

# Porosity of Carbon Nanotubes

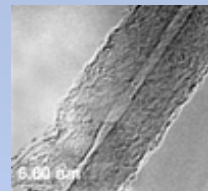
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## Carbon Nanotubes for Separation and Catalysis Applications

- Single and multiwall carbon nanotubes can be produced with narrow pore size and external diameter distributions
- These materials could be dispersed in gases or liquids, or incorporated in solids to provide selective sorption, or act as catalyst supports.

## MWNTs



## SWNT/Pitch Matrix

- SWNTs suspended in DMSO and sonicated
- Suspension + pitch mixture heated to evaporate and recover solvent
- SWNT/pitch activated by steam @ 877 C

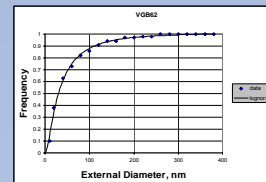
## Analytical

- Pore volume determined by nitrogen adsorption isotherms @ 77 K (Omnisorb 610)

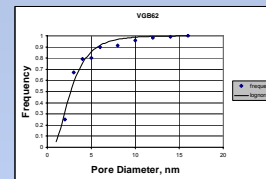
## MWNT Pore Size Distribution

- Internal and external diameters follow log normal distributions
- pore diameter averaged on area basis
- sample with broad pore and external diameter distributions follows

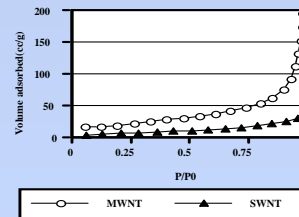
## MWNT External Diameter Distribution



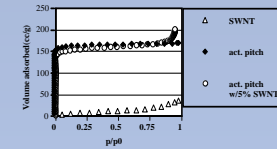
## MWNT Pore Diameter Distribution



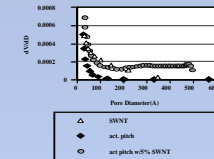
## Adsorption of N2 on MWNTs and SWNTs, 77 K



## N<sub>2</sub> Isotherms: activated pitch and activated pitch + SWNTs



## Pore Size Distributions: activated pitch, activated pitch + SWNTs



## Addition of SWNTs to Pitch for new Activated Carbon:

- Pure petroleum pitch-based activated carbons have microporous structure
- pitch with 5% SWNTs has a high mesopore volume
- the SWNTs contribute mesopore volume without affecting the micropore volume

## Conclusions

- MWNTs have potential applications in adsorption and gas separations.
- Addition of SWNTs to activated carbons based on pitch leads to fibers with more mesopore volume without affected micropore volume

## Acknowledgements

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- Photomicrographs by J. Hilding, X. Fan

## Potential Advantages of Carbon Nanotubes

- good chemical stability
- controlled/known pore sizes, wall thicknesses
- potential for use in gas separations via pore condensation
- pressure or thermal swing desorptions are possible
- controlled pore membranes with or without catalysis
- high tensile strength additive to activated carbon fibers, may change internal pore structure

## Outline

- Morphology of single and multiwall nanotubes
- N<sub>2</sub> sorption comparison
- Modify the porosity of pitch-based activated carbon fibers

## MWNTs (multiwall nanotubes)

- Chemical vapor deposition process, ferrocene catalyst
- reactor product has little amorphous carbon but retains iron
- iron can be removed by leaching with hydrochloric acid
- MWNTs are highly aligned

