Carbide-derived carbons designed for efficient hydrogen storage

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Abstract
Carbide-derived carbons (CDCs) with specific surface area (SSA) ~ 2000 m²/g and open pore volume up to 80% are produced by chlorine etching of metal carbides. Tuning the pore size distribution by carbide precursor selection and etching temperature yields enhanced hydrogen storage capacity at both ambient and elevated pressure. Our goal is to establish the fundamental relation between capacity and SSA, pore size and pore volume.

Comments

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1. INTRODUCTION to CARBIDE-DERIVED CARBONS

2. CDC’s with TUNEABLE PORE SIZE DISTRIBUTION

3. EFFECT OF SURFACE AREA ON H2 CAPACITY

4. SMALL PORES ARE CRUCIAL FOR HIGH CAPACITY

5. CAPACITY CORRELATED W/VOL. OF SMALL PORES

6. CONCLUSIONS and REFERENCES

EFFECT OF SURFACE AREA ON H2 CAPACITY

0.52 CDC-ZrC between hydrogen pores

5. CAPACITY CORRELATED W/VOL. OF SMALL PORES

6. CONCLUSIONS and REFERENCES

For similar total surface area, the trend of capacity increase with filling all the pores.

The trend of capacity increase with surface area implies that 6000 m$^2$/g will be required to 7 wt.%.

However, carbon nanomaterials with similar surface areas show large capacity variations.

Possibility: This traditional plot of wt.% vs SSA could be obscuring something important.

Activated carbon

Carbon nanotubes and other carbon nanomaterials.

H2 wt.% vs SSA could be obscuring something important.

Gravimetric density, wt% H2

Gravimetric capacity, wt.% H2

Gravimetric capacity, wt.% H2

Gravimetric density, wt% H2

Specific surface area, m2/g

Pore size, nm

synthesis temperature, ºC

B4C - CDC: reduced capacity correlates with increasing pore size when the chlorination temperature is too high.

CDC from TiC (Adsortion) CDC from TiC (Desorption)

CDC from ZrC

Metal organic framework (MOF-5)

Single-walled carbon nanotubes

Multi-walled carbon nanotubes

Reversible hydrogen storage capacity of CDC is 10 times that of multi-walled nanotubes, 3.5 times that of single-walled carbon nanotubes and 2 times than that of metal organic framework (MOF-5) at 1 atm pressure and 77K.

> Nanoporous CDC’s with tunable pore size provide SSA up to 2000 m$^2$/g, pore volume > 1 cc/g available for hydrogen storage.

> At 1 atm and 77K, gravimetric capacity > 3.0 wt.%, volumetric > 24 kg/m$^3$.

> At 1 atm and 77K, CDC capacities > MOF-5, SWNT, MWNT.

> Capacity of CDCs is higher than that of carbon nanotubes and other carbon nanomaterials.

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Gas sorption measurements were performed using Sieverts method.

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