POPULATION ANALYSIS OF DIFFERENT CHIRALITIES IN THE (8,8) & (9,9) FAMILIES IN ARMCHAIR-ENRICHED SINGLE-WALLED CARBON NANOTUBE SAMPLES VIA RESONANT RAMAN SPECTROSCOPY

A. Jeng\textsuperscript{1}, H. Sugahara\textsuperscript{2}, P. Yu\textsuperscript{3}, C. Kittrell\textsuperscript{4}, E. H. Haroz\textsuperscript{5}, J. Kono\textsuperscript{5}
\textsuperscript{1}NanoJapan Program and Department of Chemical, Biological, and Materials Science Engineering, University of Oklahoma
\textsuperscript{2}Department of Physics, Hokkaido University
\textsuperscript{3}University of North Texas
\textsuperscript{4}Department of Chemistry, Rice University
\textsuperscript{5}Department of Electrical & Computer Engineering, Rice University

Resonant Raman spectroscopy offers a nondestructive way to distinguish between the metallic and semiconductor nanotubes in mixed samples by determining the vibrational and rotational modes in molecules. Such optical characterization can be applied to many areas of nanotechnology, such as the creation of a wire spun only out of metallic carbon nanotubes, a material with far less electrical resistivity than that of copper. In order to identify the (8,8) & (9,9) family of nanotubes with resonant Raman spectroscopy, a tunable dye laser was pumped with an Nd: YAG laser. Different excitation wavelengths (570-615 nm) were scattered off of nanotube samples that had undergone density gradient ultracentrifugation (DGU). A charge coupled-device (CCD) camera was used to record the scattered light from the high resolution spectrometer. We see that the radial breathing modes in the Raman spectra indicate strong intensity of the armchair [i.e. (8,8)] and near-armchair [such as (9,6)] species within each metallic family. Additionally, the removal of other non-armchair species (both metallic and semiconducting) allows for the clean observation of a single-mode G-band peak, another hallmark of the presence of armchair nanotubes. Taken together, our results confirm that DGU strongly enriches toward large chiral angle, metallic nanotubes and specifically the armchairs (8,8) and (9,9).
Population Analysis of Different Chiralities in the (8,8) & (9,9) Families in Armchair-Enriched Single-Walled Carbon Nanotube Samples via Resonant Raman Spectroscopy

Alice Jeng1, H. Sugahara2, P. Yu3, C. Kittrell4, E. Haroz2, J. Kono5

1. Nanol Japan Program, Rice University and Department of Chemical Engineering, University of Oklahoma (alice.jeng@ou.edu); 2. Department of Physics, Hokkaido University; 3. University of North Texas 4. Department of Chemistry, Rice University 5. Department of Electrical & Computer Engineering, Rice University

1. Objective

To produce a resonant excitation profile of RBM in SWNTs to determine the different chiralities in DGU samples

2. Introduction

Purpose of Metallic Nanotubes

Construction of armchair quantum wire:
- A wire of minimal electrical resistance
- A wire consisting of armchair nanotube chiralities

Resonant Raman Spectroscopy

Resonant raman enhancement effect which increases Raman scattering
Rayleigh scattering - elastic scattering
Raman scattering - inelastic scattering

Radial Breathing Mode: isotropic vibration in radial direction that specifies (n, m)

3. Methods

A tunable dye laser was used to scatter light off of nanotube samples

Nd: YAG Laser
Wavelength: 532 nm
Power: 5W

Cylindrical lens

Dye Laser
Lasing wavelength: 584-616 nm
Rhodamine 6G Dye

Charged-coupled device—was used to record the scattered light from the spectrometer

Analysis

\[ I_\text{Raman} = gN \times \sum \frac{M_\text{AP} \times M_\text{DP}}{E_\text{Raman} - E_\text{AP} - E_\text{DP} - \Delta E} \]

- Frequency calibration with neon lamp
- Intensity calibration with CCl4
- Igor was used for peak analysis
- Peaks were fitted with a Lorentzian curve
- Cubic baseline subtraction

4. Results

Resonance Excitation Map

Excitation map shows a 3D plot of the RBM peaks observed from the DGU sample

Absorption Spectra

As-produced SWNT

RBM Resonance Spectrum

RBM peak at 596 nm excitation

5. Conclusion

- Resonance profile was observed for (9,9), (11,5), and (10,7) chirality SWNTs
- Relative abundances of the (9,9), (11,5), and (10,7) chiralities in the sample were determined
- DGU metallically enriches samples with armchair SWNT

6. References


This material is based upon work supported by the National Science Foundation under Grant No. OISE-0530220. I would like to sincerely thank J. Kono, E. Haroz, C. Kittrell, C. Matherly, and S. Phillips for making this year’s Reverse Nanol Japan Program possible. Special thanks to Professor J. Kono for giving me the opportunity to work under his guidance. http://nanojapan.rice.edu