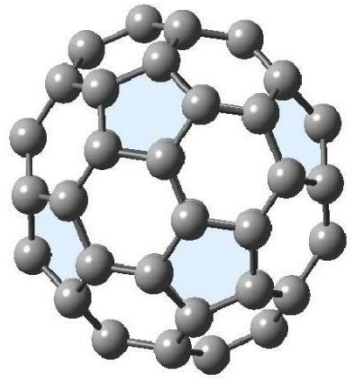
NANO – LECTURE 7



Nano Science and Nanotechnology

Applications of Nanomaterials

Dr. Mervat Kadhem

Major Application Fields

- Nanomedicine
- Energy
- Electronics & Computing
- Environment
- Materials & Engineering
- Textiles & Consumer Goods

Nanomedicine (1) - Diagnosis

- **Smarter" Detection:**
- **Lateral Flow Assays (Rapid Tests):** Gold nanoparticles provide the visible line in pregnancy or COVID-19 tests.
- **Nano-biosensors:** Can detect single molecules (e.g., a cancer biomarker) in blood years before symptoms appear.
- **Imaging Agents:** Nanoparticles (like iron oxide) act as superior contrast agents for MRI (**Magnetic Resonance Imaging)** scans.

Nanomedicine (2) - Treatment

- **Targeted Drug Delivery: The "Magic Bullet"**
- **Problem:** Chemotherapy affects healthy and cancerous cells.
- **Nano-Solution:** Drugs are encapsulated in **liposomes** or **polymer nanoparticles**.
- **How it works:** Nanoparticles are engineered to seek out cancer cells (via specific antibodies) and release their drug payload directly at the tumor site.
- **Result:** Higher efficacy, fewer side effects.

Energy Applications

- **Solving the Energy Challenge:**
- **Solar Power: Quantum dot solar cells** promise higher efficiency and lower cost than traditional silicon cells.
- **Batteries & Supercapacitors:**
  - **Anodes/Cathodes with nanostructures** (e.g., silicon nanowires) increase lithium-ion battery capacity and charging speed.
  - **Graphene-based supercapacitors** for instant charging.
- **Hydrogen Economy: Nanocatalysts** (e.g., platinum nanoparticles) make hydrogen fuel cells more efficient and affordable.
-

Electronics & Information Technology

- **Moore's Law Continues:**
- **Transistors:** We are in the era of nanoelectronics. Chips now have features sized at **5 nm or less**.
- **Memory Storage: Memristors** (nanoscale memory resistors) enable faster, denser, non-volatile memory.
- **Displays: Quantum Dot LEDs (QLED)** produce purer colors and greater energy efficiency for TVs and screens.
- **Future:** Molecular electronics and quantum computing.

Environmental Remediation

- **Cleaning Our Planet with Nano-Tools:**
- **Water Purification: Nanofiltration membranes** with pores just 1-10 nm wide can remove salts, heavy metals (arsenic, lead), and viruses.
- **Air & Soil Clean-up: Nanocatalysts** (e.g., TiO_2 nanoparticles) can break down toxic organic pollutants into harmless substances using sunlight (**photocatalysis**).
- **Pollution Sensors:** Ultra-sensitive nanosensors can detect chemical or biological agents in the environment in real-time.

Advanced Materials

- **Engineering from the Atom Up:**
- **Carbon Nanotubes (CNTs):** 100x stronger than steel, excellent conductors, used in composites for lightweight aircraft, sports equipment, and future space elevators.
- **Graphene:** A single layer of carbon atoms. The world's thinnest, strongest, and most conductive material. Potential uses: flexible electronics, super-strong coatings.
- **Self-Cleaning & Smart Coatings: TiO_2 nanoparticle coatings** on windows break down dirt using sunlight; **nanoscale additives** make surfaces scratch-resistant, anti-fog, or anti-bacterial.

Thanks for Watching