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Graphitic Carbon Nitride Modified with 1,3-Benzothiazole-2-carbaldehyde for Enhancement of Visible Light Hydrogen Production Activity

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INTRODUCTION & AIM

Massive consumption of fossil fuels
→ CO_2 emissions and resource depletion

Hydrogen Energy

Method by water splitting using photocatalyst

【Graphitic carbon nitride ($g\text{-}C_3N_4$)]】 → Visible light responsive photocatalyst

○Advantages

- Thermal and physical stability
- Low cost
- Non-toxic

×Issues

- Electron-hole pair recombination
- Narrow visible light absorption range
- Low specific surface area

In this study, we aim to increase the specific surface area by thermal exfoliation treatment and form a donor-acceptor (D-A) structure by introducing benzothiazole, an electron-withdrawing group (acceptor), to expand the visible light absorption range and promote separation of electron-hole pairs, thereby improving hydrogen production activity

METHOD

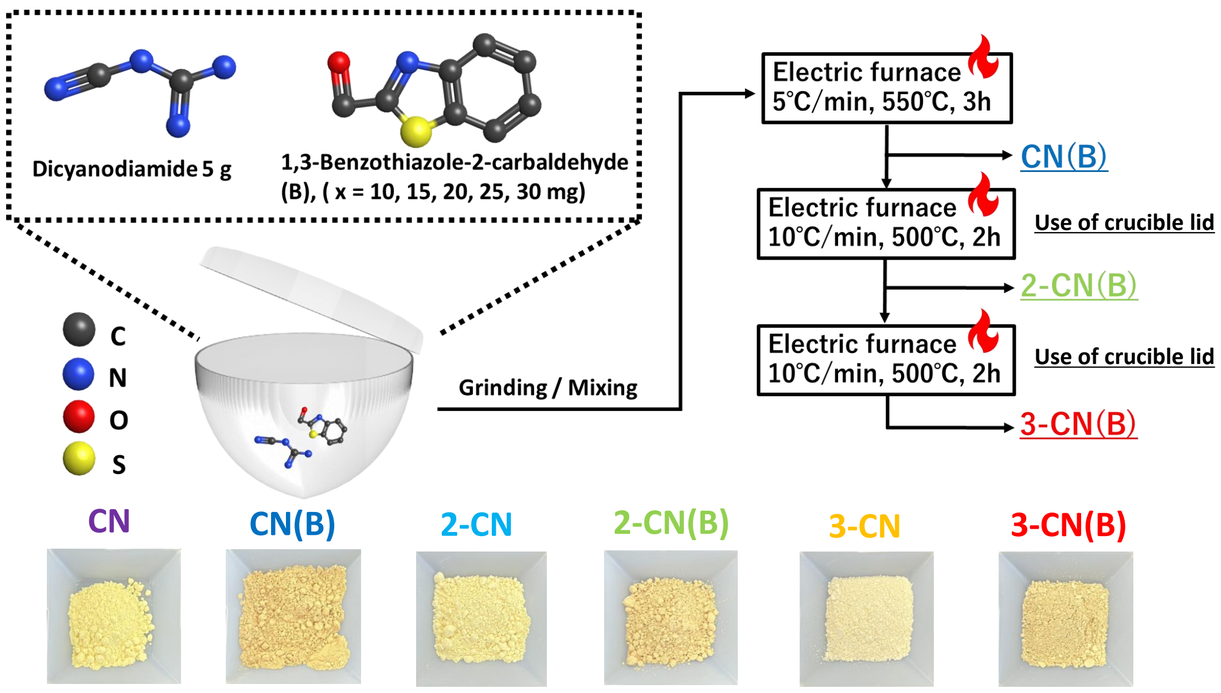

Fig. 1. Preparation of $g\text{-}C_3N_4$.

Table 1. Experimental condition.

Photocatalyst	Photocatalysts (40 mg) / Pt (0.8 mg : 2.0 wt%)
Medium	Water (35.2 mL), TEOA (4 mL : 10 vol%), H_2PtCl_6 (0.8 mL : 1000 ppm)
Reactor	Pyrex glass vessel (Volume : 123 mL)
Temperature	Room temperature (25 ℃)
Light source	Xenon lamp (λ≧420 nm, 10 mW/cm²)
Irradiation time	6 hours
Analysis	Gas chromatography (TCD)

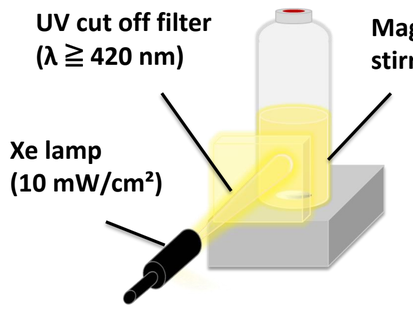

Fig. 2. Photoreactor for photocatalytic hydrogen production.

RESULTS

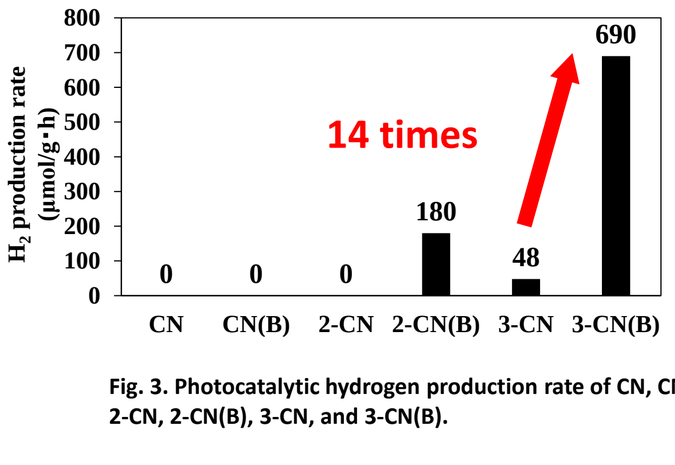

Fig. 3. Photocatalytic hydrogen production rate of CN, CN(B), 2-CN, 2-CN(B), 3-CN, and 3-CN(B).

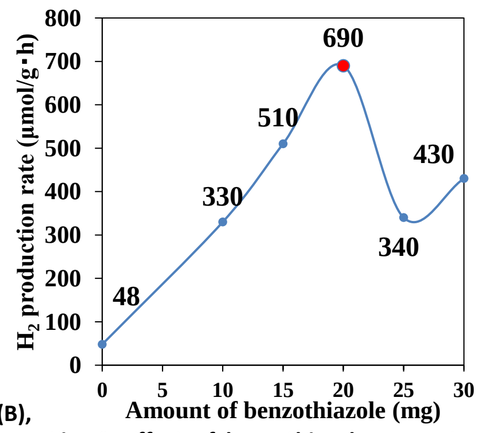

Fig. 4. Effect of benzothiazole amounts on the photocatalytic hydrogen production.

DISCUSSION

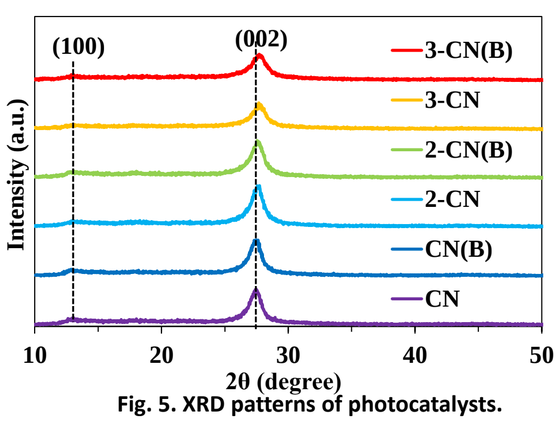

Fig. 5. XRD patterns of photocatalysts.

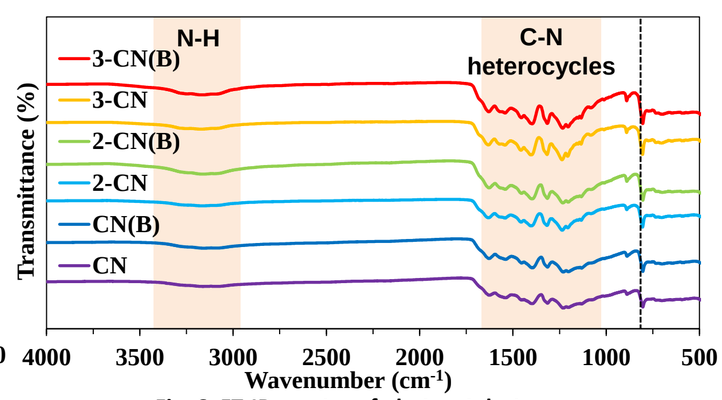

Fig. 6. FT-IR spectra of photocatalysts.

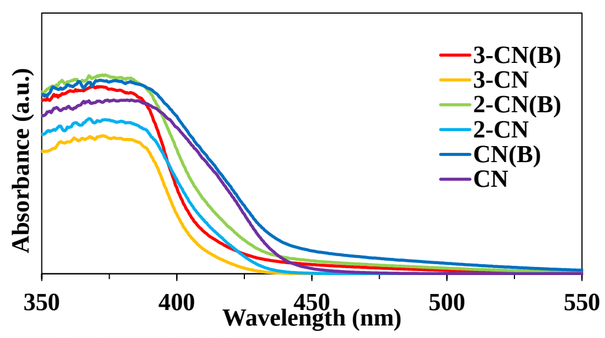

Fig. 7. UV-vis DRS spectra of photocatalysts.

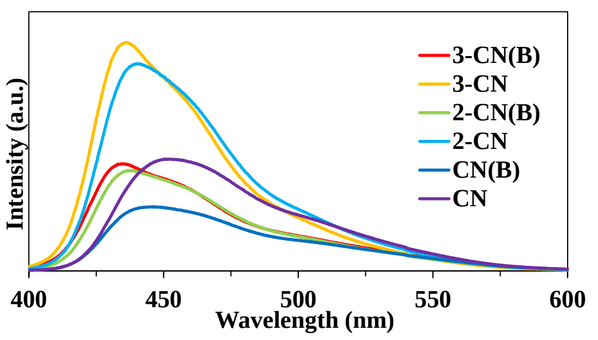

Fig. 8. PL spectra of photocatalysts.

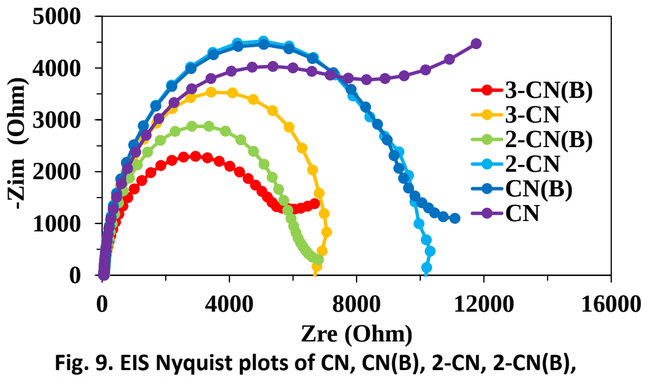

Fig. 9. EIS Nyquist plots of CN, CN(B), 2-CN, 2-CN(B), 3-CN, and 3-CN(B).

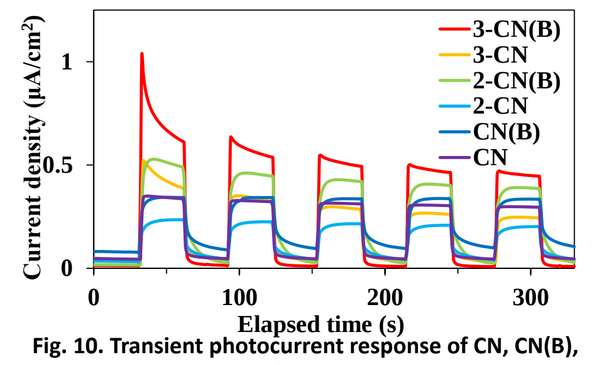

Fig. 10. Transient photocurrent response of CN, CN(B), 2-CN, 2-CN(B), 3-CN, and 3-CN(B).

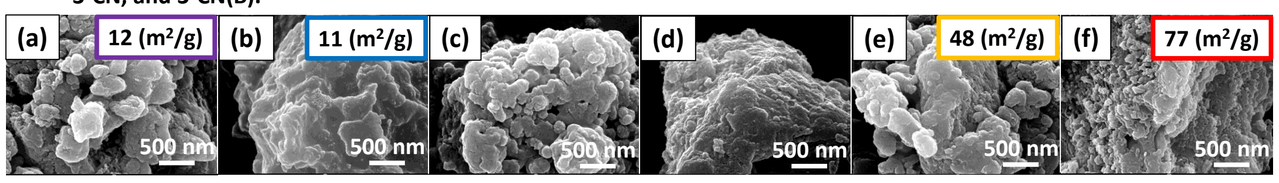

Fig. 11. SEM, and BET surface area of (a) CN, (b) CN(B), (c) 2-CN, (d) 2-CN(B), (e) 3-CN, and (f) 3-CN(B).

MECHANISM

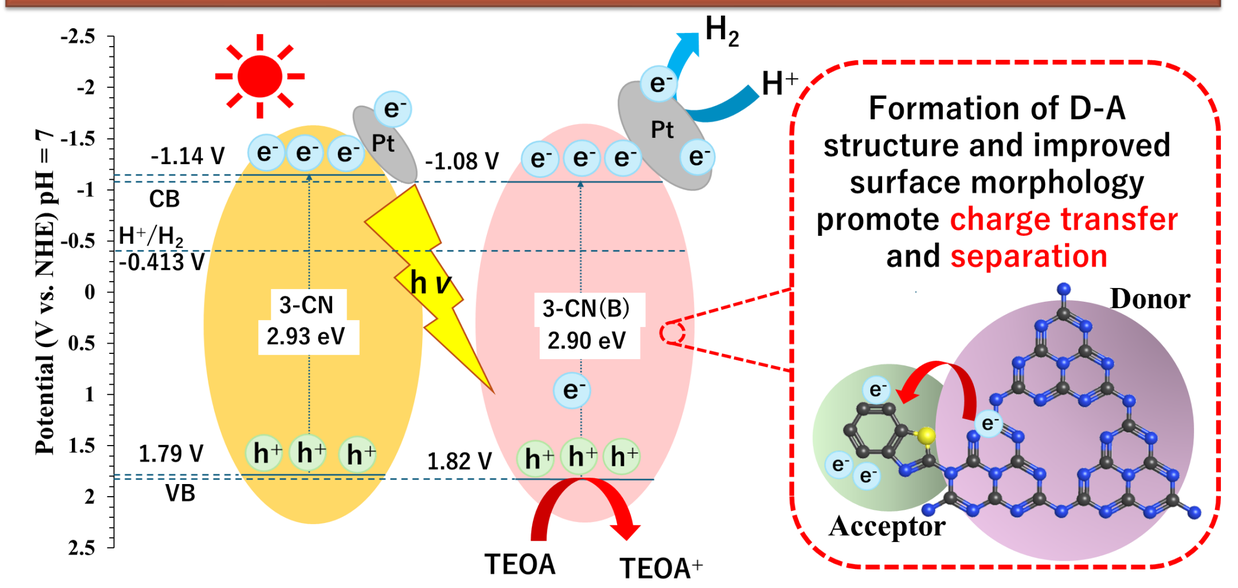

Fig. 12. Mechanism of photocatalytic H_2 production.

CONCLUSION

- The addition of 1,3-benzothiazole-2-carbaldehyde increased the hydrogen production rate by a factor of about 14 compared to pure graphitic carbon nitride.
- The construction of donor-acceptor and thermal exfoliation treatments promoted the separation and migration of photogenerated carriers, leading to an increase in hydrogen production activity.

FUTURE WORK / REFERENCES

- Introduction of electron-donating molecules
- Composite with different photocatalysts

X. Zhang, F. Wu, G. Li, L. Wang, J. Huang, A. Song, A. Meng, Z. Li, Journal of Colloid and Interface Science, 655, 2024, 439-450