Carbon based Nanotechnology

Indigenous Research in Pakistan

Sabih-ud-Din Khan, PINSTECH

KHWARZIMIC SCIENCE SOCIETY, APRIL 2006

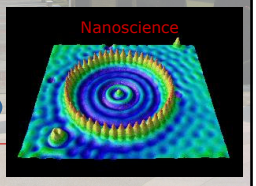
Our Team

Team Members

- Project Director:
  - Dr. Shoaib Ahmad, CS (Head PRD).
- Group Head:
  - Mr. Sohail Ahmad Janjua, PS (on study leave at University of Birmingham)
- Team Members:
  - Mrs. Rahila Khalid, SS (Acting Group Head).
  - Mr. Bashir Ahmad, PS (Registered for PhD at PU, Lahore).
  - Mr. Abid Aleem, JS (PhD Admission in progress at Austria).
  - Mr. Sabih D. Khan, JE (PhD Admission in progress at USA).
  - Mr. Mashkoor Ahmad, JS.
  - Mr. Shahid Nawaz, JS.
  - Mr. Kashif Yaqub, JS.
- Students:
  - Mr. Saif ullah, PhD at GCU.
  - Ms. Sumera Javed, MS Nuclear Engg. at PIEAS.
  - Ms. Sumera Yaseen, MS Nuclear Engg. at PIEAS.
  - Ms. Afshan Ashraf, MS Nuclear Engg. at PIEAS.

Nanotechnology or Nanoscience?

- Nanotechnology:
  - The branch of engineering that deals with things smaller than 100nm [http://www.hyperdictionary.com].
- Nanoscience:
  - New science at a scale smaller than 100nm.
- Why nano scale:
  - < nano scale – Quantum Mechanics (Quantum Physics)
  - > nano scale – Bulk Mechanics (Condensed Matter Physics)
- Nano scale – Unknown domain (something revolutionary new)



Nanotechnology in Pakistan

- National Commission on Nano Science & Technology:
  - Carbon based Nanotechnology Lab, PRD, PINSTECH.
  - Dr. Arshad Mehmood, Quantum Dot based Laser Diodes, APD, PINSTECH.
  - Dr. Arshad Bhatti, COMSATS.
  - Dr. Khurshid Hasnain, Physics Department, QAU.
  - Dr. Shahzad Alam, PCSIR.
  - Dr. Mazhar Mehmood, National Center for Nanotechnology, PIEAS.
  - National Center for Physics, QAU.

Fullerenes & Carbon Nanotubes

- 3rd Allotropic Form of Carbon.
- Carbon atoms arrange themselves as hollow 3D spherical or cylindrical structures.
- Applications:
  - Single electron transistors.
  - Building blocks for Nano-Electromechanical Systems.
  - High strength materials.
  - Direct Methanol Fuel Cell.
  - Fullernol.

Fullerenes & Carbon Nanotubes

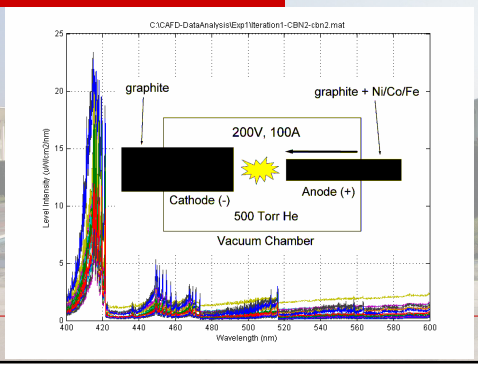
Research Areas

- Experimental Physics
- Computational Physics

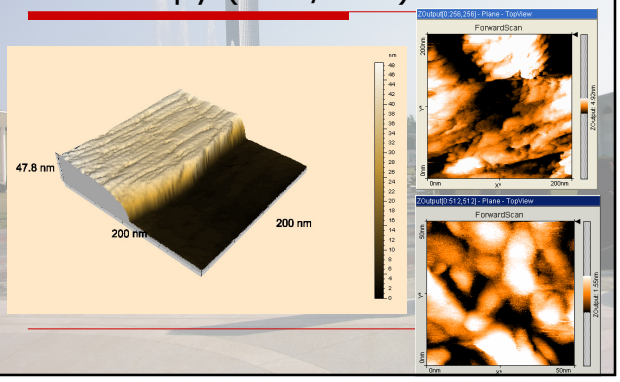
CbN Lab

- Spectroscopy:
  - Emission.
  - Absorption.
  - Raman.
- ExB Mass Spectrometry.
- In-house Spectrometer Calibration Capability.
- Nanoscopy:
  - Scanning Tunneling Microscopy.
  - Atomic Force Microscopy.
- 200kV PINSTECH Accelerator.
- Glow, Arc and Radio Frequency Plasma Sources.

Fullerene & CNT Synthesis



Nanoscopy (STM/AFM)

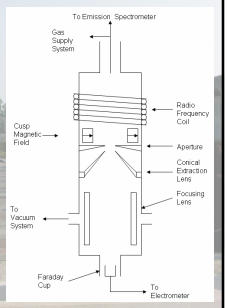


Regenerative Sooting Discharge

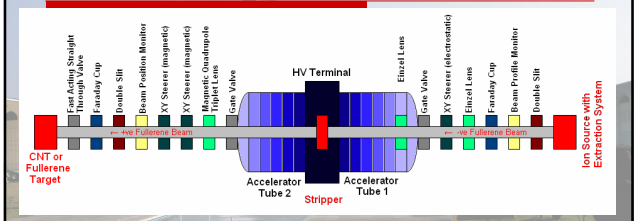
- During experiments on heavy ion acceleration in 1998 we accidentally discovered a relatively newer route of fullerene synthesis.
- Over the next few years we tried to understand the mechanism of formation and have isolated the formation process in compact, low cost, locally developed ion sources.
- Although exact formation mechanism is still under study, one of our team member is registered with PIEAS for PhD is working on this area.

Fullerene Fragmentation

- A number of experiments are in progress to study fragmentation of C_{60}.
- We have locally developed a radio frequency ion source to create fullerene plasma and extract a fullerene beam for further acceleration.
- So far we have tested the ion source with helium gas.
- Pure C_{60} powder was short, but thanks to one of our PhD student from GCU we would receive fullerene powder in good quantities from abroad.
- In the next few months we would be involved in making fullerene plasmas inside radio frequency ion source.
- We are also involved in designing and development of a high power FET based solid state high power oscillator for this ion source.

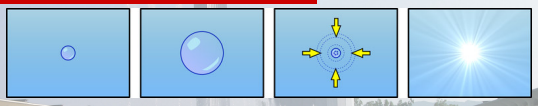


Fullerene Accelerator



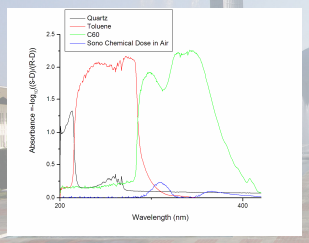
- This proposed experiment is planed to be conducted on newly installed National Accelerator Facility, National Center for Physics, which will be operational within next three to five years.
- Plan is to study effect of high momentum fullerene beams on solid and gas targets, which may lead to formation of new exotic molecules.
- At the moment a student from MS Nuclear Engineering, PIEAS is working with us to indigenously develop ion source with extraction system.

Sono-Chemistry of Fullerenes

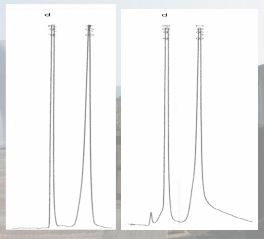


- Sonoluminescence is the emission of light by bubbles in a liquid excited by ultrasound.
- A number of explanations exist:
  - Hot Spot Model: Focusing of shockwaves produced during a collapse of a bubble.
- We exploited this energy concentration method to study the fragmentation of fullerenes.
- This work is in progress but at the moment we have evidence of atleast two new species:
  - A magnetic species which is insoluble in toluene and tend to make microscopic agglomerates.
  - A toluene soluble species with a unique absorption spectrum and HPLC peak.

Sono-Chemistry of Fullerenes

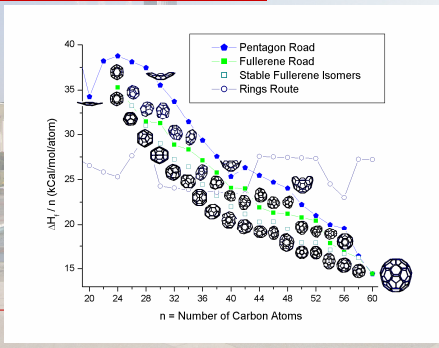


Absorption Spectra



HPLC results, courtesy of Mr. M. Riaz, NCD, PINSTECH

C_{60} Growth Models



Our Proposed Model

- Linear – n < 10
- Rings – 10<n<38
- Fullerenes – n > 38

Science of Small Nanotubes

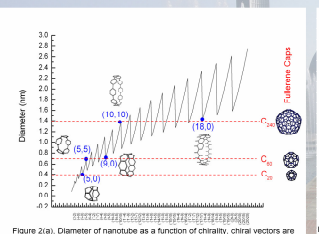


Figure 2(a). Diameter of nanotube as a function of chirality, chiral vectors are arranged on the basis of n-families.

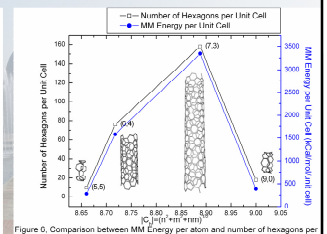
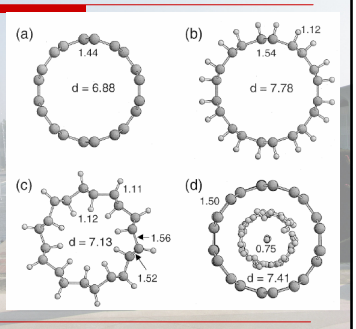


Figure 0. Comparison between MM Energy per atom and number of hexagons per unit cell both as a functions of chiral vector of C_{20} capped nanotubes.

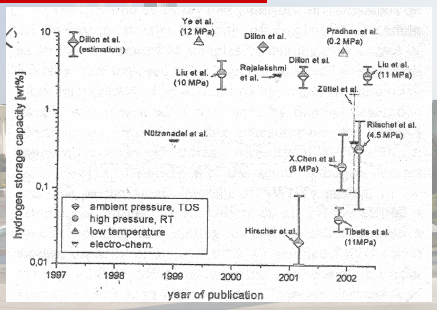
Hydrogen Storage

- Hydrogen is the fuel of future.
- Commercialization of hydrogen fuel cell and hydrogen based internal combustion engine has been already started.
- Hydrogen storage is a major safety issue, it may be safely stored as metal hydrides and on surface of nanotubes.
- Upto 7% by-weight hydrogen can be stored in carbon nanotube.
- So this is one of the short-term application area of nanotubes.



Seung Mi Lee et al.

Hydrogen Storage



Michael Hirscher, et al.

Bottom Line

- Nanotechnology or Nanoscience in Pakistan is a reality.
- Nano Research in Pakistan is at its infancy, but it has been started.
- A couple of new laboratories will be setup in the next few years.
- This is a multi-disciplinary field.
- Pakistan lack man-power !!!
- Very few engineers in this fields, we need a lot of them.