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

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

![Figure S1](image)

**Figure S1.** (a) TGA curve and (b) FT-IR spectrum 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 °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](image)

**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\textsubscript{2D amide}, with the average size of \(~4\) nm.

3. **Chemical Composition of PEI-GO\textsubscript{2D amide}/Co materials**

![Figure S3. XPS survey of (a) C\textsubscript{1s}, (b)N\textsubscript{1s} and (c) Co\textsubscript{2p} core-level spectra of PEI-GO\textsubscript{2D amide}/Co.](image)

Fig. S3a presents the C\textsubscript{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\textsubscript{1s} spectrum in Fig. S3b indicates that only amide groups exist in PEI-GO\textsubscript{2D amide}, amine groups are not significant. This is consistent with FT-IR results.

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

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

Fig. S4a shows the particle size of PEI-GO\textsubscript{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\textsubscript{2D amide}/Co after five cycles. The average particle size increases from \(~4\) nm to \(~5\) nm. Therefore, PEI-GO\textsubscript{3D} has much better dispersing ability for Co NPs than PEI-GO\textsubscript{2D amide}.

5. **Hydrogen evolution of AB catalyzed by PEI-GO\textsubscript{2D amide}/Co at different temperatures**
Figure S5. (a) Hydrolysis of AB by PEI-GO\textsubscript{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\textsubscript{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\textsubscript{2D amide}/Co is 27.55 ± 0.94 kJ mol\textsuperscript{-1}, which is slightly higher than that of PEI-GO\textsubscript{3D}/Co.