Quantum Entanglement

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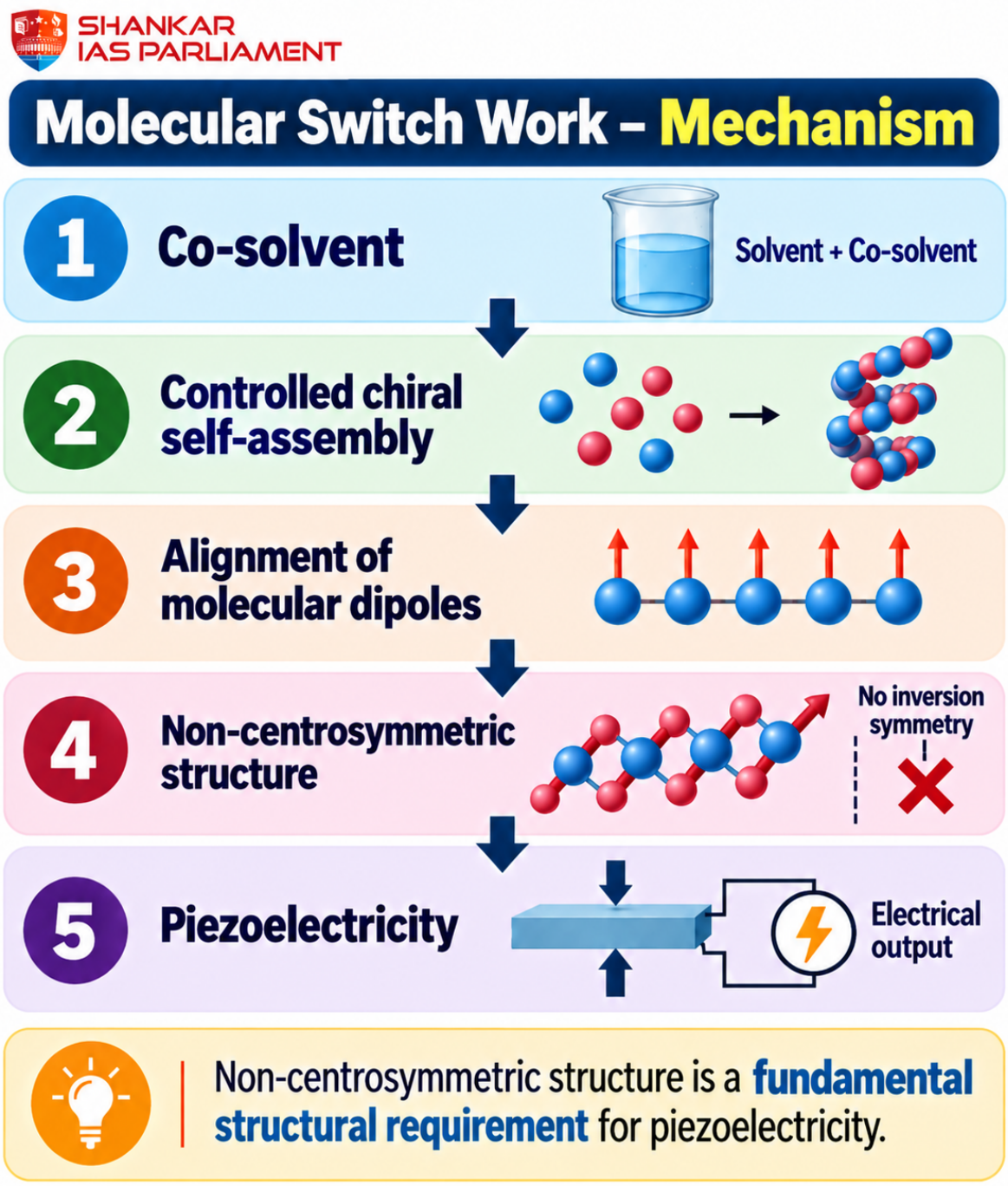
Why in News?

Recently, scientists from RRI, University of Calgary & LSU demonstrated a method to delay/avoid sudden quantum entanglement loss using a single flip operation.

- **Quantum entanglement –** It is a phenomenon in which the quantum states of two or more particles become correlated, so that the measurement of one particle's state is directly related to the state of the other, regardless of the spatial separation between them.
- **Example:** Consider a pair of entangled particles: **Particle A and Particle B**
- The quantum states of these particles are correlated.
- If environmental factors cause the quantum state to deteriorate, the **entanglement may weaken or be lost entirely**.
- Entanglement serves as a fundamental resource in the following areas:
    - Quantum computing
    - Quantum communication
    - Quantum information processing
    - Quantum cryptography

- **Loss of Quantum Entanglement –** Quantum systems exhibit significant sensitivity to external interactions.
- Environmental noise or interactions can result in the loss of quantum information. This phenomenon is generally referred to as **decoherence**.
- In the experimental setup, particles were assumed to possess the following states:
    - An excited state - Higher-energy state of a quantum system
    - A ground state - Lower-energy state
- Typically, the following transition occurs: from the excited state to the ground state
- As the particles decay, the degree of entanglement may diminish.
- **Entanglement Sudden Death –** A notable phenomenon is that entanglement can vanish entirely within a finite time, even when the underlying particle decay process remains incomplete.
- **New study –** A **single flip operation** was applied at a strategically chosen point during the decay process.



- The timing of the **flip operation** determines its effect, which can include the following:
  - Delaying the onset of entanglement sudden death
  - Preventing entanglement sudden death entirely
  - In certain instances, accelerating the occurrence of entanglement sudden death.
- **Significance –** Extending the lifetime of entanglement addresses a critical challenge in the development of quantum technologies.
- The findings indicate that:
  - Existing quantum hardware may not require modification.
  - Precisely timed operations can modulate entanglement dynamics.
  - These strategies may enable the preservation of quantum information for extended durations.

- Control strategies can complement hardware-based methods for managing quantum errors and decoherence.

Reference

PIB | Outsmart Quantum Entanglement