Use of transition metals in nanotechnology

Part 1: Introduction 1. 1

Nanotechnology or “ nanotech” is the branch of engineering that deals with things smaller than 100 nanometers. It is the study of the controlling of matter on an atomic and molecular scale. It deals with creating of nanoparticles and of manufacturing machines which have sizes within the range of 1 to 100 nanometres.

Nanotechnology offers the potential to overcome many of the serious issues facing mankind over the coming decades. Climate change, pollution control and prevention, access to clean water, falling energy reserves and the diagnosis and treatment of diseases such as cancer all represent significant challenges to man and the planet. New scientific and technological breakthroughs will be needed to deliver solutions. Over the last decade almost $50 billion of government funding has been invested into nanotechnologies, and this investment is now starting to bear fruit with a steady stream of commercially viable nanotechnologies which are positively impacting human health, the environment and technology. Gold is at the forefront of this ‘ nanotechnology revolution’.

1. 2 What are Transition Metals?

Elements whose atom has an incomplete d sub-shell, or which can give rise to cations with an incomplete d sub-shell. They are ductile, malleable, and conduct electricity and heat. Their valence electrons are found in more than one shell, that is why they have more than one oxidation number.

Some of the transition metals that are used in nanotechnology are Gold, Platinum, Iron, Cadmium, Nickel, Cobalt.

1. 3 Transition Metals which are used in Nanotechnology

- Gold
- Platinum
- Nickel
- Cobalt
- Iron
- Cadmium

Part 2: Project Overview

2. 1: Why Transition Metals can be used in nanotechnology?

Explanation of some of transition metals which can be used in nanotechnology:-

2. 1. 1: Gold

Gold is widely used to build nanostructures because it is relatively chemically inert, although gold clusters can become quite reactive as they get smaller. Indeed, positive gold ions can react with noble gases, and gold particles just a few nanometres in diameter can act as catalysts in many reactions, as can single gold atoms bound in suitable complexes.

The nobility of gold and its resistance to surface oxidation which makes it ideal material for wide range applications in nanotechnology. Gold nanoparticles have a colour varying from red to purple depending on particle size, a property that can be successfully exploited in a range of applications.

2. 1. 2: Nickel

The reason for working with nickel is that it responds to electrochemistry, has good mechanical and corrosion properties and is inexpensive. It is strong and cheap and easily processed in this particular style.

2. 1. 3: Iron

Iron oxide nanoparticles are considered promising because they are maneuverable by remote magnetic fields, and can be coated with various marker molecules to make them stick selectively to tumors and other targets within the body. The particles can also be made to carry anti-cancer drugs or radioactive materials directly to a tumor. Magnetic nanoparticles designed to attach to cancerous tissue can also be made to heat up by using a remote, alternating magnetic field, thereby selectively killing cancer cells in a process called magnetic hyperthermia.

2. 2 Use of Transition metals in nanotechnology

2. 2. 1: Gold

Gold nanoparticles are a popular choice for medical research, diagnostic testing and cancer treatment. By using gold nanoparticles it improves the drug delivery efficiency of anticancer drug.

It may sound odd, but the dye in your blue jeans or your ballpoint pen has also been paired with gold nanoparticles to fight cancer. This dye, known as phthalocyanine, reacts with light. The nanoparticles take the dye directly to cancer cells while normal cells reject the dye. Once the particles are inside, scientists “ activate” them with light to destroy the cancer. Similar therapies

have existed to treat skin cancers with light-activated dye, but scientists are now working to use nanoparticles and dye to treat tumors deep in the body.

2. 2. 2: Platinum

The researches in their latest word incorporated platinum metals into their nanotubes structures. Platinum can add useful catalytic, electronic, luminescent, and magnetic functionalities to the nanotubes.

Catalysts are used with fuels such as hydrogen or methanol to produce hydrogen ions. Platinum, which is very expensive, is the catalyst typically used in this process. Companies are using nanoparticles of platinum to reduce the amount of platinum needed, or using nanoparticles of other materials to replace platinum entirely and thereby lower costs.

2. 2. 3: Nickel

Applications for nickel nanocrystals include numerous catalytic functions such as in the anode of solid oxide fuel cells (SOFC) or in the conductive electrolytic layer of proton exchange membrane (PEM) fuel cells, in replacement of platinum. Also, substituting all or a portion of the platinum with nickel nano particles in automotive catalytic converters would significantly reduce their cost and in coatings, plastics, nanowire, nanofiber and textiles and in certain alloy and catalyst applications . Further research is being done for their potential electrical, dielectric, magnetic, optical, imaging, biomedical and bioscience properties. Nickel Nano Particles are generally immediately available in most volumes.

Nickel nanoparticles could even be used in biomedical applications, such as implants that dispense drugs, though the metal would likely be coated to prevent possible allergic reactions. The metal’s magnetic properties make it a natural choice for magnetic applications.

2. 2. 4: Cobalt

The nanoparticle films of transition metals such as iron, nickel, or cobalt may be used to catalyse the growth of carbon nanotube.

The Nickel or Cobalt nanotubes with larger diameters(around 160 nm) show a nearly isotropic magnetic moments arranged in a vortex state at zero field.

2. 2. 5: Iron

Hot iron nanoparticles could be used to carve electronic circuits out of graphene sheets. The excellent electronic properties of graphene have prompted scientists to try cutting it into ‘ nanoribbons’, which might be used in electronic devices of the future. Attempts with lithography, however, have left rough edges to the nanoribbons that could affect their performance.

Widely used iron nanoparticles exhibit toxic effects on neuronal cells. “ Iron is an essential nutrient for mammals and most life forms and iron oxide nanoparticles were generally assumed to be safe”

Part 3: Analysis

3. 1 Nanotechnology and Cancer

In a study published in the July 2007 issue of Analytical Chemistry, scientists from Purdue University detailed their use of gold nanoparticles to detect

breast cancer. Their work, along with similar studies at other universities, has the potential to radically change breast cancer detection.

The procedure works by identifying the proteins found on the exteriors of cancer cells. Different types of cancer have different proteins on their surfaces that serve as unique markers. Nanorods, gold nanoparticles shaped like rods, use specialized antibodies to latch onto the protein markers for breast cancer, or for another cancer type. After the nanorods bind to proteins in a blood sample, scientists examine how they scatter light. Each protein-nanorod combination scatters light in a unique way, allowing for precise diagnoses.

The use of gold nanoparticles is not new to this study. These tiny particles — it would take 500 of them to span the width of a human hair — are particularly suited to detect toxins, pathogens and cancers and are a subject of much experimentation. The scientists at Purdue used nanorods capable of attaching to three types of breast cancer markers, with two of the markers identifying how invasive the cancer is. The lead researcher on the study, Joseph Irudayaraji, said that these nanorods could one day form part of a much more thorough test, binding to up to 15 unique markers.

Using nanorods cuts the price of the diagnosis by two-thirds compared to the similar method of flow cytometry, in which fluorescent markers bind to cancer cells. Flow cytometry requires a bigger sample size with thousands of times more cells than is needed for nanorods, meaning that nanorods are capable of helping to determine earlier diagnoses. Nanorods prove much less invasive than some other methods because they use blood samples and

don’t require a biopsy. Part of the cost savings comes from scientists being able to use a conventional microscope and light source to view the samples, unlike other methods that employ expensive microscopes or lasers.

In a different study, Dr. Irudayaraj showed that gold nanorods could be used to detect cancer stem cells. The discovery is particularly valuable because cancer stem cells cause the out-of-control growth that makes malignant tumors so deadly.

Dr. Irudayaraji said that gold nanoparticles could be widely available for cancer diagnoses sometime in 2011.

Besides being part of exhaustive tests that can detect cancers early on, nanoparticles may also form the basis of future cancer treatments. Lasers that react with gold nanoparticles could be used to destroy cancer cells. Or, nanoparticles could be used as targeted drug-delivery systems.

Part 4: Conclusion

After the completion of the term paper on “ Use of Transition Metals in Nanotechnology” I got many new things to learn about. The term paper helped me to know more about nanotechnology and the different transition metals and about its use in nanotechnology. The nanoparticles, how it is useful in treatment of cancer, and its uses in biomedicals and others.

The term paper also gives the structures of some of the transition metals nanoparticles and about the extensive use of the transition metals in nanotechnology.

I have worked very hard on this project and wanted to build it in a very simple and lucid manner so that it could be easy for the reader to go through and understand the term paper.

Hopefully, I think that you would have gained some knowledge on transition metals nanoparticles and could have well understood it. I grant a sincere apologize if any mistake would have crept in my work.