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Applications of Nanotechnology in Green Chemistry

Rawya Z Al-khayat *[1], Ammar Gh. Ameen AL-dabbagh [2], Seba S. Mohammed [3], Raya Doraid Mohammed[4]
[1]Chemical and Petroleum Industries Techniques, Mosul Technical Institute, Northern Technical University, Iraq
[2] University of Mosul, Biology Department, Mosul, Iraq
[3]Chemical and Petroleum Industries Techniques, Mosul Technical Institute, Northern Technical University, Mosul, Iraq
[4]Center of Technical Research, Northern Technical University, Mosul, Iraq
Email : rawya.zaghlwl@ntu.edu.iq *amrksbio100@uomosul.edu.iq che.19.13@ntu.edu.iq mti.lec92.raya@ntu.edu.iq

Abstract*. Nanotechnology is the science of present and future, it has different physical, chemical, biological preparation methods, it has many applications in green chemistry, agriculture, industry, electronics, environmental pollution. Gold, silver, zinc oxide and titanium dioxide nanoparticles are among most important particles that have many advantages and uses.*

Keywords: *Nanotechnology; Nanoparticles; Laser Ablation.*

1. INTRODUCTION

Nanotechnology is the science of technology of very small particles or small technology.

It is the science concerned with studying the processing of matter on the atomic and molecular scale, so that its dimensions are measured in nanometers, so that the material becomes one billionth of a meter, i.e with atomic clusters ranging from 5-1000 atoms, which are dimensions much smaller than the dimensions of bacteria. This technology is concerned with properties of materials (molecular self –assembly), so the features of traditional materials change to extraordinary.

This specification by measurement is matched by an expansion in the nature of the materials used, so the optical and electromagnetic features change and melting point decreases.

Principle of nanotechnology: is to capture very small atoms of any materials, manipulate and move them to other positions, increasing their surface area, then combining them with atoms of other materials to form a crystalline network to obtain nano -dimensional materials with distinct properties and high performance.

Function of nanotechnology: is develop materials with unique new properties, such as increased strength, long –term stability, reuse multiple times nor affected by time factors improving electrical conductivity, or enhancing chemical catalysis activity due to large size and expansion of surface to quantum ratio.

Nano materials properties

- Increased surface area to volume

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- Mechanical strength
- Magnetic properties
- Self –assembly
- Optical properties
- Quantum effects
- Electrical conductivity
- Chemical reactivity
- Thermal conductivity

Nano materials types

- Nanoparticles
- Nanotubes
- Nanowires
- Nano plates
- Nano composites
- Nanostructured film
- Nano clusters
- Quantum dots

physical methods Preparing Nano materials by

- Ball milling
- laser ablation
- physical vapor deposition (PVD)
- Electro spinning
- thermal evaporation
- hydrodynamic cavitation

Chemical methods Preparing Nano materials by

- Sol –Gel methods
- Chemical vapor deposition (CVD)
- Co-Precipitation method
- Micro emulsion method
- Chemical Reduction method
- Hydrothermal and solvo thermal methods
- Template –Assisted methods
- Electrochemical methods

Biological methods Preparing Nano materials by

-fermentation example production ethanol from glucose by yeast

- Biodegradation example bacteria break petroleum products into simpler compounds
- Bio mining example using bacteria to oxidation copper
- Bio catalysis example use lipases to produce biodiesel from fats
- Plant-Based methods example algae used as biofuels to package Materials
- Mycoremediation example use mushrooms in contaminated soil to break hydrocarbons
- Tissue culture example growing new plants from small tissue sample
- Bio plastics production example use corn starch to produce poly lactic acid(PLA) or produce create bio plastics from algae.

Mechanisms action of nanoparticles:

Increasing surface to volume ratio increasing chemical reactions

- Changing optical and light properties such as light absorption and emission, result different colors for same molecules, gold is red at five nanometers and green at 10 nanometers (color changes with molecules size)
- Adsorption other molecules absorb from their surface, which enhances chemical reactions or activity, acting as a catalyst that greatly increases reaction rate
- Interacting with other molecules in specific ways, such as oxidation and reduction processes.
- Changing electrical properties, such as plastic becoming an electrical conductor thanks to nanoparticles.
- Changing physical properties the melting point of gold is 1063 degrees Celsius, but it drops to only 500 degrees Celsius when gold is transformed into nano scale form
- Changing mechanical properties, such as replacing diamond with nano-carbon, with a strength and hardness that exceeds diamond

  Cellular absorption cells participate in membrane fusion processes
- Biological response affects growth and division.
- Adopting various technologies such as green chemistry, evaporation and lasers
- Solubility Enhancement nanoparticles used to help improve solubility of drugs, facilitating their absorption and increasing effectiveness
- Oxidative stress reactive oxygen cause damage to bacterial cells

Methods for diagnosing nanoparticles

- Spectroscopy

- Mass spectroscopy to determine the mass and chemical composition of molecules

Infrared spectrometry FTIR to analyze chemical bonds and functionality -

- Microscopy

- Scanning Electron Microscope (SEM) provides accurate images of nanoparticles

Transmission Electron Microscope (TEM) gives detailed information About internal structur

- Atomic Energy Microscope (AFM) measures changes in force to analyze the surface

– Fluorescence Microscope used image nanoparticles labeled with dyes

- Chromatography high –performance liquid chromatography(HPLC) separation and analysis nanoparticles

- X-ray techniques

x-ray diffraction (XRD) analysis to determine the crystal structure -

- Electrical measurements

- Electrical conductivity measurements to determine electrical properties of molecules

- Quantitative Analysis

-UV- Vis spectroscopy to determine concentration of molecules in solutions

- Bio Sensing Techniques

-Using nanoparticles as sensing agents to detect biological compounds

- Dynamic Analysis Devices (Dynamic Light Scattering – DLS)

To determine the size molecules and know their distribution in solution

- electrophoresis

To separate molecules based on their size and charge-

- Rheometry determine the viscous properties of nano particles

- Ultrasound Aanlysis detect size and distribution of particles in solutions

- Fluorescence Resonance to study interactions between molecules

- Nuclear Magnetic Resonance (NMR)

Determine chemical structure of nanoparticles

- Genetic sequencing technology DNA

Develop complex DNA nanostructures

- Magnetic resonance imaging (MRI)

Green chemical pathway

Both, physical and chemical methods are used in producing nanoparticles require long durations , solvent and hazardous materials materials that can pose risks to humans and the envairoment, these materials are difficult to dispose of and demand a significant energy source in contrast, biological technique are more productive cost effective faster safer and

environmentally friendly they do not require high energy inputs and rely on metabolism of microscopic organisms such as bacteria fungi and algae, as well as plant extracts that include organic substances such proteins, amino acids, carboxylic acids, flavonoids, phenyls, and ketones, these materials are crucial for recovering mineral salts and producing nanoparticles quickly, simple, and affordable ways that enhanced processing by controlling the size, shape, growth, purity, and stability of nano crystals.

Factors affecting green chemistry

- Temperature

-Increased temperature it can enhance certain chemical reactions, leading to formation of smaller –sized nanoparticles

-Decreased temperature it may improve stability of particles and reduce agglomeration

-Pressure

-High pressure it can help improve specific reactions, resulting in more uniform nanoparticles

Low pressure it may lead to reduced interactions between materials

- Time

Increased time it can allow for more reactions improving the nano scale properties

Decreased time it may produce heterogeneous or unstable particles

- PH

-Basic PH it can affect solubility and chemical interaction, leading to nanoparticles with specific properties.

-Acid PH it may help stabilize particles and prevent agglomeration

Nano principles of green chemical

- waste reduction and environmental protection
- use safe materials less toxic
- energy efficiency to reduce consumption and decrease carbon Emissions.
- sustainable product design to reusable or biodegradable to minimize environmental impact
- process control
- use of renewable resources instead of petroleum -based materials
- economic efficiency reduce production costs, reduce waste, and use energy more efficiently

gold nanoparticles in green chemistry Applications use

-Catalyzing chemical reactions in oxidation reaction of alcohol to ketone

- renewable energy solar cells improve efficiency converting solar energy in
- environmental analysis in sensors to detect pollutants such as lead and mercury in water
- wastewater treatment to remove organic pollutants from water and soil

Use nano zinc oxide in green chemistry Applications

- water treatment removes organic pollutants such as phenols
- transparent conductive layer in solar energy cells
-gas sensors to detection of pollutants in air sunscreen agent protect skin from ultraviolet rays in cosmetic
- added to fertilizers as a source of zinc, improving soil quality, raising its efficiency, and increasing agricultural productivity.
- Added as a fungicide and insecticide to reduce the number of fungi, insects and treat seeds before planting

Applications use TiO2 in green chemistry

- used in photo catalytic techniques to break down harm full organic materials pollute water and air.
- antibacterial coatings instead of toxic chemicals and increase product life.
- improve efficiency of converting solar energy into electricity.
- in water treatment acting as catalyst in oxidation reactions.
- added to concrete to increased corrosion resistance.
- added to fertilizers to increase effectiveness of light in metabolic processes, increase soils ability to retain moisture, and improve roots ionic activity

Applications use silver nanoparticles in green chemistry

-biocides to reduce fungi and bacterial growth
-remove contaminants and germs from drinking water
- catalytic agents in fuel cells to increase energy efficiency, reduce emissions and use harmful chemicals
- catalyst chemical reactions reduce consumption large quantities of solvents, which reduces costs and protects environment
- added in nano coating to prevent corrosion, increase strength and durability, and reduce toxic effects of chemicals

APPLICATIONS of nanotechnology in chemistry are most important

- chemical catalysis
- pollutant removal
- energy storage

-Development new materials

- improving manufacturing processes

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