Electronic Supplementary Information (ESI) for Catalysis Science & Technology

A stable, efficient 3D Cobalt-graphene composite catalyst for the hydrolysis of ammonia borane

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This PDF includes:

1. TGA and FT-IR characterization of PEI-$GO_{2D\ amide}$;
2. Morphology observation of PEI-$GO_{2D\ amide}$ and PEI-$GO_{2D\ amide}$ /Co;
3. Chemical Composition of PEI-$GO_{2D\ amide}$/Co materials;
4. TEM images of PEI-GO_{3D}/Co and PEI-$GO_{2D\ amide}$/Co after stability test;
5. Hydrogen evolution of AB catalyzed by PEI-$GO_{2D\ amide}$/Co at different temperatures.

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1. TGA and FT-IR characterization of PEI-$GO_{2D\ amide}$

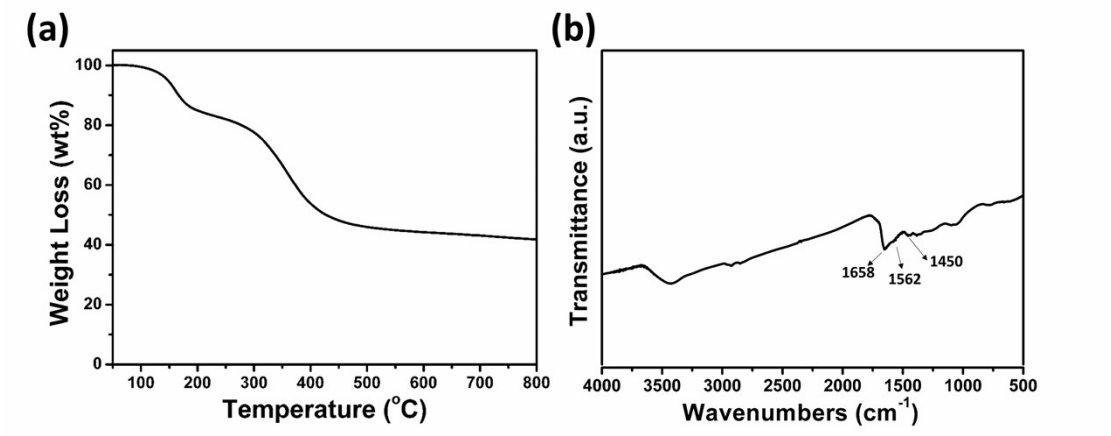

Figure S1. (a) TGA curve and (b) FT-IR sprectrum of PEI-$GO_{2D\ amide}$.

Fig. S1a shows the TGA curve of PEI-$GO_{2D\ amide}$. The mass loss of PEI molecules mainly occurs between 300-400 ^{o}C; therefore, PEI-$GO_{2D\ amide}$ contains about 30% PEI, lower than PEI-GO_{3D} (45%). Fig. S1b gives the FT-IR spectrum of PEI-$GO_{2D\ amide}$. The peak at 1658 cm^{-1} indicates the existence of large amount of amide group. However, the peaks at 1562 (NH_2) and 1450 cm^{-1} (C-N) are weak, meaning that the content of amine groups is quite low.

2. Morphology observation of PEI-$GO_{2D\ amide}$ and PEI-$GO_{2D\ amide}$/Co

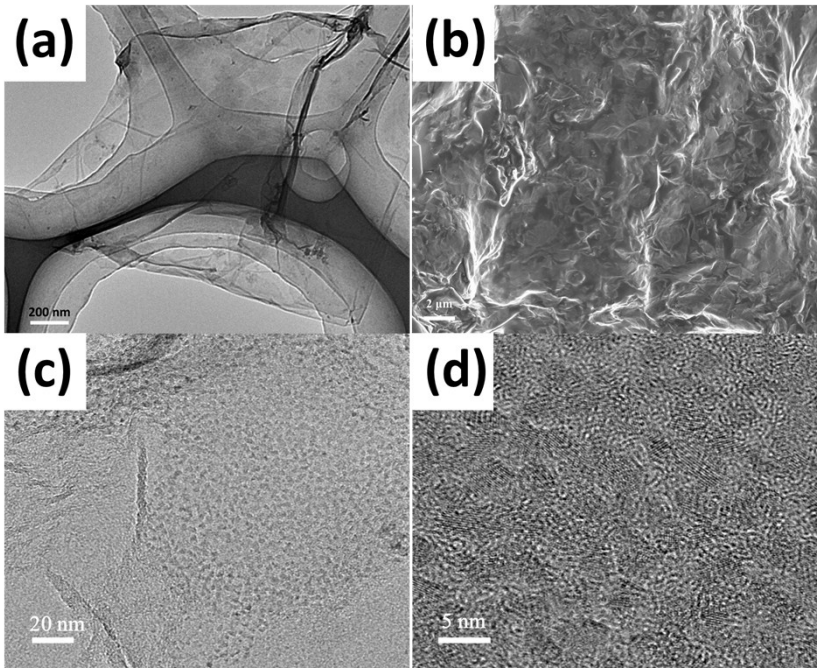

Figure S2. (a) TEM and (b) FESEM images of PEI-$GO_{2D\ amide}$. (c, d) HRTEM of PEI-$GO_{2D\ amide}$/Co.

Fig. S2a is the TEM image of PEI-$GO_{2D\ amide}$. No obvious corrugations are obtained, indicating a low content of PEI molecules linked on GO. The FESEM image in Fig. S2b shows that PEI-$GO_{2D\ amide}$ has a typical 2D structure. HRTEM images of Fig. S2c and d shows the uniform and dense

deposition of Co NPs on PEI-$GO_{2D\ amide}$, with the average size of ~4 nm.

3. Chemical Composition of PEI-$GO_{2D\ amide}$/Co materials

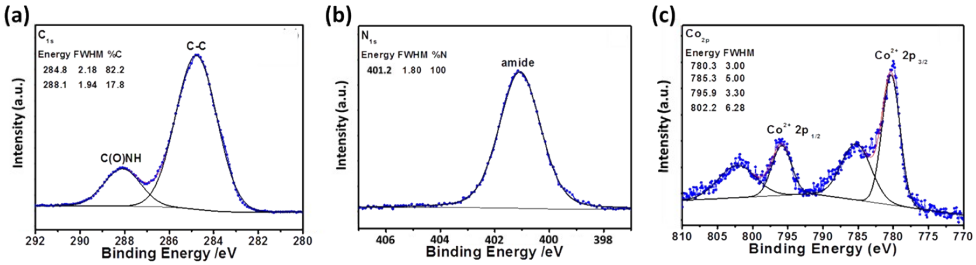

Figure S3. XPS survey of (a) C_{1s}, (b)N_{1s} and (c) Co_{2p} core-level spectra of PEI-$GO_{2D\ amide}$/Co.

Fig. S3a presents the C_{1s} core-level spectrum. The peaks at 284.8 and 288.1 eV are ascribed to C-C and C(O)NH species, respectively. And the N_{1s} spectrum in Fig. S3b indicates that only amide groups exist in PEI-$GO_{2D\ amide}$, amine groups are not significant. This is consistent with FT-IR results.

4. TEM images of PEI-GO_{3D}/Co and PEI-$GO_{2D\ amide}$/Co after stability test

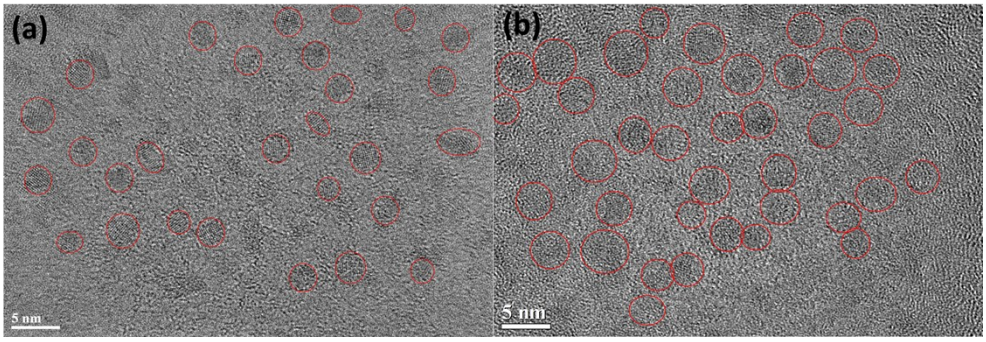

Figure S4. TEM image of (a) PEI-GO_{3D}/Co and (b) PEI-$GO_{2D\ amide}$/Co after five cycles of the catalytic hydrolysis of AB.

Fig. S4a shows the particle size of PEI-GO_{3D}/Co after five cycles catalytic hydrolysis of AB. The particle size doesn't have obvious increment. Fig. S4b shows the particle size of PEI-$GO_{2D\ amide}$/Co after five cycles. The average particle size increases from ~4 nm to ~5 nm. Therefore, PEI-GO_{3D} has much better dispersing ability for Co NPs than PEI-$GO_{2D\ amide}$.

5. Hydrogen evolution of AB catalyzed by PEI-$GO_{2D\ amide}$/Co at different temperatures

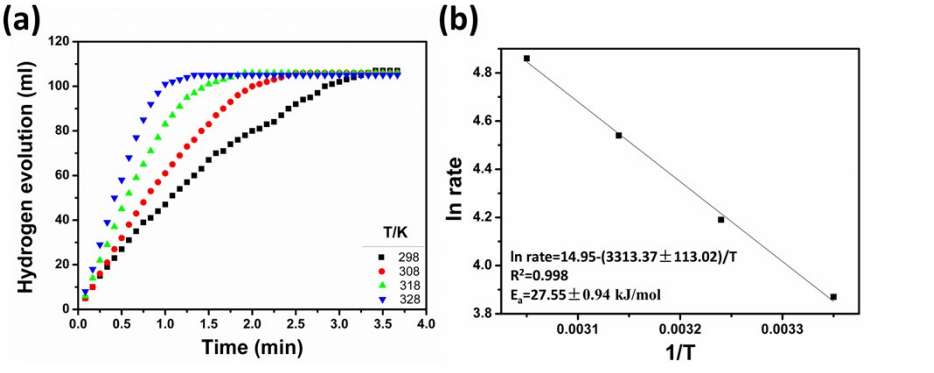

Figure S5. (a) Hydrolysis of AB by PEI-$GO_{2D\ amide}$/Co at different temperatures and (b) the corresponding Arrhenius plot of ln rate vs. (1/T)

Fig. S5a shows the AB hydrolysis behavior catalyzed by PEI-$GO_{2D\ amide}$/Co at different temperatures. The linear part of these hydrogen evolution curves are used to calculate hydrogen generation rate (r). Then, ln(r) verses 1/T is re-plotted in Fig. S5b. The calculated activation energy of PEI-$GO_{2D\ amide}$/Co is 27.55 ± 0.94 kJ mol^{-1}, which is slightly higher than that of PEI-GO_{3D}/Co.