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HYDROGEN ENERGY

Co-production of hydrogen and nanocarbon from methane

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Fossil Fuel and GHG emission

- Fossil fuels dominate energy consumption with a market share of 87%
- Emission of GHGs like CO_x, C_xH_y, NO_x, SO_x, etc.

- Atmospheric CO_2 level hits awful record highs
- Global warming, climate change and ocean acidification
- Alternatives - Wind, solar, bio and nuclear energy

Introduction

Jos G.J. Olivier GJ-M, Jeroen A.H.W. Peters. *Trends in Global CO_2 Emissions*. PBL; 2012

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Hydrogen

- **Hydrogen - a clean fuel - produces water only on its combustion**
- The simplest, the lightest and the most abundant element
- Greenest energy
- 3X energy than any other fuel on a mass basis
- Secondary energy carrier.

Introduction

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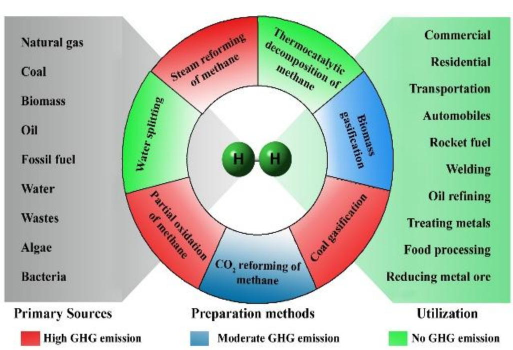
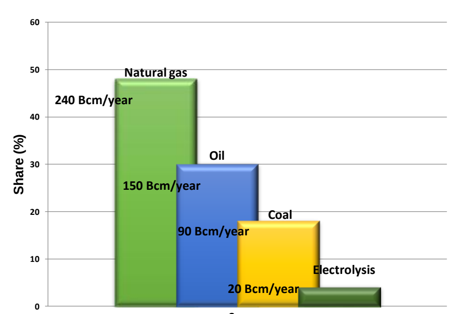
Hydrogen production





Introduction

Ashik, U. P. M., & Daud, W. M. A. W. (2015). *Nano-nickel catalyst reinforced with silicate for methane decomposition to produce hydrogen and nanocarbon: synthesis by co-precipitation cum modified Stober method*. RSC Advances, 5, 46735-46748.

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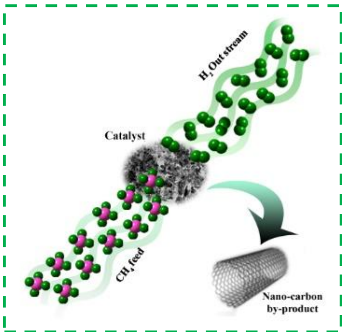
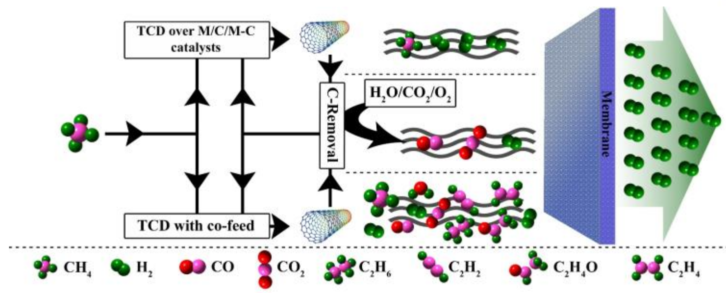
Thermocatalytic decomposition of methane

- $CH_4 \rightarrow C + 2H_2$
- The prime benefit of TCD is the elimination of GHG release





Introduction

Ashik, U. P. M., Wan Daud, W. M. A., & Abbas, H. F. (2015). *Production of greenhouse gas free hydrogen by thermocatalytic decomposition of methane – A review*. Renewable and Sustainable Energy Reviews, 44(0), 221-256. doi: 10.1016/j.rser.2014.12.025

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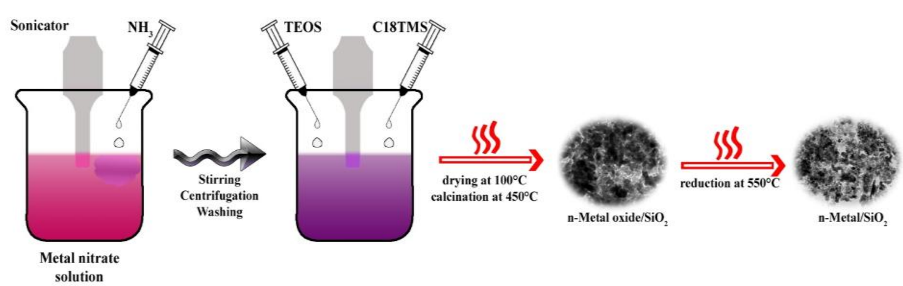
Preparation of nano-metal/SiO_2 catalyst



Experimental

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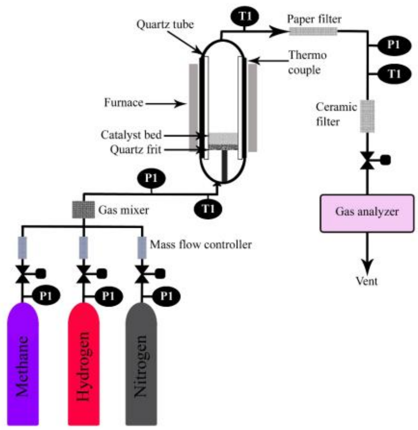
Isothermal methane decomposition



- Fixed catalyst bed reactor
- Inner diameter = 3.03 cm,
- Wall thickness = 0.87 cm
- Height = 120 cm
- ***0.5 g of catalyst***
- ***Reduction at 550 °C***
- ***99.995% methane***

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Experimental

Ashik, U. P. M & Daud, W. M. A. W. (2015). *Probing the differential methane decomposition behaviors of n-Ni/SiO_2, n-Fe/SiO_2 and n-Co/SiO_2 catalysts prepared by co-precipitation cum modified Stöber method*, RSC Advances, 5, 67227-67241.

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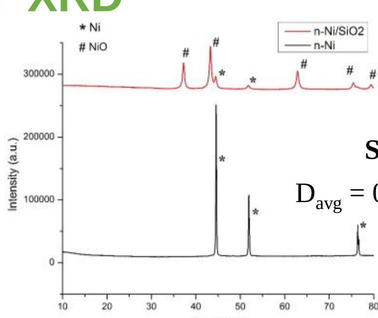
XRD

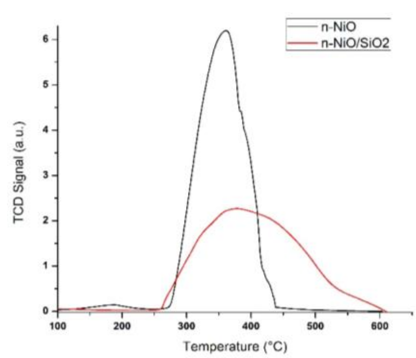


Scherrer equation

$$D_{avg} = 0.9\lambda / \beta cos\theta \text{ x } (180 / \pi)$$

Sample	Ni (111) (nm)	Ni (200) (nm)	Ni (220) (nm)	Avg. (nm)
n-Ni	61.18	78.71	72.06	70.65
n-Ni/SiO_2	28.54	43.84	29.26	33.88

H_2-TPR



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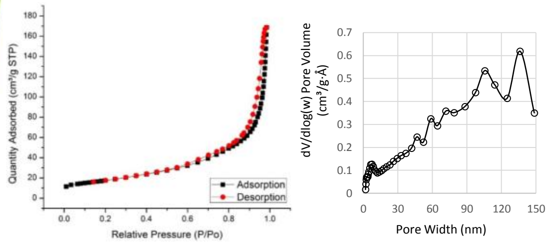
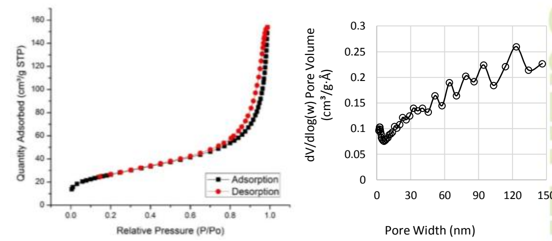
Brunauer–Emmett–Teller (BET)

n-NiO



n-NiO/SiO$_2$



Catalyst	Single point SA[a] (m²/g)	BET SA (m²/g)	Micropore area[b] (m2/g)	Mesopore + external area[c] (m²/g)	Micropore volume[d] (cm³/g)	Mesoporous volume (cm³/g)	BET pore size (nm)	Mean particle size (nm)
n-NiO	62.22	62.46	5.17	57.28	0.0020	0.2479	16.274	48.02
n-NiO/SiO$_2$	91.50	93.18	5.17	88.01	0.0024	0.2277	9.987	32.19

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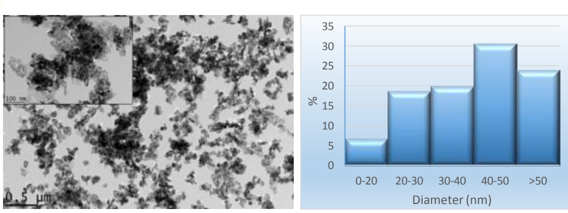
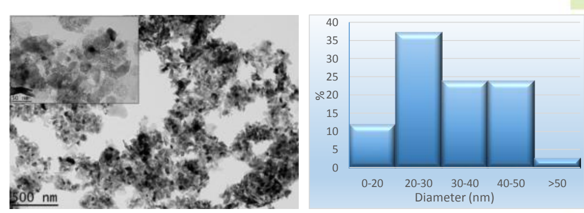
TEM-EDX



n-NiO



n-NiO/SiO$_2$

Catalyst	Oxygen			Silicon			Nickel		
	Line type	Weight %	Atomic %	Line type	Weight %	Atomic %	Line type	Weight %	Atomic %
n-NiO	(K)	24.04	53.73	-	-	-	(K)	75.95	46.26
n-NiO/SiO$_2$	(K)	25.98	55.09	(K)	3.37	4.07	(K)	70.64	40.83

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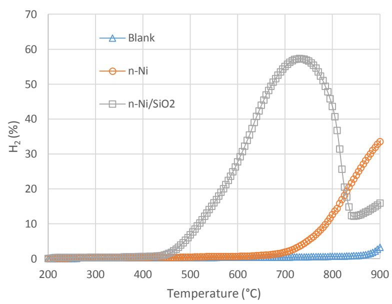
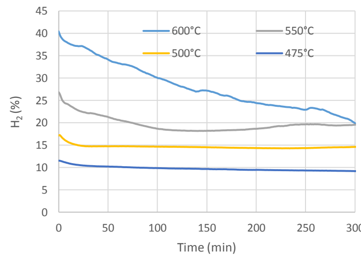
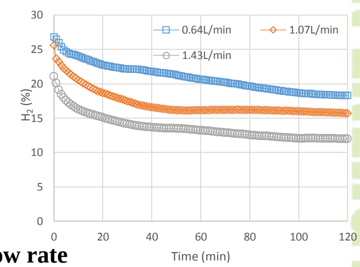
Catalytic methane decomposition



Temperature programmed methane decomposition



Influence of temperature



Influence of flow rate

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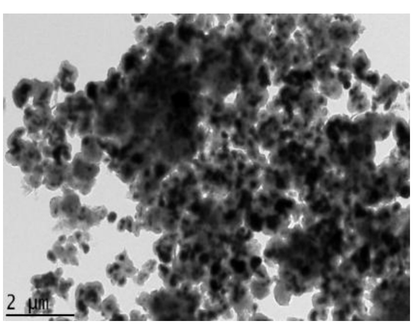
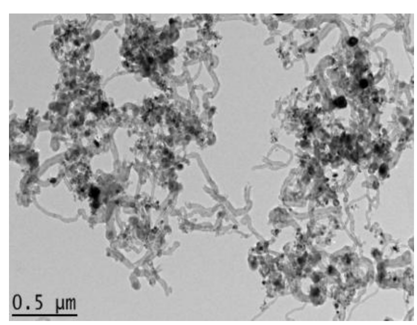


n-Ni



n-Ni/SiO_2

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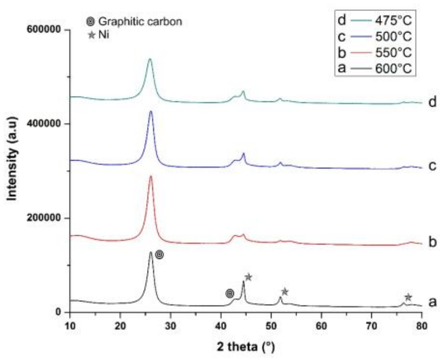
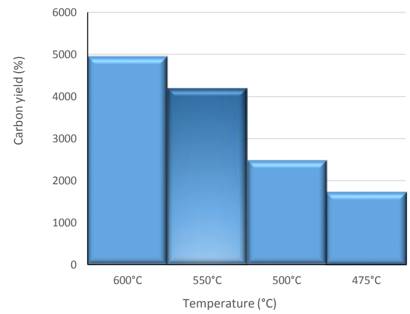
Catalytic methane decomposition





$$\text{Carbon yield (\%)} = \frac{\text{weight of deposited carbon on the catalyst}}{\text{weight of metal portion}} \text{ x } 100$$

Result & discussion

Conclusion

- Thermocatalytic decomposition of methane conducted over *n*-Ni and *n*-Ni/SiO_2 catalysts to produce hydrogen and nano-carbon.
- *n*-Ni/SiO2 catalyst exhibited an outstanding performance compared to naked and conventionally prepared catalysts.
- The poor performance of naked nickel catalysts were attributed to the formation of giant metal particles with unfavourable crystal size for growth of nano-carbon

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Thank you!