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Silicon Based Nano Composites for Photodegradation of Water Pollutants

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ABSTRACT:

Water purification is an essential process to ensure access to clean and safe drinking water. Nanocomposites have emerged as a promising technology for water purification due to their unique physicochemical properties. Nanocomposites are materials that are composed of nanoparticles integrated into a polymer matrix, resulting in a material with enhanced mechanical, thermal, and electrical properties. The integration of nanoparticles into the polymer matrix has been shown to improve the removal of pollutants, bacteria, and viruses from water. This paper provides an overview of the recent advancements in the use of nanocomposites for water purification. The paper discusses the types of nanocomposites used for water purification, the methods of synthesis, and the mechanisms of pollutant removal. The paper also highlights the potential of nanocomposites for future developments in the field of water purification.

1. INTRODUCTION:

The use of matter at the atomic, molecular, and supramolecular scales for industrial applications is known as nanotechnology, or nanotech for short. The initial, most popular definition of nanotechnology, currently known as molecular nanotechnology, focused on the specific technological objective of accurately manipulating atoms and molecules for the creation of macroscale objects. The National Nanotechnology Initiative subsequently created a broader definition of nanotechnology, defining it as the manipulation of matter with at least one dimension scaled from 1 to 100 nanometers (nm). This definition changed from a specific technological goal to a research category inclusive of all types of research and technologies that deal with the unique properties of matter that occur below the specified size threshold in order to reflect the importance of quantum mechanical effects at this quantum-realm scale. As a result, the term "nanotechnologies" or "nanoscale technologies" is frequently used to refer to a wide range of research and applications that share the characteristic of being small.

A size-based definition of nanotechnology encompasses a variety of scientific disciplines, including surface science, organic chemistry, molecular biology, semiconductor physics, energy storage, engineering, microfabrication, and molecular engineering. The related research and applications include a wide range of topics, from modifications of traditional device physics to entirely novel strategies based on molecular self-assembly, from creating novel materials with nanoscale dimensions to precise control of matter at the atomic level.

2. ORIGINS:

Richard Feynman, a renowned physicist, originally presented the ideas that gave rise to nanotechnology in 1959 in his lecture There's Plenty of Room at the Bottom, when he described the prospect of synthesis via direct atom manipulation.

Although it was not well known, Norio Taniguchi coined the phrase "Nano-technology" in 1974. K. Eric Drexler coined the term "nanotechnology" in his 1986 book Engines of Creation: The Coming Era of Nanotechnology, which put forth the concept of a nanoscale "assembler" capable of creating copies of itself and other objects of arbitrary complexity with atomic precision. Drexler was inspired by Feynman's ideas. In an effort to promote a better understanding of the concepts and implications of nanotechnology among the general public, Drexler also co-founded The Foresight Institute in 1986. He is no longer a part of this organization.

The Bucky ball, sometimes referred to as buckminsterfullerene C60, is an example of the class of carbon compounds called fullerenes. The fullerene family is a key focus of research that falls under the category of nanotechnology.

Second, Harry Koto, Richard Smalley, and Robert Curl, who collectively received the 1996 Nobel Prize in Chemistry, made the discovery of fullerenes in 1985. The term "nanotechnology" was first used in relation to later research on closely related carbon nanotubes (also known as graphene tubes or Bucky tubes), which showed possible uses for nanoscale electronics and gadgets. C60 was not first described as nanotechnology. Sumio Ijma of NEC is primarily credited for discovering carbon nanotubes in 1991, for which Ijma received the first Kavli Prize in Nanoscience in 2008.

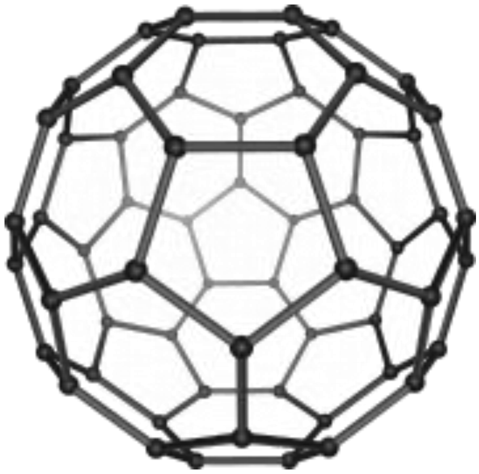

FIG. Bucky ball

3. Fundamental concepts :

Engineering functional systems at the molecular level is known as nanotechnology. This covers both the most recent research and more complex ideas. In its original sense, the term "nanotechnology" refers to the anticipated capacity to build things from the ground up utilizing currently being developed methods and tools to create finished, high-performing products.

One billionth of a meter, or 109, is a nanometer (nm). Comparatively, a DNA double helix has a diameter of around 2 nm, and average carbon-carbon bond lengths, or the spacing between these atoms in a molecule, are in the range of 0.12-0.15 nm. The bacteria belonging to the genus Mycoplasma, on the other hand, are the smallest known cellular life forms and measure about 200 nm in length. According to custom, nanotechnology is understood to cover the size range of 1 to 100 nm, as per the National Nanotechnology Initiative's definition in the US. Since nanotechnology must construct its gadgets from atoms and molecules, the lower limit is set by the size of atoms (hydrogen contains the smallest atoms, which are around a quarter of a nanometer kinematic diameter). The top limit is more or less arbitrary, although it roughly corresponds to the size below which phenomena not seen in bigger structures start to emerge and can be utilized in the Nano device. These novel phenomena set nanotechnology apart from devices that are essentially scaled-down counterparts of a comparable macroscopic device; these larger-scale devices fall under the category of microtechnology.

4. Nanomaterials :

As the system gets smaller, a number of phenomena become more obvious. These include statistical and quantum mechanical effects, such as the "quantum size effect," which modifies the electrical characteristics of solids when particle size is drastically reduced. Going from macro to micro dimensions has no impact on this effect. However, when the nanoscale size range is reached, often at distances of 100 nanometers or less, the so-called quantum world, quantum effects can become substantial. When compared to macroscopic systems, a number of physical (mechanical, electrical, optical, etc.) attributes also alter. One illustration is how changing the surface area to volume ratio can change a material's mechanical, thermal, and catalytic properties.

Nanoionics is the broad term for nanoscale diffusion and reactions, nanostructured materials, and nanodevices with quick ion transport. The study of Nano mechanics is interested in the mechanical characteristics of Nano systems. Nanomaterials' catalytic activity makes their interactions with biomaterials potentially dangerous.

The nanomaterials field includes subfields which develop or study materials having unique properties arising from their nanoscale dimensions.

- Materials like carbon nanotubes and other fullerenes, as well as different nanoparticles and nanorods, have been developed thanks to interface and colloid research. Nanoionics and nanoelectronics are also connected to nanomaterials with rapid ion transport.
- Nanoscale materials can also be utilized in large-scale applications; the majority of current commercial uses for nanotechnology fall into this category.
- The usage of nanoscale materials for medical purposes has advanced; for more information, see Nanomedicine. Nanoscale materials, such as nanopillars, are occasionally employed in solar cells to reduce the cost of conventional silicon solar cells.

5. Top-down approaches:

These seek to create smaller devices by using larger ones to direct their assembly.

a. The term "nanotechnology" refers to a variety of processes that evolved from standard solid-state silicon methods for making microprocessors and are now capable of producing features smaller than 100 nm. This includes existing giant magnetoresistance-based hard drives as well as atomic layer deposition (ALD) technologies. In recognition of their contributions to the field of spintronics and discovery of giant magnetoresistance, Peter Grunberg and Albert Fert were awarded the 2007 Nobel Prize in Physics.

b. Devices known as nanoelectromechanical systems, or NEMS, which are linked to microelectromechanical systems, or MEMS, can also be made using solid-state processes.

c. When sufficient precursor gases are delivered simultaneously, focused ion beams have the ability to directly remove material or even deposit material. For instance, this method is frequently used to produce sub-100 nm material slices for transmission electron microscopy investigation.

Atomic force microscope tips can be used as a nanoscale "write head" to deposit a resist and then, using a top-down approach, etch the resist away.

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6. Bottom-Up Approaches:

These seek to arrange smaller components into more complex assemblies.

- Watson-Crick base pairing's specificity is used in DNA nanotechnology to create precisely defined structures from DNA and other nucleic acids. Approaches from the field of "classical" chemical synthesis (Inorganic and organic synthesis) also aim at designing molecules with well-defined shape (e.g. bis-peptides).
- Methods used in the "classical" field of chemical synthesis (inorganic and organic synthesis) aim to create molecules with clearly defined shapes, such as bis-peptides.
- In a technique known as dip pen nanolithography, atomic force microscope tips can act as a nanoscale "write head" to deposit a chemical upon a surface in a specified pattern. This method falls under the broad category of nanolithography.
- Materials can be constructed from the bottom up using Molecular Beam Epitaxy, particularly semiconductor materials frequently employed in chip and computing applications, stacks, gating, and nanowire lasers.

SYNTHESISING THE NANO COMPOSITE USING BOTTOM-UP METHOD:

- The experiment was started with the aim of producing the Nano Magnesium Silica composite and the alumina silica composite and conducting the experiments over them.
- So for the past of the of the experiment the equal proportions of Magnesium oxide (MgO) and the Silicon oxide (SiO) in the nano powder state are considered and taken individually and the weighing of the Nano powder was done on The weighing machine as the butter paper was considered to make the external reaction of the Nano powers negligible as they are highly reactive in the nature.
- Distilled water was taken with the ratio of 1:100 i.e. the Nano powder (in grams) to the distilled water (in ml) and then the Nano Magnesium oxide in the distilled water was stirred on a Magnetic stirrer over period of 30 minutes as the stirring mechanism in the magnetic stirrer was using a magnetic rotating magnetic field to stirrer the required respective content
- And on sideways the distilled water was taken with the ratio of 1:100 i.e. the Nano powder (in grams) to the distilled water (in ml) and then the Nano Silicon oxide in the distilled water was stirred on a Magnetic stirrer over period of 30 minutes

- Now both the individual compositions are integrated and then the combined composition was stirred for over a period of 3 hours for the purpose of making matrix and reinforcement.
- The combined composition is will be in the liquid state as i.e., the Nano Magnesium and the Nano Silica are integrated and freely suspended. Now for making the respective composition liquid free the water content should be completely dried, this can be achieved by heating the composition in a closed space the reactions which might happen as the Nano compositions are highly reactive in the nature
- As the dring process of the compositon caried out on the furnance, as the respective composition is placed in a appropriate container and place in a closed furnance for a period of 6 hours with the gradually increasing temperature upto 600degrees celsius.
- After the 6hours in the furnance the output will be solidifed magnesium silica composte in completely solidified form. As when ever required the solidified matter is made into small powder with the help of mechanical grinding process as the powder form of the Nano composite react rapid comparitively due to more surface area and more intraction.

FIG.FURNACE

And the composition of the aluminum silica should be prepared as the equal proportions of aluminum oxide(AlO) and the Silicon oxide(SiO) in the nano powder state are considered and taken individually and the weighing of the Nano powder was done on the weighing machine as the butter paper was considered to make the external reaction of the Nano powers negligible as they are highly reactive in the nature.

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As stirring is required for perfect integration of water and the nano particles and formation of matrix and the reinforcement.

Matrix will be the metal used and the reinforcement will be the silicon

FIG.MAGNETIC STIRRER

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Now this prepared Nano powder should be tested for the observing the performance in filtering out the pollutants from the liquid taken, for that repective purpose Malachite Green Oxalate as impurity.

FIG.SILICON OXIDE NANO POWDER

FIG.MAGNESIUM SILICON NANO COMPOSITE

7.OBSERVATION:

Start time 1:00pm

TEST TUBE NUMBER	TIME	EXPOSURE TIME
23	1:15pm	15 minutes
24	1:30pm	30 minutes
25	1:45pm	45 minutes

FIG.SAMPLE BEFORE SUNLIGHT EXPOSURE

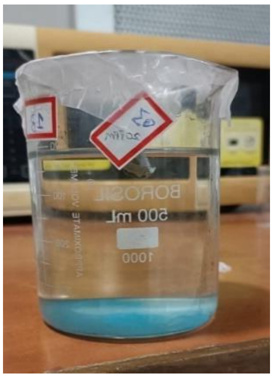

FIG.SAMPLE AFTER SUNLIFGT EXPOSURE

so we are getting favorable results while using the Magnesium silicon composite at nano state but there are no noticeable change in the characteristics of dyeing and filtration of the impurities in the samples using aluminum silicon of different ppm concentrations i.e. at10 ppm, 50 ppm, 100 ppm. So magnesium silicon Nano powder is considered and selected for the filtration and increasing the properties of silicon in water filtration in Nano state

8.POTENTIAL OF HYDROGEN:

Now the pH value of the respective tested samples of magnesium and silica are follows. And the quantity of catalyst is 0.20 and 0.30

OBERVATION FOR pH:

SAMPLE CONCENTRATION	CATALIST QUANTITY	pH VALUE
10 ppm	0.20 grams	8-9
50 ppm	0.20 grams	8-9
100 ppm	0.30 grams	8-9
50 ppm	0.0 grams	7

And from the above experimentations we conclude thatfor concentration of 10ppm the 0.20 grams of the catalist is sufficient so the filtration is rapid and comped in 60 to 70 minutes.

If the concentration of the sample is increased and the same amout of nano composite i.e 0.20 grams added is not that sufficient so the filtration takes more time, it almost tool 3hours for the complete decolourisded while using 0.20 grams of Magnesium silicon nano composite.

9.FILTERATION:

As no we should determine weather the catalist can be restored or not and tested for that reason the sample which is exoposed to sunlight will be filtered out this is done with the help of the filter paper

As our sample is puored in small quantities on the filter paper and by the end only catalist and the impurities are in the filter paper.

10.TESTING AND RESULTS:

The filtered out output will be in the slightly liquid form do it is to be made dry so that the filtered sample is to be placed in the furnance for 30 after that the powdered form of the catalist and impurities are obtained. And this powder form is sent for the XRD testing for identification of the sample in the catalist.

After the XRD the data received in sin the firm of the co-ordinates which should be analysed for obtaining the graphs

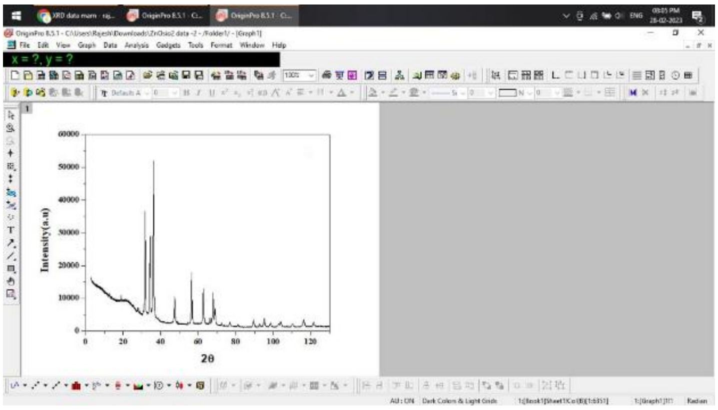

FIG.XRD GRAPH OF FILTERED OUT NANO POWDER AND IMPURITIES

Now this graph should be compared with the standars graph that is the graph of the impurities so the XRD test for the impurities are also performed

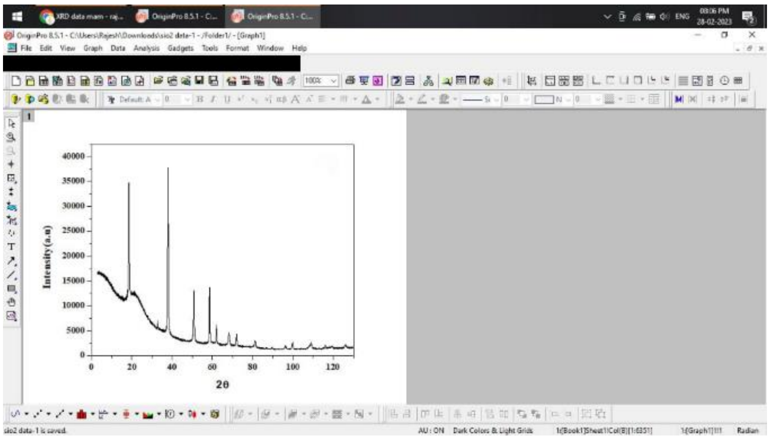

FIG.XRD GRAPH OF IMPURITIES

By analysing the graphs of the both filtered out materials which are tested individually, the perks indicate the content of the impurity in the filtered out material from the sample which is exposed to the sunlight over a period of time

11.Advantages:

[1] **Enhanced capacity for adsorption:** Nanocomposites has a high surface area to volume ratio that enables them to absorb more water pollutants. As a result, nanocomposites are able to filter out more contaminants than conventional filtering techniques.

[2] **Enhanced selectivity:** The surface chemistry of nanocomposites can be adjusted to remove particular contaminants from water in a selective manner. This enables the elimination of pollutants in a more efficient and effective manner.

[3] **Increased durability:** Traditional filter media has to be replaced less frequently because nanocomposites are more durable. Over time, this may lead to cost savings.

[4] **Enhanced performance:** By boosting the effectiveness of the filtering process, nanocomposites can enhance the performance of water treatment systems. This translates to faster and less energy-intensive water treatment.

[5] **Eco-friendly:** Materials that are friendly to the environment, like biodegradable polymers and natural minerals, can be used to create nanocomposites. This lessens the negative effects of water filtering procedures on the environment

[6] In comparison to conventional filtering techniques, the use of nanocomposites in water filtration has a number of benefits, including increased efficiency, selectivity, and durability as well as lessened environmental effect.

12.Limitations:

a) Cost: The production of nanocomposites can be expensive, especially when using certain materials, such as graphene or carbon nanotubes. This can limit their use in large-scale water filtration applications.

b) Potential health risks: Some types of nanocomposites, such as those containing nanoparticles, may pose health risks to humans and the environment. These risks are not yet fully understood and require further research.

c) Clogging: Nanocomposites can become clogged when filtering water with high levels of suspended solids or organic matter. This can reduce their filtration efficiency and require more frequent maintenance.

d) Limited understanding: Since the creation of nanocomposites for water filtration is a relatively new topic, much remains to be discovered about their characteristics and possible uses. To completely comprehend their limitations and how to get around them, more research is required.

e) Nanocomposites may be difficult to dispose of because they don't always degrade quickly in the environment. Concerns concerning their effects on the environment and public health may arise as a result.

Overall, although though nanocomposites have numerous benefits for filtering water, their drawbacks also need to be carefully studied and resolved in order to assure their safe and efficient use.

13. Applications:

i. Membrane filtration: By eliminating impurities including heavy metals, bacteria, and viruses, nanocomposite membranes can be used to purify water. A greater level of water quality results from the use of nanocomposites, which increase the membrane's selectivity and filtration effectiveness.

ii. Adsorption: Nanocomposites are effective adsorbents that can be utilized to filter out impurities from water. Nanocomposites made of activated carbon, for instance, have been used to purge water of organic contaminants.

iii. Photocatalysis: Nanocomposites can be utilized as photocatalysts to break down organic contaminants in water by photocatalysis. It has been demonstrated that titanium dioxide-based nanocomposites are good at removing pollutants from wastewater.

iv. Coagulation: To remove suspended particles and other contaminants from water, nanocomposites can be utilized as coagulants. For this aim, iron-based nanocomposites have been used because they are very good at eliminating arsenic and other heavy metals from water.

v. Desalination: Since nanocomposites can take the salt ions out of saltwater, they can also be utilized for desalination. As they have excellent water permeability and have the ability to remove salt ions with precision, graphene-based nanocomposites have demonstrated potential in this field.

vi. All things considered, nanocomposites have the power to revolutionize water filtration technology and offer a long-term answer for the accessibility of clean water.

14. CONCLUSION:

As the resuts of various experiments indicte that the aluminium silicon composite doesn't show positive results in filtration of the impurities and the aluminium silicon composite doesn't even degrade the colour or redure the dyeing proprty of the test sample in ehich the impurities are added.

But un like Aluminium silicon Nano composite the Magnesium silicon Nano composite shows the adverse positive results whilte testing. As it filters out the impurities added to the water and also the dyeing property of the water after the addidion of the impurity changed i.e the water became back to transparent. So magnesium is considered to be our working sample of catalist.

Even XRD results shows the content of the impurities in the filtered out material i.e the material that is filter out from the sample which contains the imputities and the Magnesium silicon Nano composite powder that means that nano composite attempts to remove the content of the impurities from the sample.

And it takes 60-90 mintutes for Magnesium silicon Nano composite Nano powder of 0.20 grams to filter out the impurity sample of concentration 10 ppm.

And it takes almost 180 minutes for Magnesium silicon Nano composite Nano powder of 0.20 grams to filter out the impurity sample of concentration 50 ppm and 100ppm.

The filtration is rapid in the first scenario than the second one the difference between the both the cases is the concentartion of the impuraties

So according to the observation it seems that for every impurity concentration of 10 ppm the Magnesium silicon Nano composite Nano powder of 0.20 grams is required to filter out the impurities and to change the dyeing charateristis of the impurity and reduce the eefect of impurities in the water same for rapid results.

FIG. SAMPLE BEFORE EXPOSURE TO SUN LIGHT

FIG. SAMPLES AFTER EXPOSURE TO SUNLIGHT

15. FUTURE SCOPE:

- Magnesium-silicon nanocomposites have demonstrated promising results in a number of applications, including water filtering. These composites have a number of benefits that make them an appealing material for water filtration, including a high surface area, superior mechanical strength, and exceptional thermal stability.
- Magnesium-silicon nanocomposites may one day be employed to create extremely effective water filtering systems. They could be used to get rid of bacteria, heavy metals, and organic compounds from drinking water and wastewater.
- These nanocomposites could also be utilized to create portable water filtration systems that could be employed in distant locations with limited access to clean water. In order to offer affordable and effective water treatment options, they could potentially be employed in large-scale water treatment facilities.
- Additionally, studies are being done to examine the possibility of improving the efficiency of magnesium-silicon nanocomposites in water filtration by functionalizing them with other components. For instance, scientists are looking into the usage of graphene oxide to increase the capability of magnesium-silicon nanocomposites to purify water.
- Magnesium-silicon nanocomposites have a potential future in water filtration, and more study and development in this field may result in the creation of extremely effective and affordable water treatment systems.

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