

# Hybrid purification of semiconducting single-walled carbon nanotubes for use in optoelectronic devices and chemiresistive gas sensors

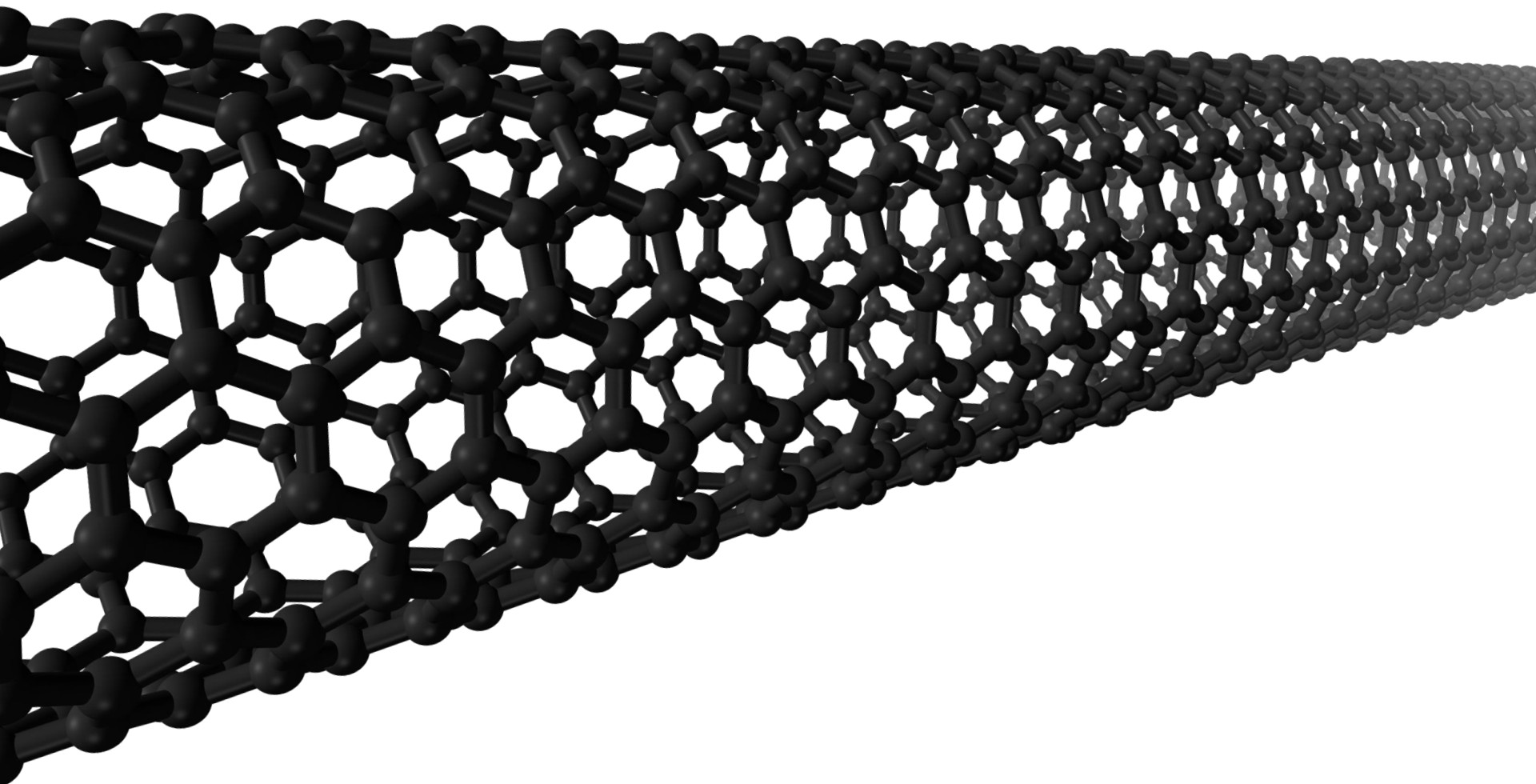
21 April 2022  
Charles Yang



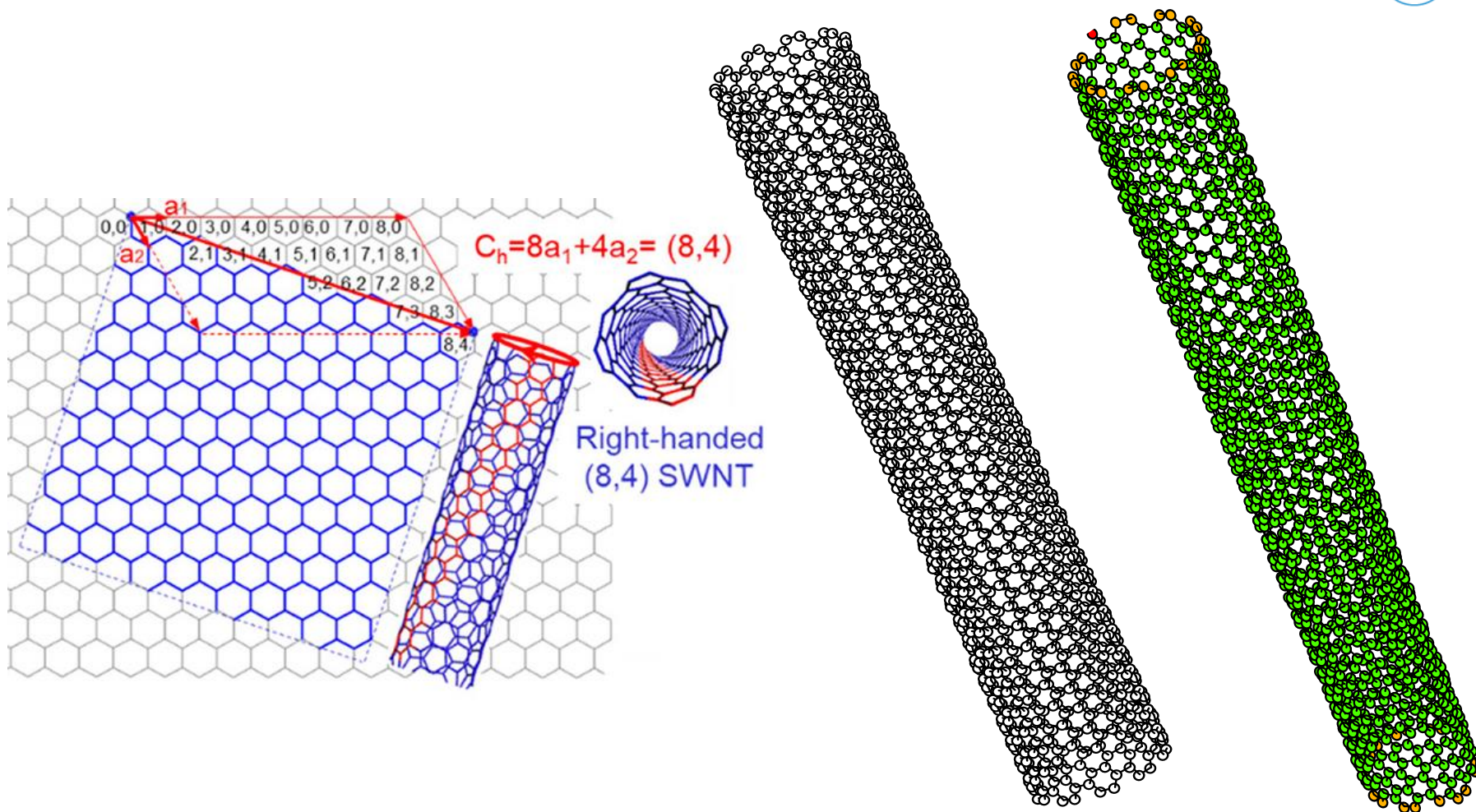
# Outline

- Introduction on the electronic structure of SWCNTs
- Hybrid CPE/IPA purification scheme for sc-SWCNTs
- Implementation as chemiresistive gas sensors

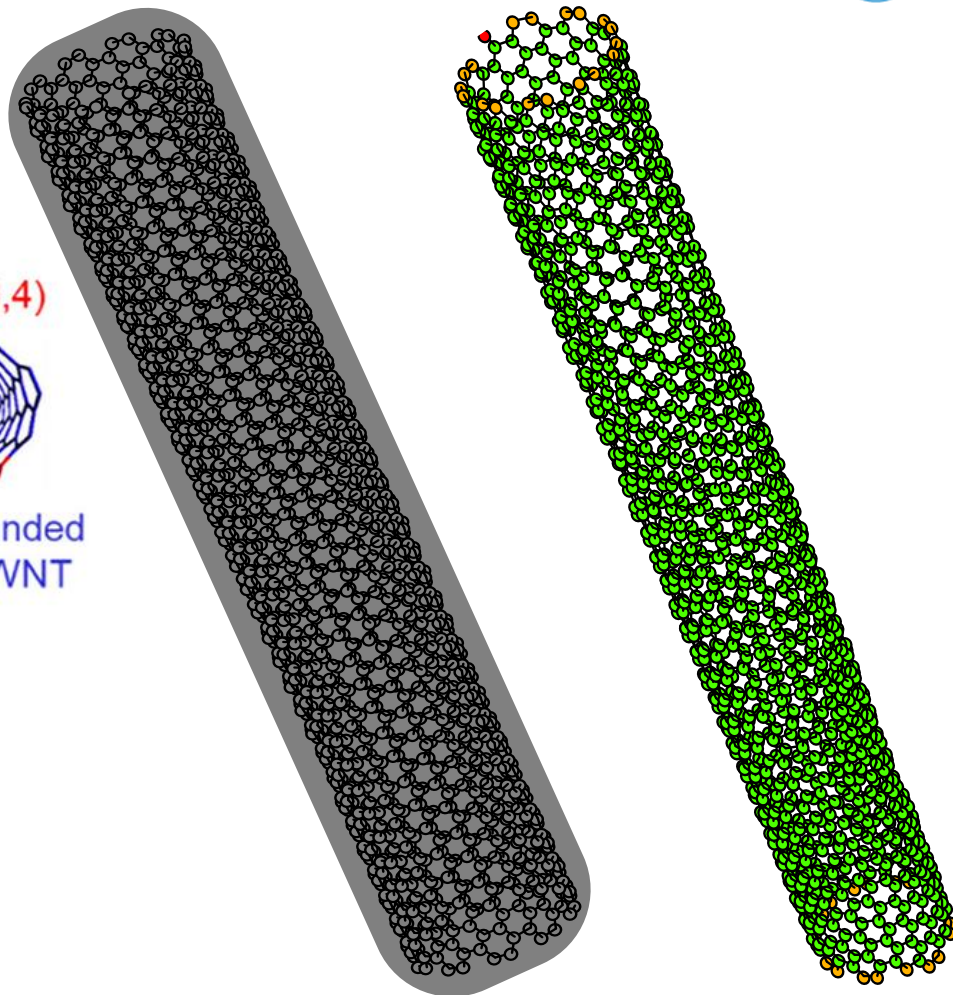
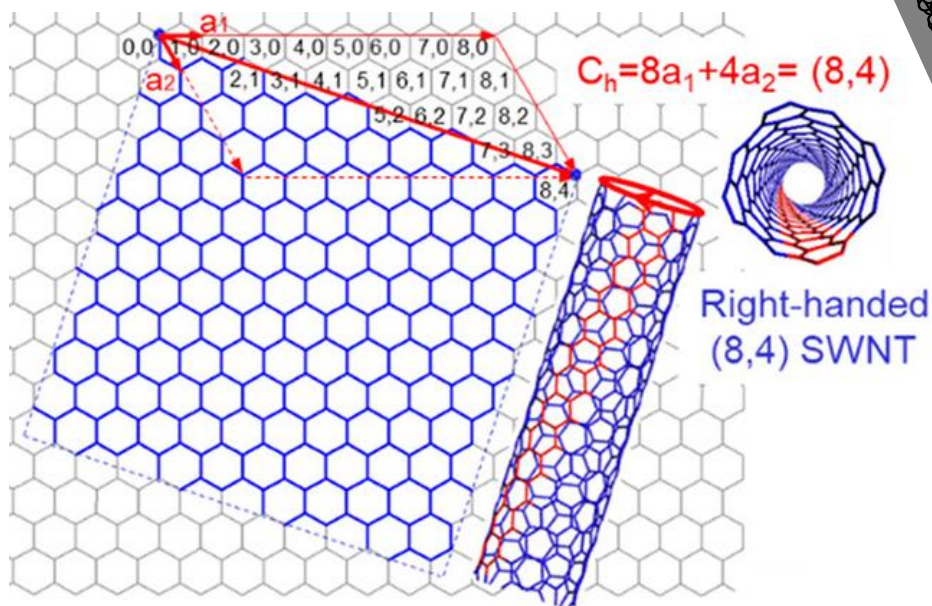
# Single Walled Carbon Nanotubes (CNTs)



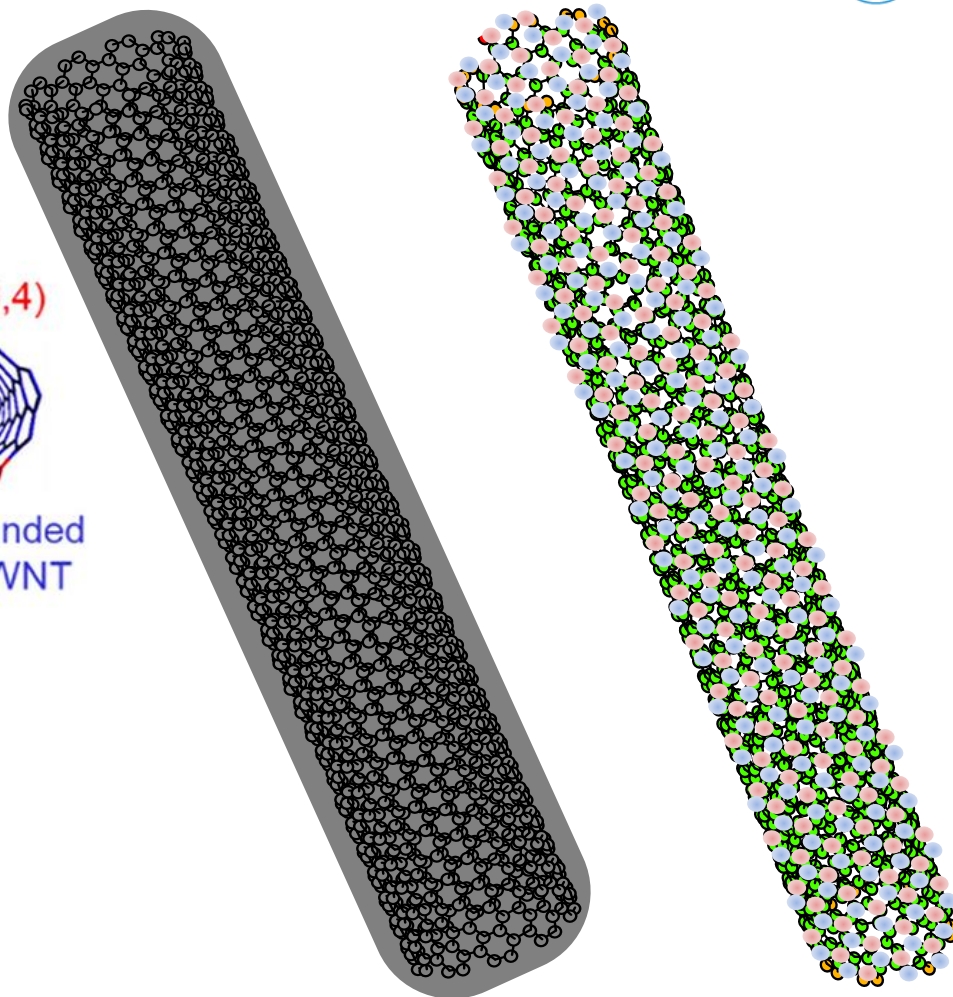
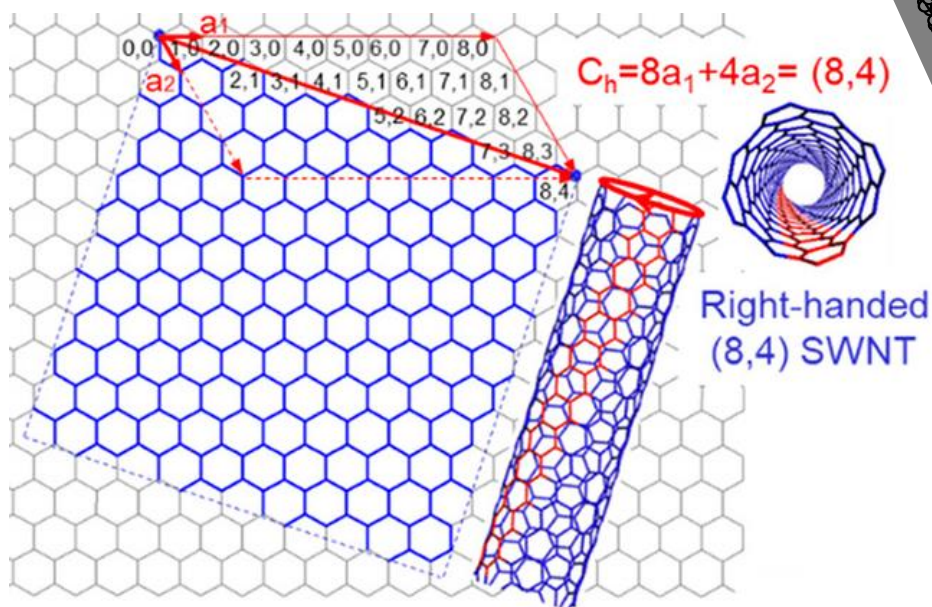
# Semiconducting vs Metallic NTs



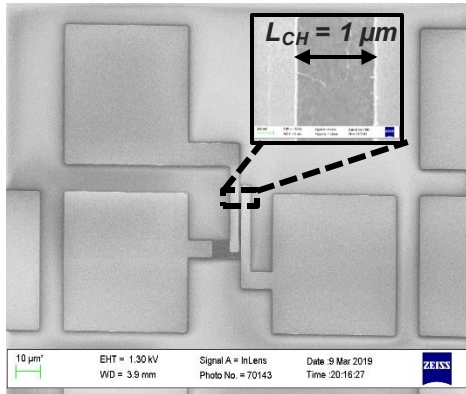
# Semiconducting vs Metallic NTs



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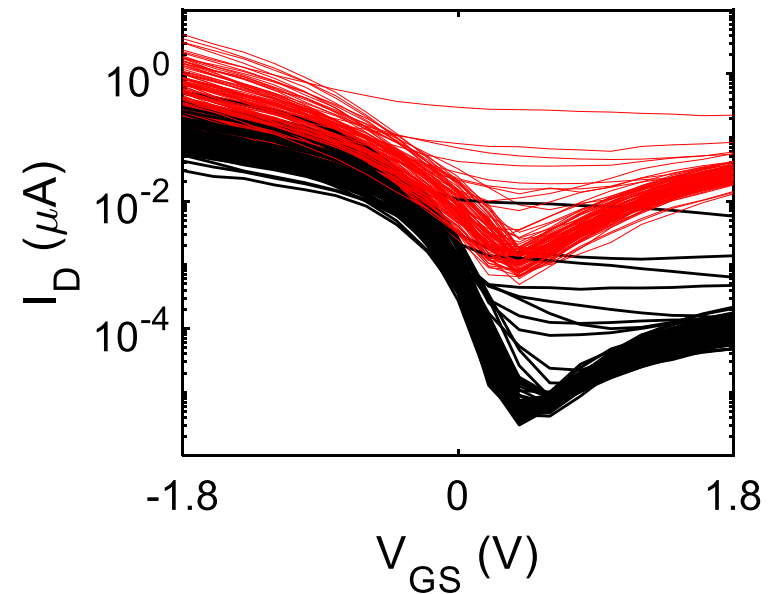
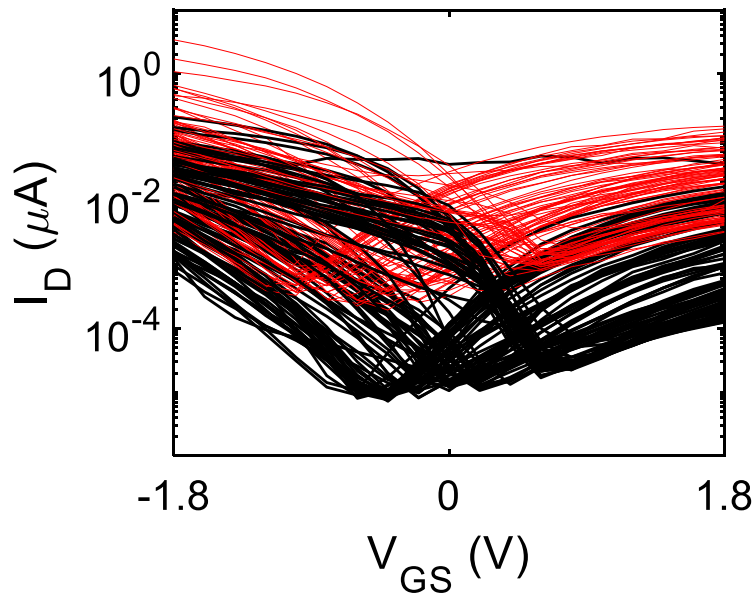
# Purity to Consistency



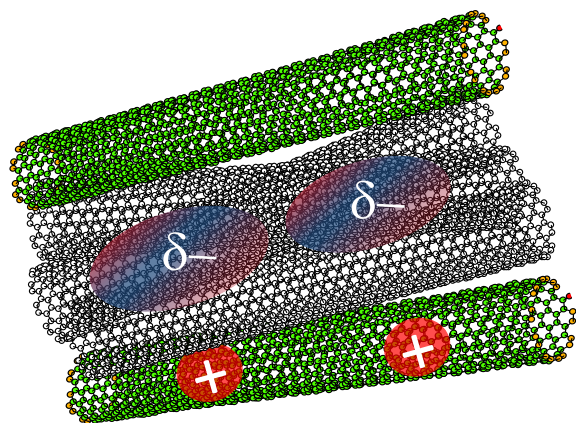
Goals:

<20% device variation

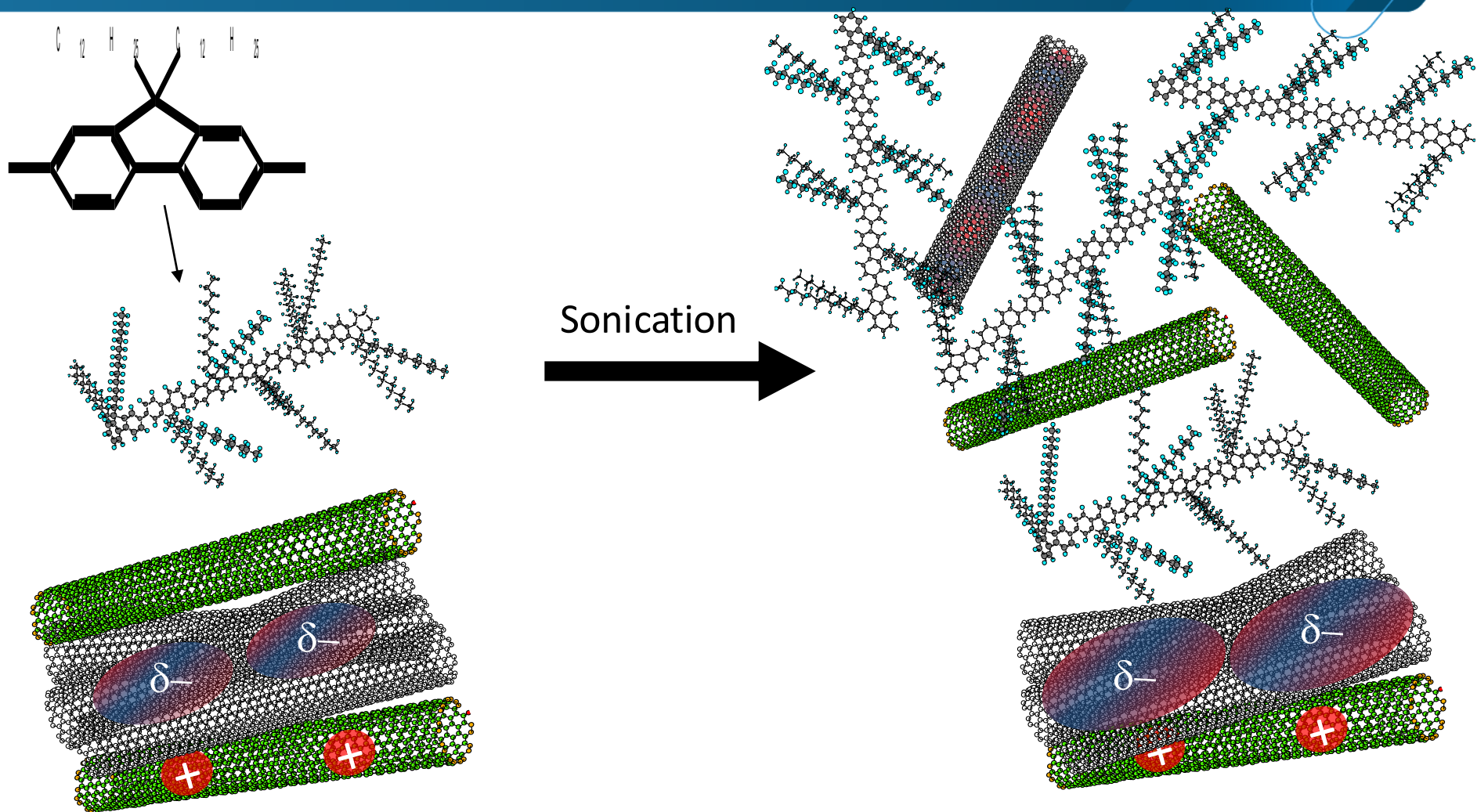
<15/500 device failure rate



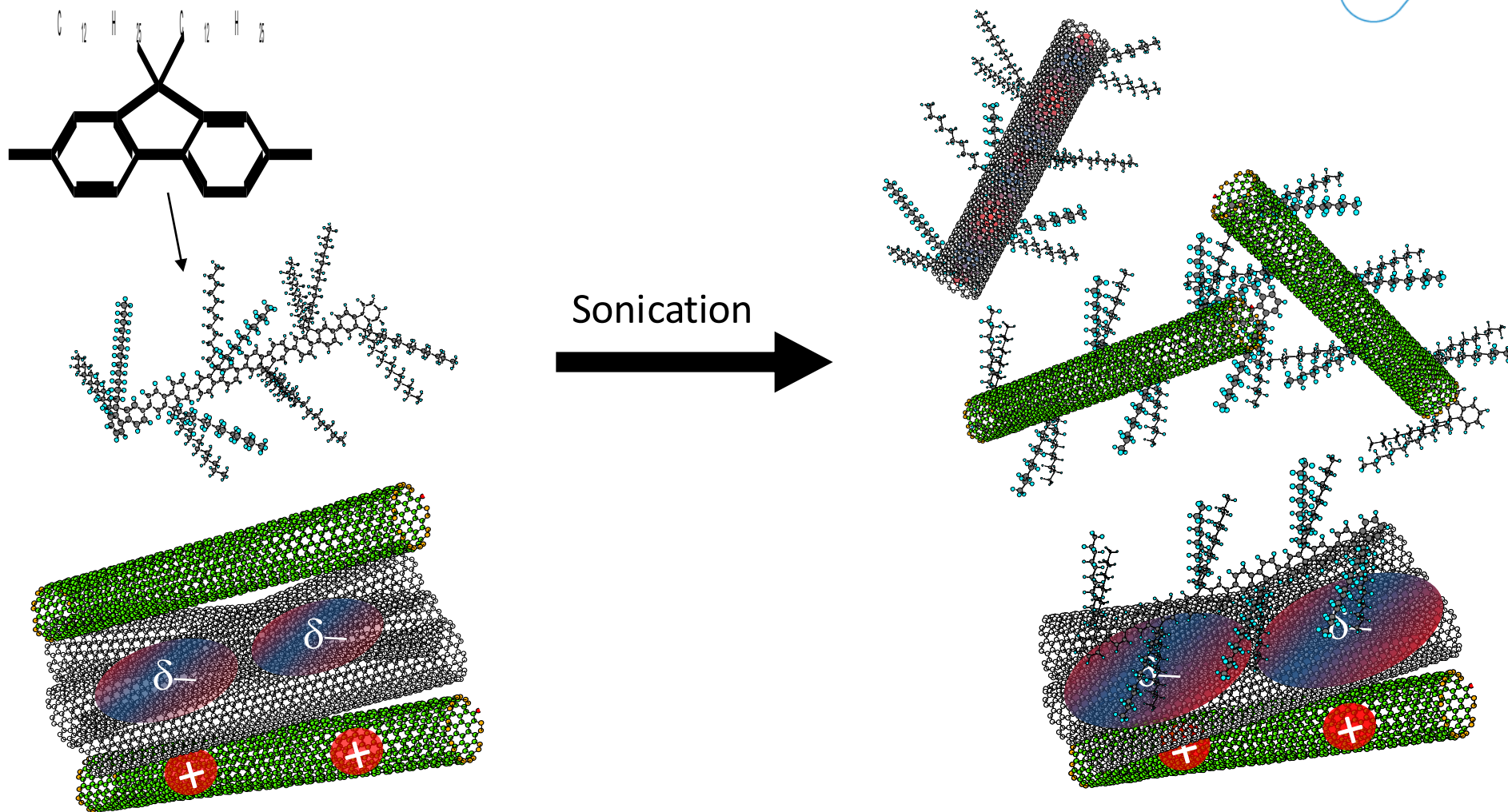
# Conjugated Polymer Extraction



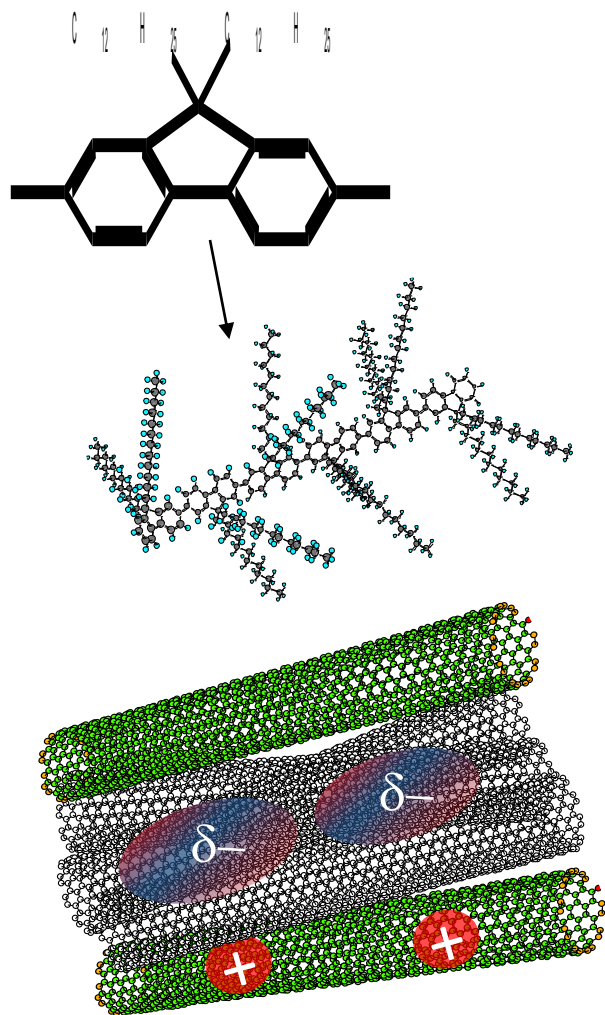
# Conjugated Polymer Extraction



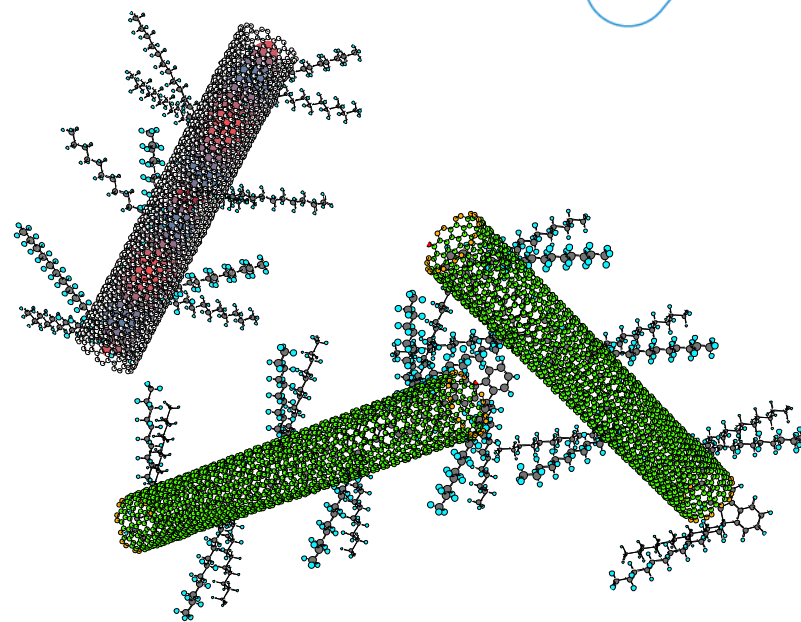
# Conjugated Polymer Extraction



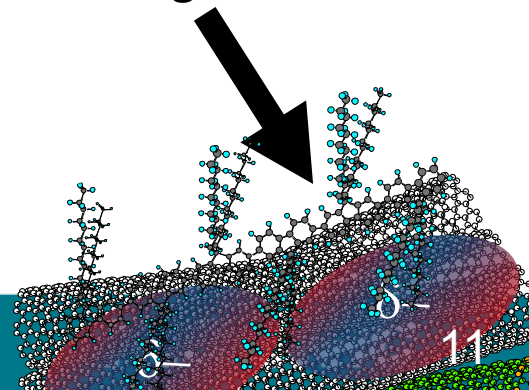
# Conjugated Polymer Extraction



Sonication

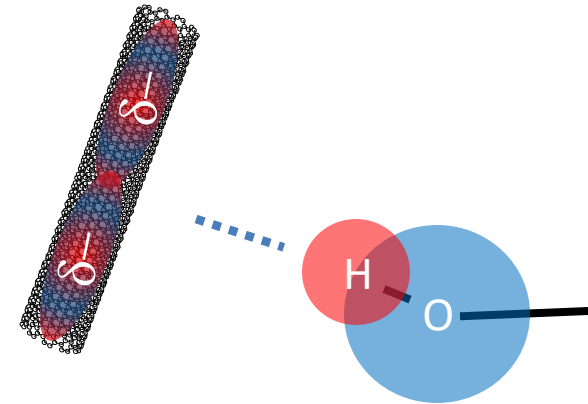
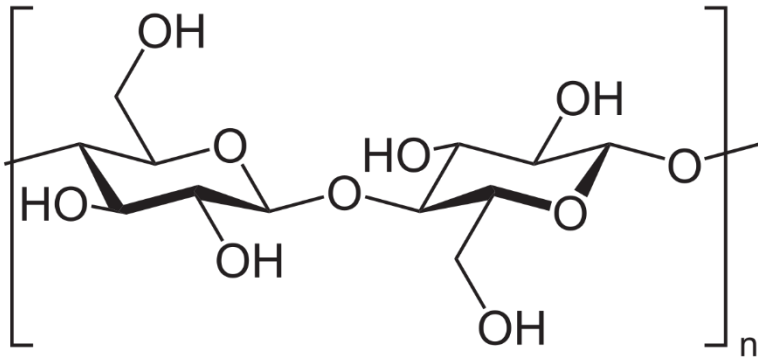


Centrifugation



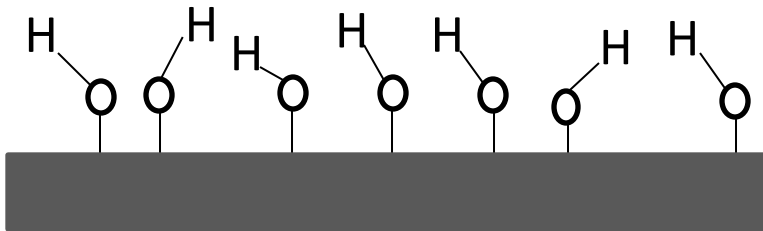
# Inorganic Particle Adsorption

## > Cellulose

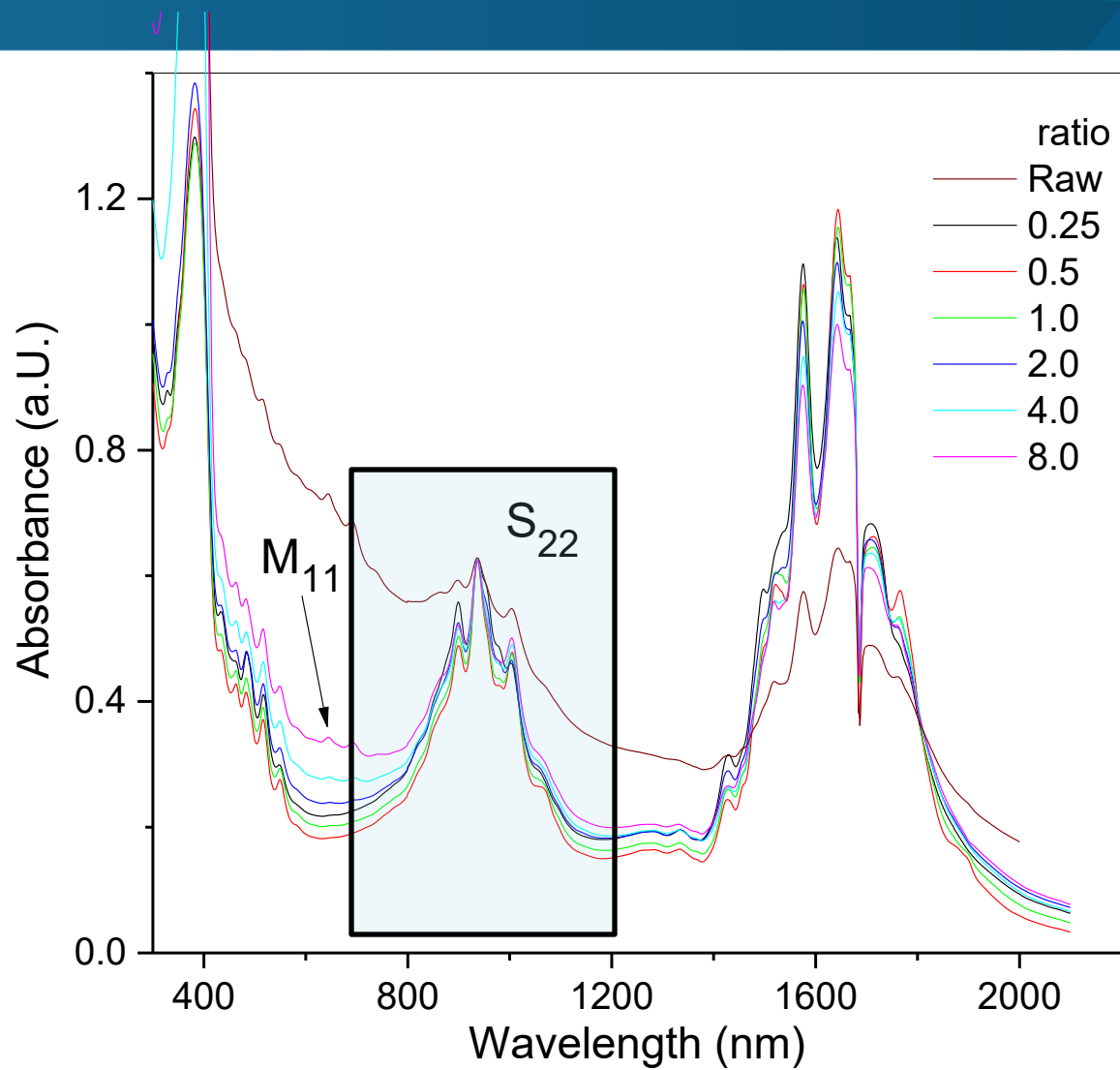


Interaction

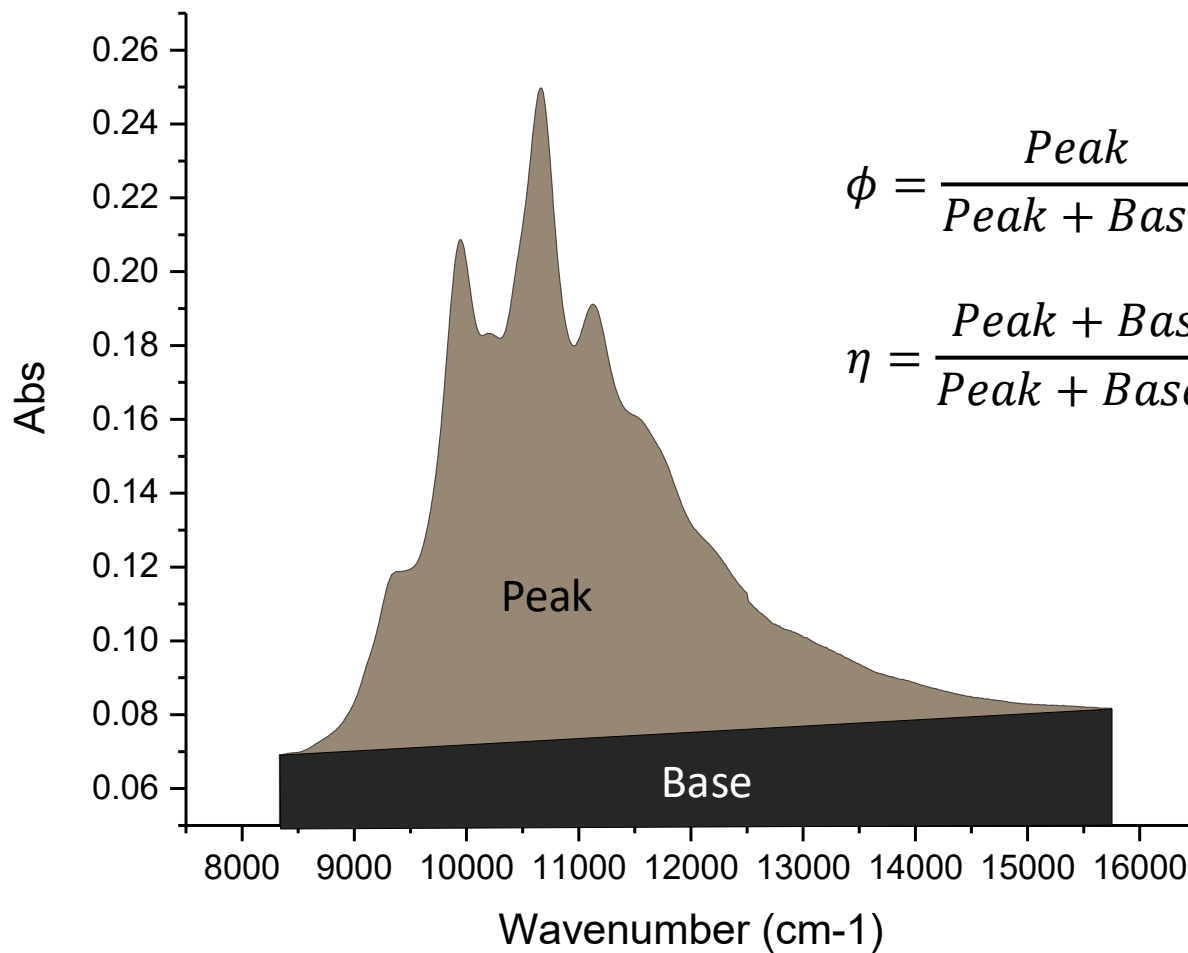
## > Silica Gel



# Metrics



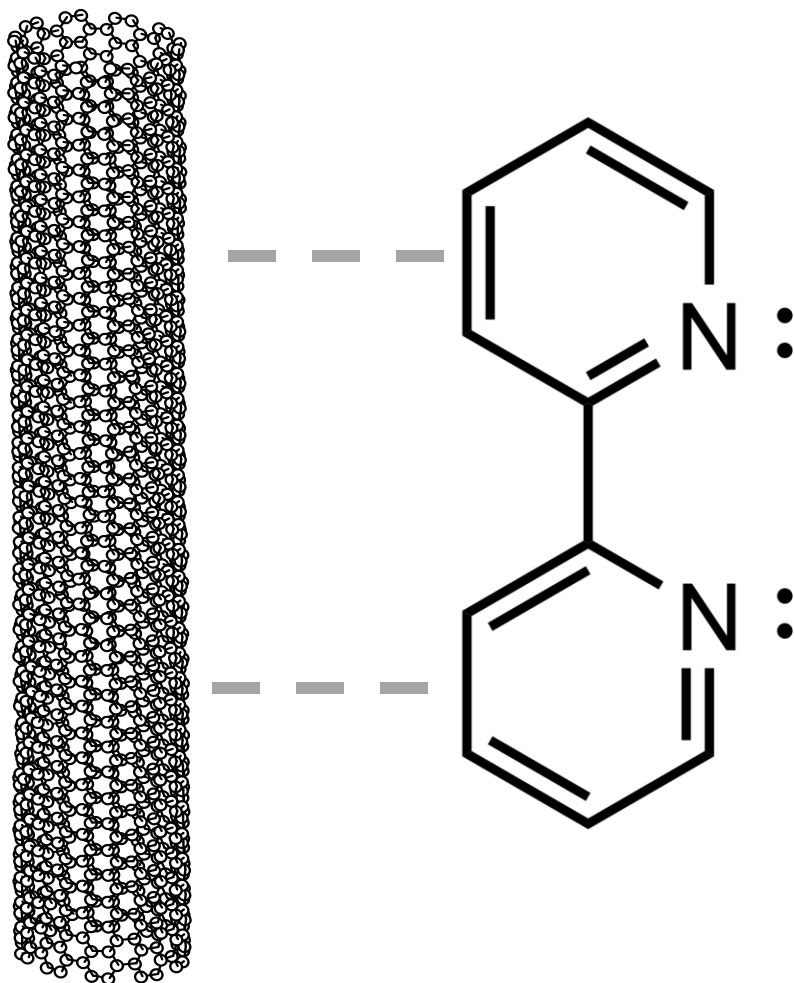
# Metrics



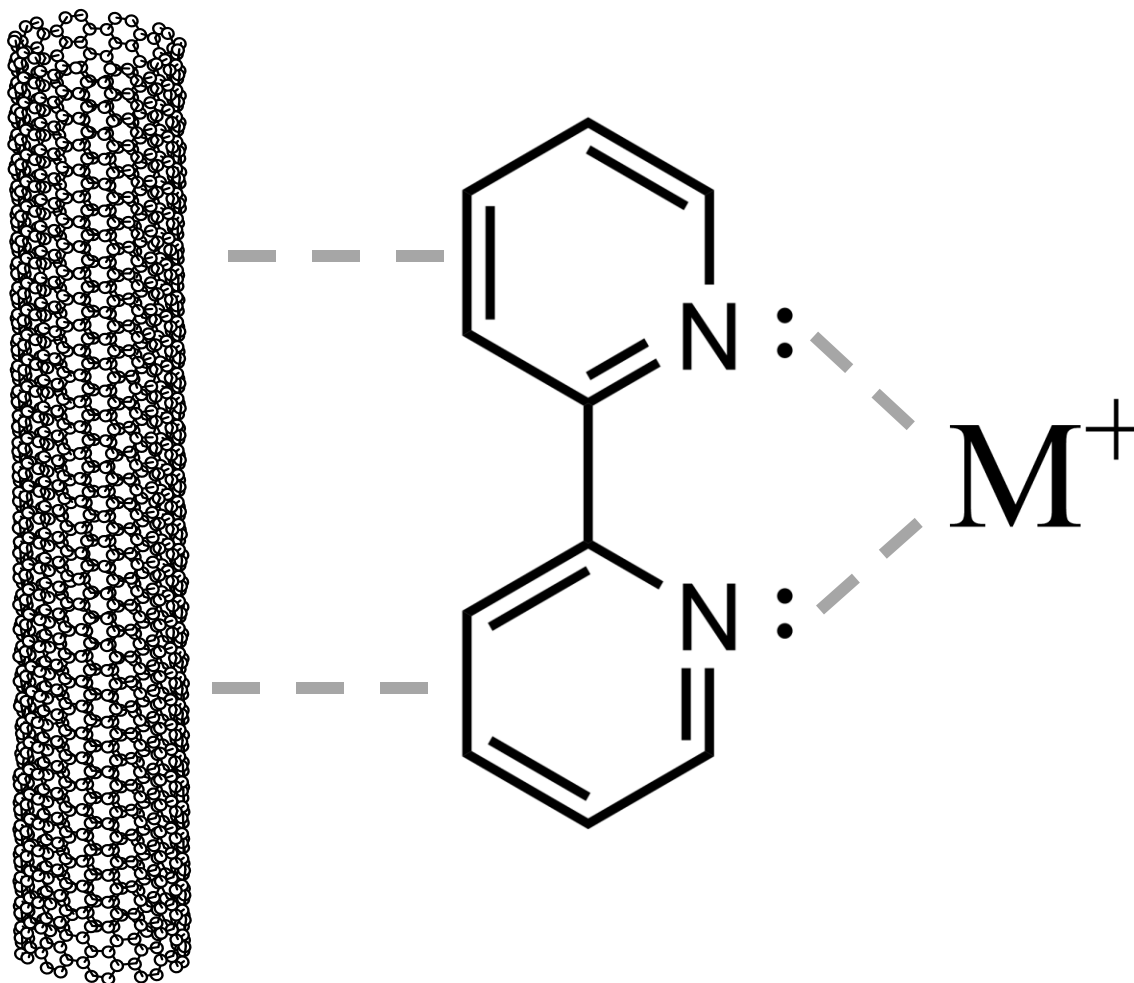
$$\phi = \frac{\text{Peak}}{\text{Peak} + \text{Base}}$$

$$\eta = \frac{\text{Peak} + \text{Base (after Treatment)}}{\text{Peak} + \text{Base (before Treatment)}}$$

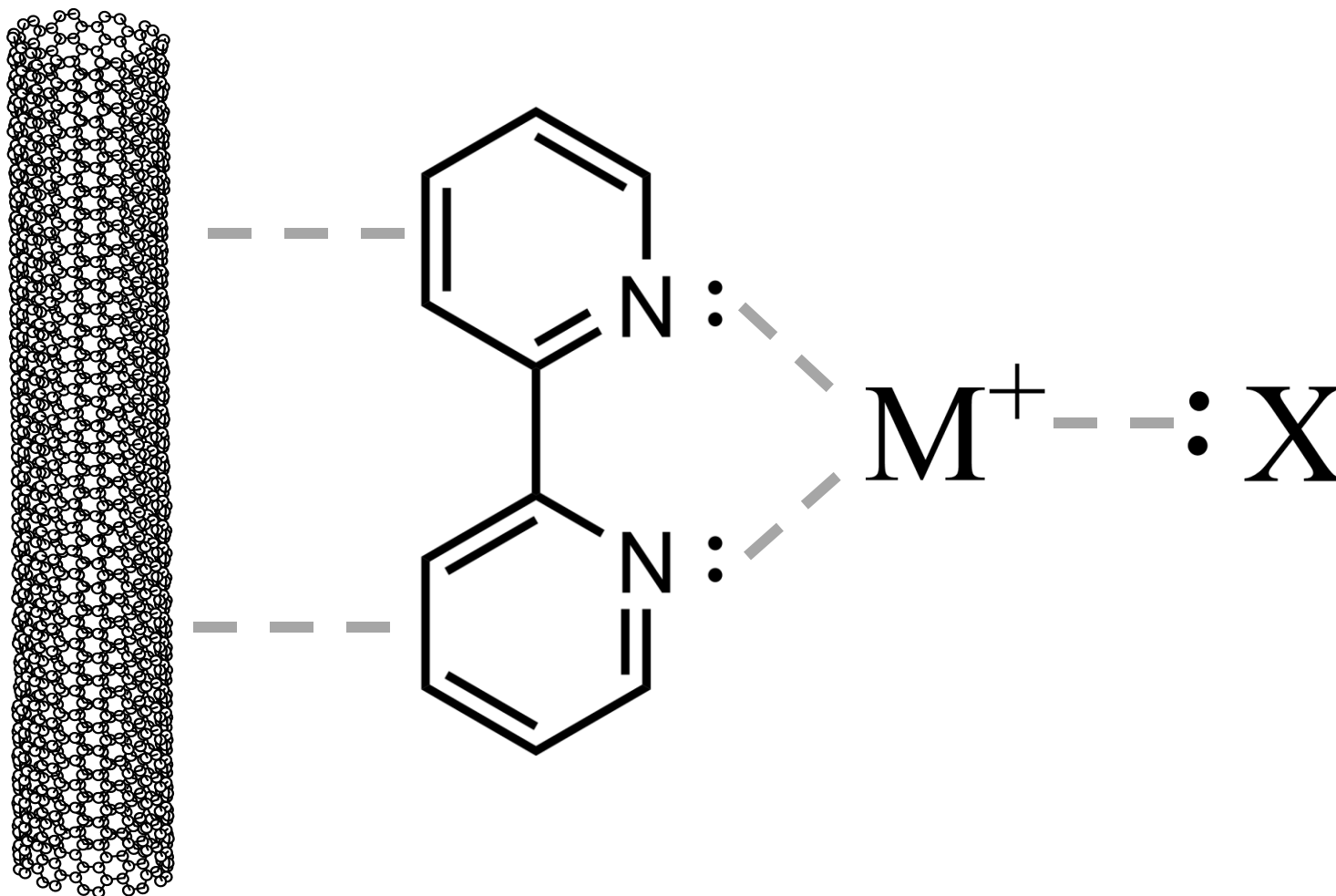
# Non-Covalent Functionalization



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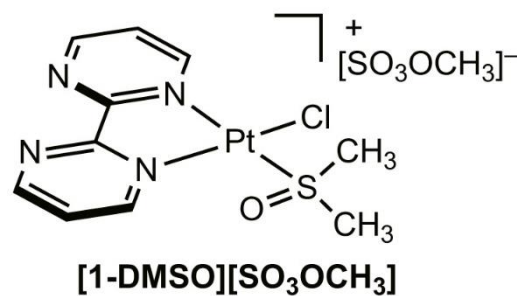
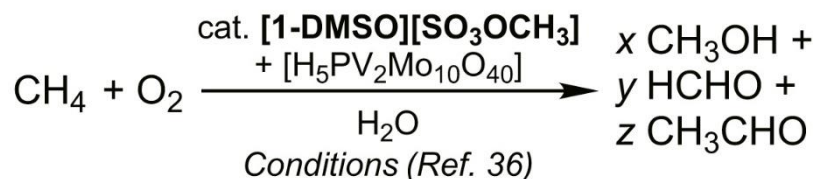


# Non-Covalent Functionalization

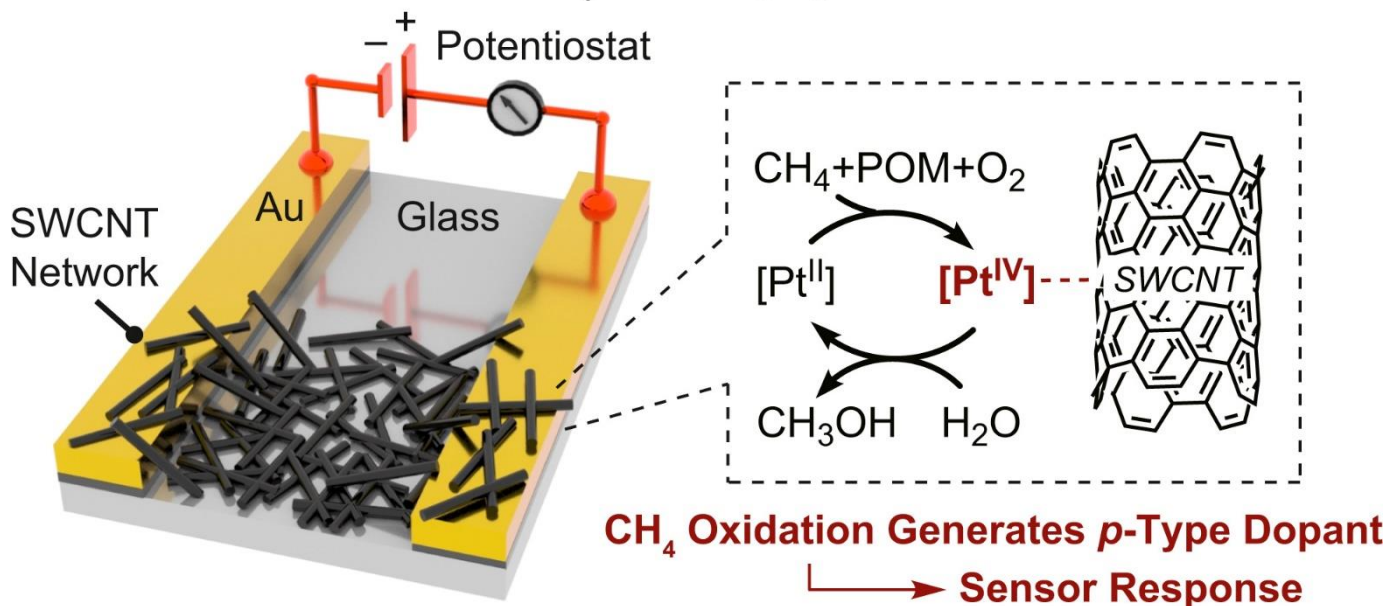


# Applications: Gas Sensors

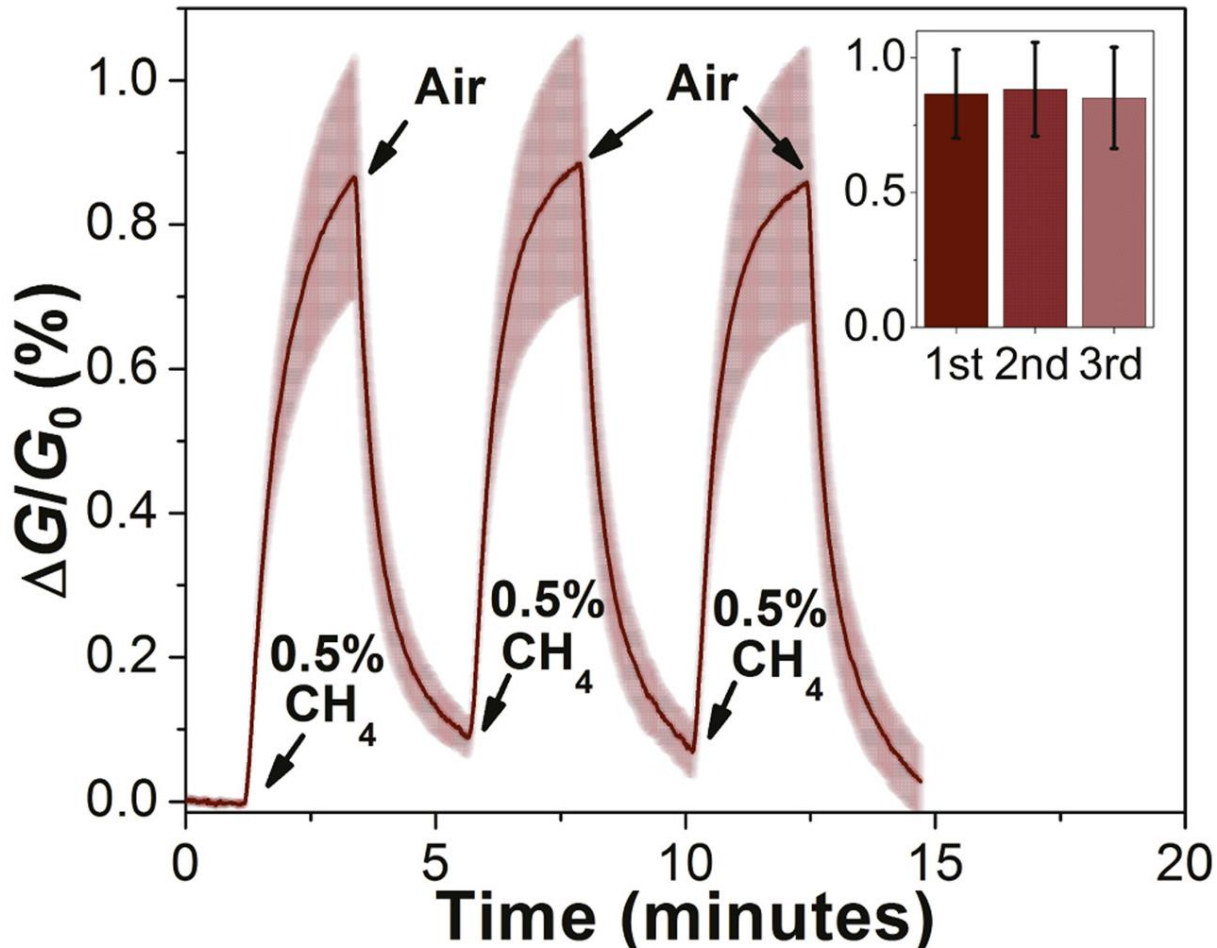
## Aerobic CH<sub>4</sub> Oxidation



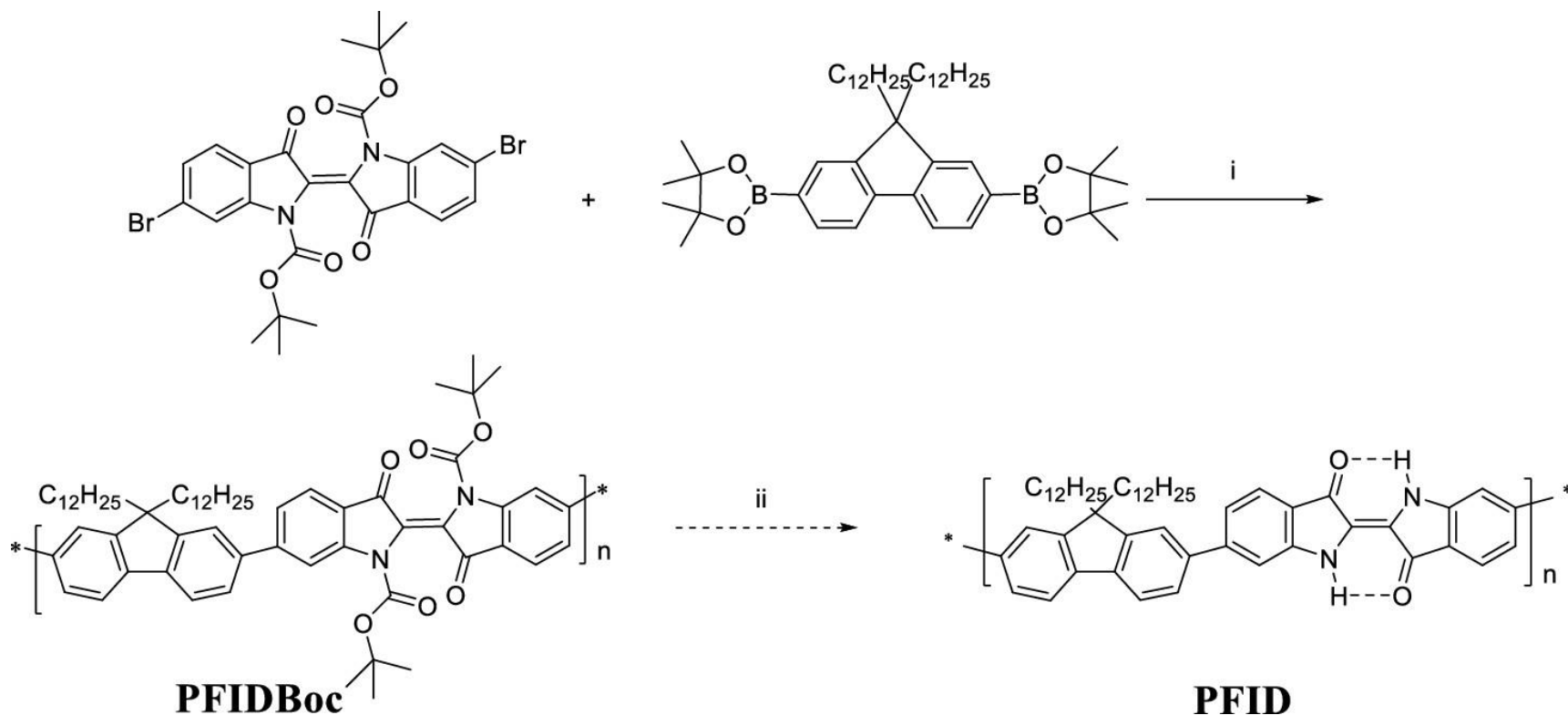
## This Work: Chemiresistive CH<sub>4</sub> Sensing by Pt-Mediated Oxidation



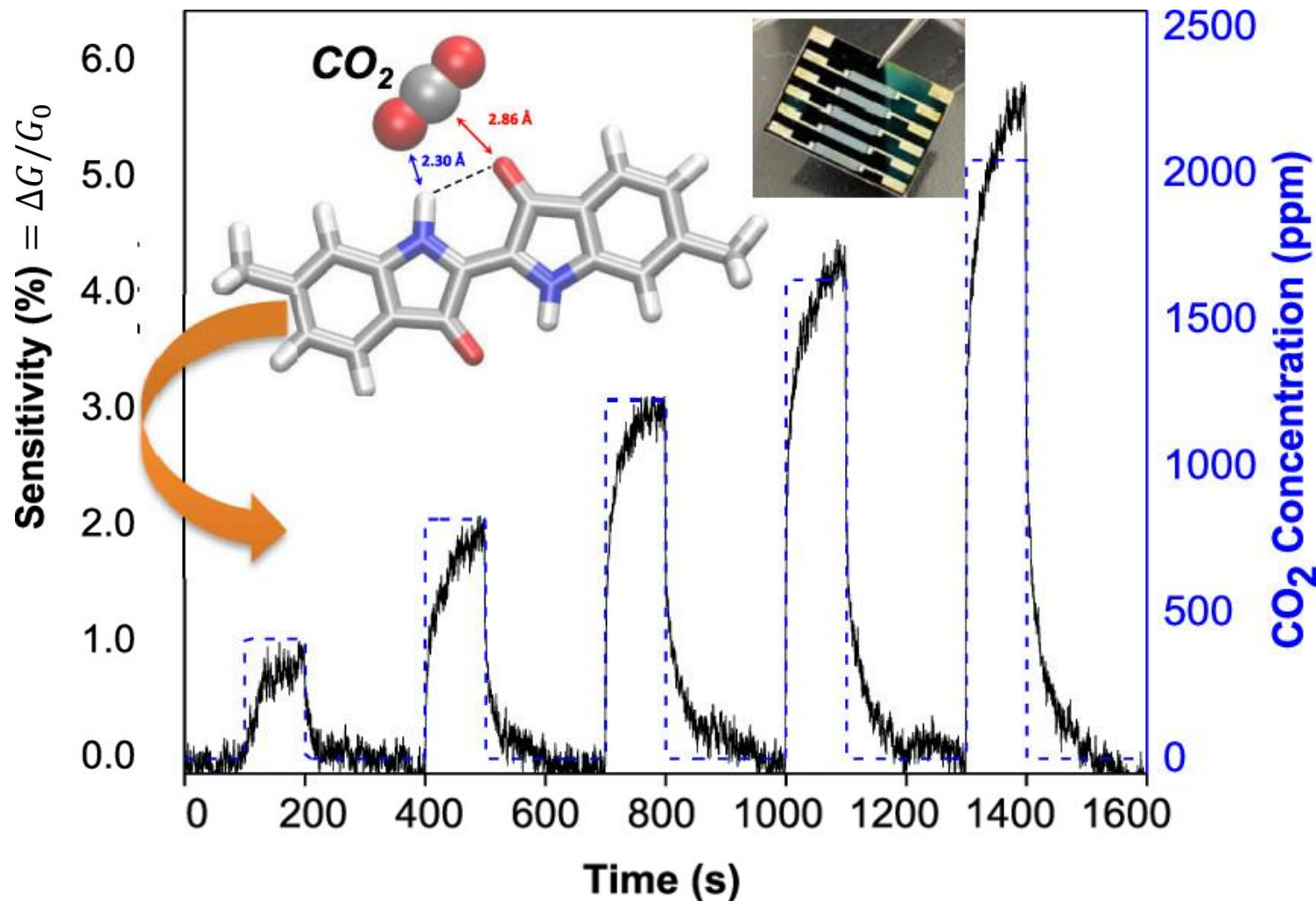
# Applications: Gas Sensors



# Combining CNT Purification and Gas Sensing



# Combining CNT Purification and Gas Sensing: PFID/PFIDBoc



# Conclusions

- Our optimized hybrid purification scheme yields >99.99% sc-SWCNTs based on differences in polarizability
- Carbon nanotubes can be non-covalently functionalized to act as chemiresistive gas sensors

# Acknowledgements

- › Dr. Jianfu Ding, Nanotechnologies Group
- › SDTech, NRC
- › MIT, Raymor-NanoIntegris, DARPA

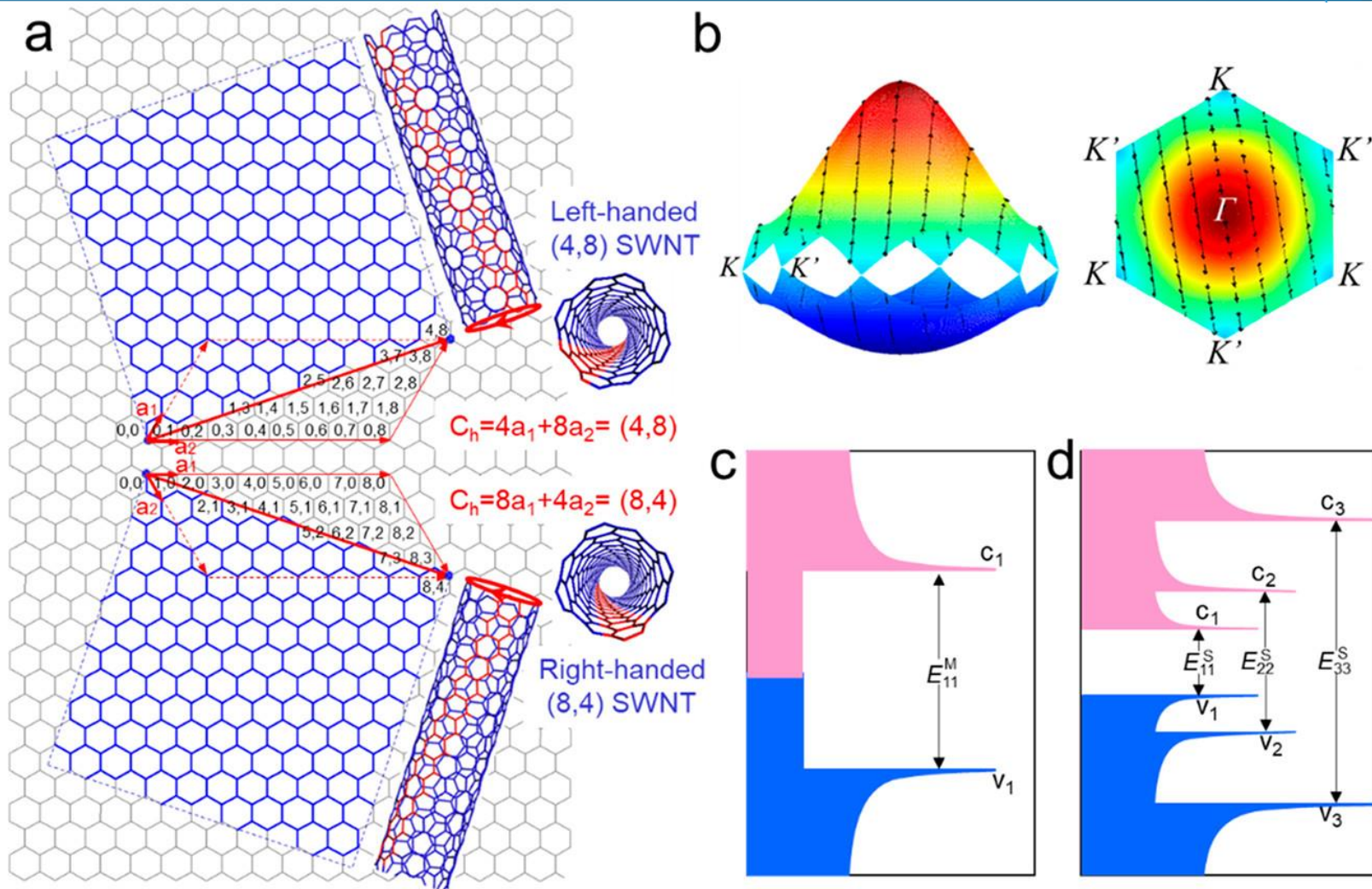
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# Conclusions

- Our optimized hybrid purification scheme yields >99.99% sc-SWCNTs based on differences in polarizability
  
- Carbon nanotubes can be non-covalently functionalized to act as chemiresistive gas sensors

# Chirality and Band Structure



# Applications: Gas Sensors

