



Role of Nanomaterials in Solving Environmental Issues

For Prelims: Nanomaterials, Carbon Dots, Nanotechnology

For Mains: Scientific Innovations & Discoveries, Nanotechnology

Why in News?

The use of modern technology like nanomaterials or Carbon Dots (CD) **may offer solutions to environmental issues like water pollution.**

- The urban development of modern society has resulted in the introduction of harmful and toxic pollutants into waterbodies, disturbing the integrity of the aquatic environment.
- Novel technological developments like [nanotechnology](#) provide innovative solutions for sustainable and efficient environmental cleanup.

What is Nanotechnology?

- **About:**
 - Nanotechnology is the **use and the development of techniques to study physical phenomena** and develop new material and devices structures in the physical size range from 1 to 100 nanometres (nm).
 - Nanotechnology **influences almost all areas of our lives**, including manufacturing, electronics, computers and information technologies, medicine, the environment and energy storage, chemical and biological technologies and agriculture.
- **Nanotechnology in India:**
 - The emergence of nanotechnology in India has **witnessed the engagement of a diverse set of players**, each with their own agenda and role.
 - Presently nanotechnology in India is mostly a government-led initiative. Industry participation has very recently originated.
 - Nanotechnology R&D barring a few exceptions is largely being ensued at public-funded universities as well as research institutes.

What are Carbon Dots?

- **About:**
 - CDs are **one of the youngest members of the carbon nanomaterial family.**
 - They were discovered in 2004 and have an average diameter of less than 10 nanometres.
 - CDs possess remarkable optical properties, which differ peculiarly based on the precursor used for synthesis.
 - They are becoming more popular as candidates in applications such as sensing and bioimaging due to their good electron donors and acceptors.
 - Bioimaging relates to methods that non-invasively visualise biological processes in real time.
 - Moreover, **CDs are inexpensive, highly biocompatible**, and environment-friendly.

▪ **Role of CDs in Managing Environmental Issues:**

◦ **Pollutant Sensing:**

- CDs **provide an excellent possibility for fluorescence** and colourimetric environmental pollutants detection.
- They are widely used as a fluorescent nanoprobe for pollutant detection because of their high fluorescence emission.
- They also enable the detection of pollutants with colour change by the colourimetric method.

◦ **Contaminant Adsorption:**

- The technology can provide many surfaces adsorption sites due to their small size and large specific surface area.

◦ **Water Treatment:**

- CDs can also be **useful for water treatment as they are promising nano-fillers** in fabricating thin-film nanocomposite membranes where they can form chemical bonds with other compounds.
- CDs have been produced from water hyacinth waste, which showed green fluorescence under UV light. They were also proven to be fluorescent sensors to detect herbicides causing trouble in aquatic bodies.

◦ **Pollutant Degradation:**

- The technology can **also be useful for pollutant degradation** by providing a cutting-edge approach for next-generation photocatalysis.
 - Photocatalysis includes reactions that take place by utilising light and a semiconductor.
- Organic pollutants in polluted water can act as electron and hole transferring agents, while carbon dots act as photosensitiser.

◦ **Antimicrobial:**

- Antimicrobial mechanisms of CDs mainly include physical/mechanical destruction, oxidative stress, photocatalytic effect and inhibition of bacterial metabolism.
- CDs in contact with the bacteria cell under visible or natural light could efficiently generate reactive oxygen species.
- This can damage [Deoxyribonucleic Acid \(DNA\)](#) or Ribonucleic Acid (RNA), causing bacteria death.

What is Categorization of Green Synthesis of Carbon Dots?

- Generally, the synthesis of carbon dots can be categorised into “top-down” and “bottom-up” methods.
 - The **top-down approach** converts large carbon structures into quantum-sized carbon dots by laser ablation, arc discharge, and chemical or electrochemical oxidation.
 - In the **bottom-up method**, CDs are produced from carbonising small molecule precursors by pyrolysis, carbonisation, hydrothermal processes or microwave-assisted synthesis.

UPSC Civil Services Examination, Previous Year Questions (PYQs)

Prelims

Q. With reference to the use of nanotechnology in the health sector, which of the following statements is/are correct? (2015)

1. Targeted drug delivery is made possible by nanotechnology.
2. Nanotechnology can largely contribute to gene therapy.

Select the correct answer using the code given below:

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

Ans: (c)

Exp:

- Nanotechnology is the study and use of structures between 1 nm (i.e., nanometer) and 100 nm in size.
- Nanotechnology in health sector can be used for targeted drug delivery as well as it can also help in gene therapy.
- Gene therapy uses genes to treat or prevent a disease. It allows the doctors to treat a disorder by inserting a gene into the patient's cells instead of using drugs or surgery. Hence, statements 1 and 2 are correct. Therefore, option (c) is the correct answer.

Mains

Q. What do you understand by nanotechnology and how is it helping in the health sector? **(2020)**

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