Green Synthesis of Nanostructured Photocatalysts for Solar Hydrogen Production

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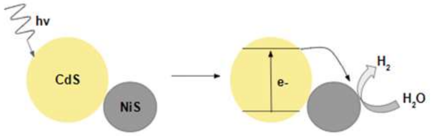
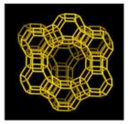
Background

- Water-splitting to form H_2 using solar energy in the presence of a photocatalyst is a method of producing clean and renewable energy
- Semiconductor photocatalysts form an electron-hole pair that can participate in redox reactions when excited by light
- Use of a cocatalyst can reduce electron-hole charge recombination rates, thus improving H_2 production rates



- Encapsulation of photocatalyst/cocatalyst systems inside the pores of zeolites (aluminosilicate microporous crystalline supports) has been reported to improve stability of photocatalysts and production rates[1, 2]
- Increased production rates are likely due to zeolite Lewis acid sites further preventing fast charge recombination and pore structure promoting increased contact between photocatalyst and cocatalyst[1, 2]



Microporous structure of zeolite Y[3]

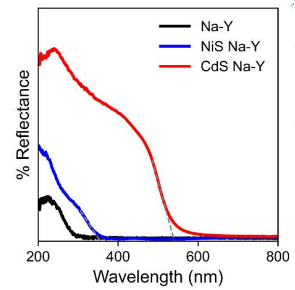
- This study reports the synthesis of CdS/NiS in a zeolite Na-Y support to be used for improved photocatalytic H_2 production using visible light

References

1. Zhou, Xiaoxia, et al. *Applied Catalysis B: Environmental*, vol. 152-153, 2014, pp. 271–279.
2. Chatti, Ravikrishna V., et al. *International Journal of Hydrogen Energy*, vol. 35, no. 5, 2010, pp. 1911–1920.
3. http://www.iza-structure.org/databases/
4. Guan, Shundong, et al. *Chemical Science*, vol. 9, no. 6, 2018, pp. 1574–1585.
5. Artagan, Öge, et al. *Journal of Taibah University for Science*, vol. 15, no. 1, 2021, pp. 154–169.
6. Saleem, Muhammad Farooq, et al. *Journal of Raman Spectroscopy*, vol. 48, no. 2, 2016, pp. 224–229.
7. Herron, N., et al. *ChemInform*, vol. 20, no. 17, 1989.

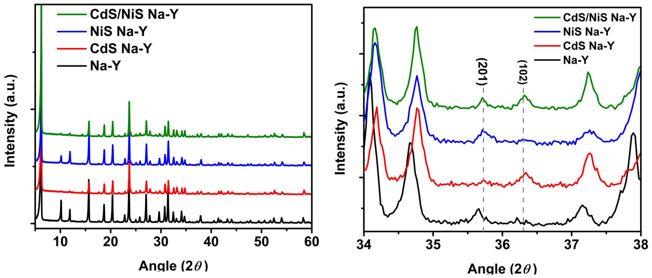
Results

Ultraviolet-Visible Diffuse Reflectance Spectroscopy Data



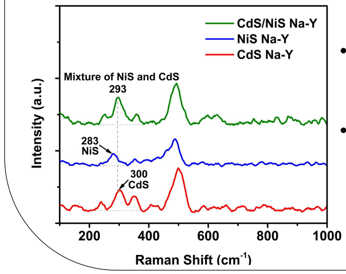
- Indicates presence of NiS and CdS in Na-Y due to differences in spectra and band gaps
- Band gaps of CdS and NiS were calculated to be 2.29 eV and 3.48 eV, confirming that CdS absorbs energy in the visible range and NiS does not

X-Ray Diffraction Data



- Similar XRD peaks among samples indicates retention of zeolite structure after incorporation of CdS and NiS (left)
- (102) plane of CdS and (201) plane of NiS are present in samples containing CdS and NiS (right)[4]
- **Indicates the incorporation of CdS and NiS, simultaneously, in zeolite Na-Y**

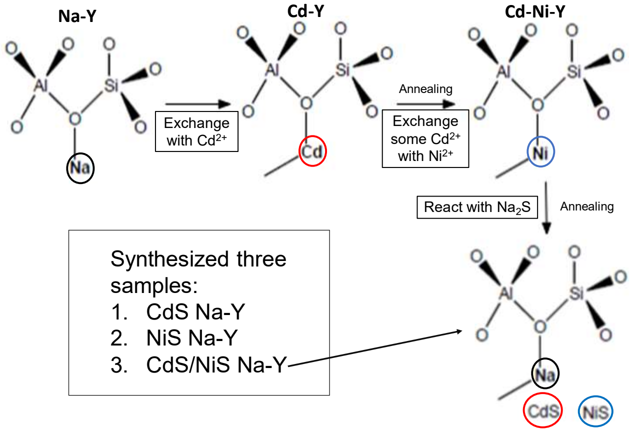
Raman Spectroscopy Data



- CdS/NiS Na-Y sample shows peak at 293 cm^{-1}, indicating mixture of NiS and CdS[5, 6]
- **Further indicates simultaneous incorporation of CdS and NiS in Na-Y**

Method

- Incorporated CdS and NiS into zeolite Na-Y using ion-exchange technique[7]



Synthesized three samples:

1. CdS Na-Y
2. NiS Na-Y
3. CdS/NiS Na-Y

Future Directions

- Use XPS to determine valence band for CdS and NiS in Na-Y to better understand band gap structure
- Use TEM to see if CdS and NiS are encapsulated and/or on the surface of zeolite
- Use BET to analyze pore size change before and after addition of photocatalyst system
- Run photocatalytic water-splitting reactions with synthesized samples and observe H_2 production rates and photostability

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