obtained at room temperature and pressure by hydrolysis of sodium borohydride, as described in Equation 1,

$$NaBH_4 + (2+x)\ H_2O \rightarrow NaBO_2 \bullet x\ H_2O + 4\ H_2 \quad (1)$$

where x is the hydration factor. Excess of water is necessary since the by-product of reaction, sodium metaborate, retains typically 2 or 4 water molecules, decreasing the hydrogen yield and generation rate [1]. Thus, additives can be added to alter this reaction, for example, sodium carboximethyl cellulose (CMC). Ferreira et al. [2] observed the rearrangement of the sodium metaborate molecules when additive CMC was used in the hydrolysis of sodium borohydride. This way, sodium boron hydroxide was formed, a compound that does not retain water molecules and it is easier to recycle than sodium metaborate. Due to the cost of sodium borohydride, its regeneration is essential to implement a circular economy in a system that aims the production of *green* hydrogen for energy applications. Overall, this work focuses on the by-product of sodium borohydride hydrolysis: additives were used to observe its composition and a new method to regenerate sodium borohydride was developed.

[1] M. J. F. Ferreira, C. M. Rangel and A. M. F. R. Pinto (2012). Water handling challenge on hydrolysis of sodium borohydride in batch reactors. *International Journal of Hydrogen Energy*, 37 (8), pp.6985–6994.

[2] M. J. F. Ferreira, V. R. Fernandes, L. Gales, C. M. Rangel and A. M. F. R. Pinto (2010). Effects of the addition of an organic polymer on the hydrolysis of sodium tetrahydroborate in batch reactors. *International Journal of Hydrogen Energy*, 35 (20), pp.11456–11469.