Intercalation of Poly-acrylonitrile (PAN) into Carbon Nanotubes

TEM images of various materials in carbon nanotubes.¹

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¹. Courtesy of Prof. Margeridis and Prof. Yarin, UIC
Outline of Presentation

• Background
• Goals of this research (applications)
• Work that has been done over summer
  - The intercalation process
  - Thickness of polymer filling
  - Carbonization (structure of polymer filling)
• Conclusion
Why is this important?

Once we understand the intercalation process of polymers into CNTs, we can extend intercalation process to other fluids and nano-medias.
Background

- In the past we can only fill CNTs with polymer using supercritical CO$_2$\(^1\).
- Our lab has demonstrated a technique to fill CNTs using diffusion process – room temperature and atmospheric pressures\(^2\).

The Diffusion Process

- Solvent
- Particles
- Carbon nanotube
- Diffusion Process
Significance of Poly-Acrylonitrile (PAN)

- We chose PAN because it is Carbonizable.
- Provides us with option to control the structure of the polymer.

![PAN structure](https://web.umr.edu/~wlf/Synthesis/pacrylonitrile.html)

1. [web.umr.edu/~wlf/Synthesis/pacrylonitrile.html](http://web.umr.edu/~wlf/Synthesis/pacrylonitrile.html)
Goals of research

• Fill CNTs with PAN through diffusion process.
• Quantify the extent of PAN filling in CNTs.
• Control the structure of the PAN that is inside CNTs.

• End product: to produce nano-porous membranes with different thicknesses.
Intercalation of PAN

- Demonstrates that we can intercalate CNTs with PAN as well.

- A lot of PAN can be seen on the outer walls of the CNTs – makes interior structure difficult to see.

5 wt% PAN solution
Dimethylformamide (DMF) rinse process

- DMF is solvent that dissolves PAN.

DMF rinse set up

60 /80 degrees Celsius
1 -2 hours
Results of rinse
(80 degrees celsius, 2 hours)

0.5 wt% PAN solution before rinse

0.5 wt% PAN solution after rinse

This method can be extended to controlling thickness of polymer filling!
Extent of polymer filling

Three parameters that can be changed
- Concentration of PAN solution
- Time of DMF rinse
- Temperature of DMF rinse
Concentration

0.1 wt% PAN soln
0.5 wt% PAN soln
1 wt% PAN soln
2 wt% PAN soln
5 wt% PAN soln
Reasoning

Equilibrate $\rightarrow$ Evaporation $\rightarrow$ Concentration gradient

Diagram of intercalation process.
DMF rinse

- Time variation

0.5 wt% PAN solution filled CNTs

2 hour rinse

21 hour rinse

- Temperature variation

- More work needs to be done in this area.
- So far only 60 and 80 degrees Celsius has been looked at – no significant differences.
Carbonization

0.5 wt% PAN intercalated CNTs

- CNT walls are damaged.
- The PAN structure looks less packed – which may suggest porosity.
- Only one experimental run has been performed.
Conclusion

• Shown that PAN can be intercalated into CNTs through diffusion process.

• Concentration of PAN solution does not have effect on thickness of polymer filling.

• Rinsing time also does not seem to have any effect on thickness of polymer.

• More test have to be performed on effect of temperature on thickness of PAN.

• More test need to be performed on Carbonization process.
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