Pore-confined NaNH2 and KNH2 as catalysts for low temperature ammonia decomposition

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Ammonia is considered as an attractive energy carrier because of its high energy density (4 kWh/kg), high hydrogen content (17.7 wt%), and well-developed storage and transportation technology. On-site generation of hydrogen via NH3 decomposition at low temperatures (< 450 °C) can bypass the challenges of hydrogen storage and transportation, thus, has received considerable attention in recent times.[1] However, the use of NH3 as hydrogen source relies on the development of high efficiency NH3 decomposition catalysts.[2]

In the last two decades, many traditional catalysts, including transition metals (TMs), alloys, carbides and nitrides, have been investigated for ammonia decomposition.[3-5] A more recent development is those catalysts based on alkali metal amides.[4-6] Previous report showed that the use of composites of transition metals and lithium amide leads to high catalytic activities for NH3 decomposition.[4,5]

Here we report on the decomposition of ammonia using nanopore-confined NaNH2 and KNH2 catalysts. Transition metal (Ni or Ru) doped NaNH2 and KNH2 were deposited in the pores of carbon supports by a combination of solution impregnation and melt infiltration. NaNH2/C and KNH2/C nanocomposites show < 10% NH3 conversion even at 500 °C, while the 8 wt% Ni doped NaNH2 and KNH2 nanocomposites give NH3 conversions of 79% and 60% respectively at 425 °C, close to the performance of a 5 wt% Ru/C reference catalyst. 1.6 wt% Ru doped NaNH2 and KNH2 nanocomposites exhibit even better catalytic performance, with about 95% NH3 conversion at a moderate temperature of 375 °C. The apparent activation energies (53-63 kJ mol⁻¹) of the Ru or Ni doped amide/C nanocomposites are among the lowest values for ammonia decomposition catalysts reported in the literature. The excellent catalytic performance is attributed to the synergy between the transition metals and amides due to the nanoscale intimacy by co-confinement in the carbon nanopolare. The strategy of nanoconfinement of alkali metal amides in porous hosts may open a new avenue for effectively generating H2 from NH3 at low temperatures.

a-c. STEM-EDX images and particle size distributions of the Ru-sodium amide nanocomposite. d-e. the comparison of ammonia decomposition activities and apparent activation energies of carbon supported catalysts.


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