Optimizing Conditions for the Hydrogen Release from Ammonia Borane – A Systematic Study on the Effect of Boric Acid or Different Additives to Catalytic Activity

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Background

Hydrogen storage is one of the hindrances to the implementation of hydrogen fuel. Ammonia borane (AB) has been regarded as an appealing hydrogen storage material to resolve the technical challenges of hydrogen storage. The release of hydrogen from AB can be achieved through hydrolysis, but a catalyst is required for enhancing the dehydrogenation performance. Thus, developing a cost-effective catalyst for AB hydrolysis is essential for tackling the hydrogen storage problem, which is crucial to the hydrogen economy. Boron-nitride (BN), which can be prepared from boric acid and melamine, has been increasingly implemented in the field of catalysts due to its high thermal conductivity and stability. Nonetheless, the studies on developing boron-supported catalysts (especially with carbon nanotubes) for AB hydrolysis and the effect of boric acid ratio on catalytic activity are still limited.

Research Objectives

There are 2 main objectives in this project:

- ◆ To develop a series of catalysts with binary metal nanoparticles and dual atoms dispersed on boron nitride carbon nanotubes (BNCNT).
- ◆ To determine the effect of boric acid on the catalytic activity of ammonia borane hydrolysis by adjusting the ratio of boric acid to melamine.

Methodology

Experiment: Hydrolysis of ammonia borane with as-prepared catalyst

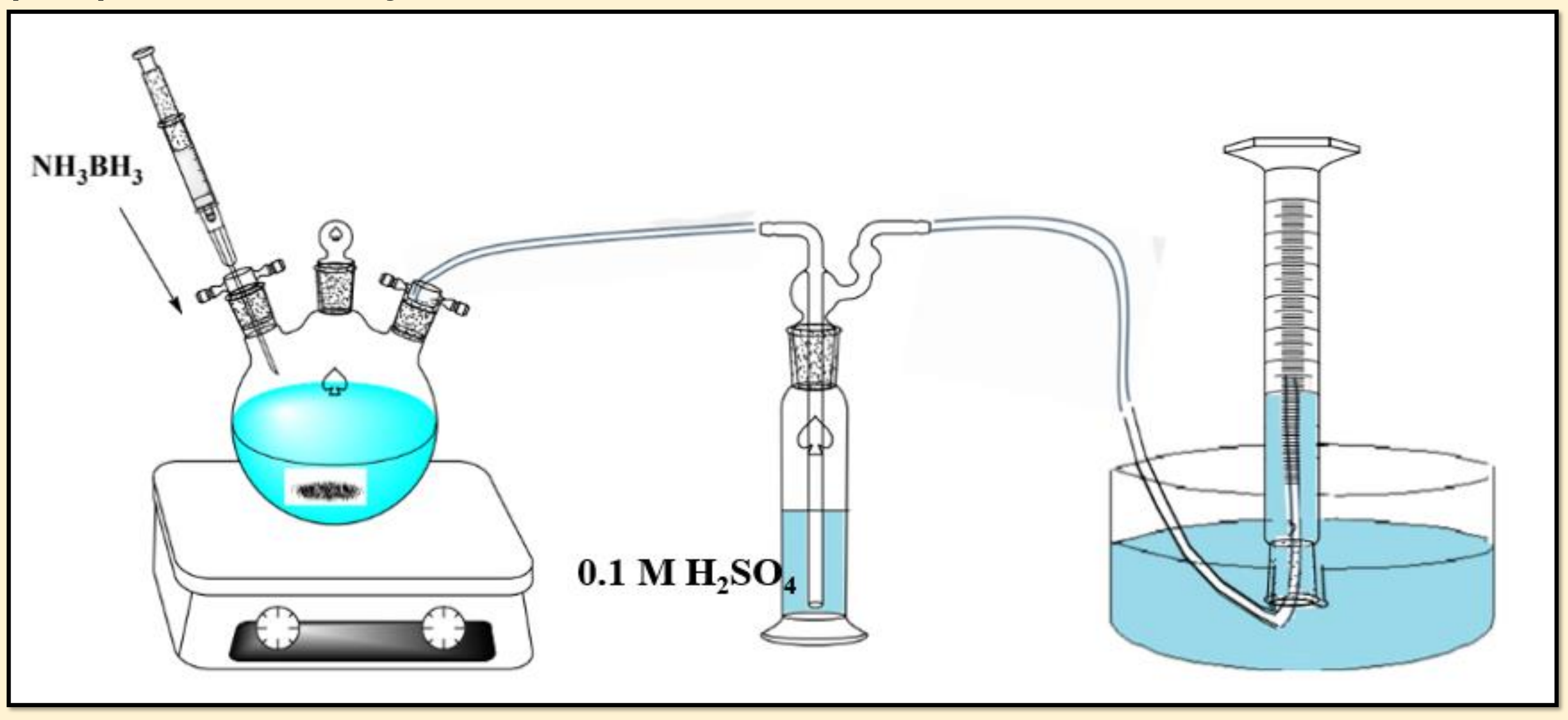

Figure 1. Lab-scale experimental setup for the hydrolysis of ammonia borane.

Analysis: Structural characterization techniques for catalyst

- ◆ X-ray Powder Diffraction (XRD)
- ◆ Ramen Spectroscopy
- ◆ X-ray Photoelectron Spectroscopy (XPS)
- ◆ Scanning Electron Microscopy (FE-SEM)
- ◆ Transmission Electron Microscopy (TEM)

Analysis: Catalytic activity evaluation & Kinetic Studies

- ◆ Specific Hydrogen Generation Rate
- ◆ Turnover Frequency (TOF)
- ◆ Cycling Performance
- ◆ Activation Energy

Results

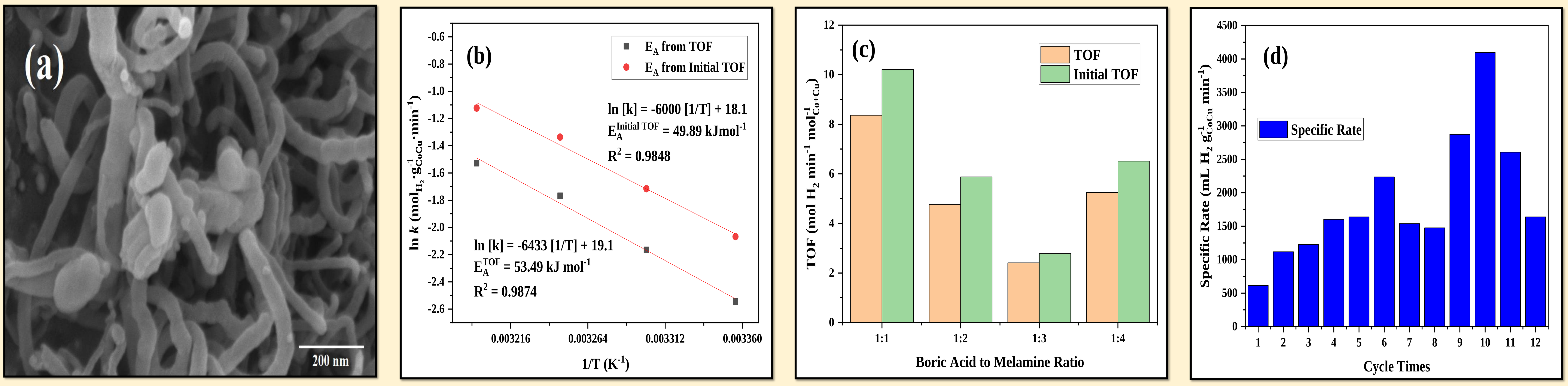

Figure 2. a) The CNT structure of catalyst (1:1) under FE-SEM; b) Arrhenius plots obtained from the kinetic data; c) TOF ratios of catalysts with different boric acid to melamine ratio; d) Plot of specific rate versus cycling times of catalyst.

Conclusion

To conclude, the CoCu/CoCuN$_x$-CNT-900T catalysts with different boric acid to melamine ratios (1:1, 1:2, 1:3, and 1:4) were successfully synthesized in this project. The catalyst with boric acid to melamine ratio = 1:1 demonstrated the best catalytic activity among the 4 catalysts. It has a specific hydrogen generation rate of 4096.98 $\mathrm{mL_{H_2} g_{CoCu}^{-1} min^{-1}}$ and an average TOF value of 8.51 mol H_2 min^{-1}$\mathrm{mol_{Co+Cu}^{-1}}$. The activation energy of this catalyst was determined to be 53.49 kJ $\mathrm{mol^{-1}}$. Consequently, the optimized ratio of boric acid to melamine for preparing the catalyst was found to be 1:1 in this research.