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Biomaterials Science and Nanotechnology

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Abstract—*As a science, biomaterials is about fifty years old. The study of biomaterials is calledbiomaterials science or biomaterials engineering. Biomaterials science encompasses elements of medicine, biology, chemistry, tissue engineering and materials science. Nanotechnology is the design, characterisation, production and applications of structures, devices and systems by controlling shape and size at the nanometre scale. Nanotechnology is the design, characterisation, production and applications of structures, devices and systems by controlling shape and size at the nanometre scale.*
In the nanoscalen properties of materials can be very different from those at a larger scale. However, advances in the tools that now allow atoms and molecules to be examined and probed with great precision have enabled the expansion and development of nanoscience and nanotechnologies.
Nano is associated with the SI length unit metre and denotes one-billionth (10-9). Thus, nanomaterials are characterised at the nanometre scale in one, two or three dimensions, leading to quantum wells, quantum wires (e.g., nanotubes, nanowires) or quantum dots (qdots), respectively. Nanoparticles with a diameter of less <100 nm are for example fullerenes, dendrimers and semiconductor quantum dots.. At the nanoscale, physics, chemistry, biology, material science, and engineering converge toward the same principles and tools. As a result, progress in nanoscience will have very far-reaching impact.
In order to employ for various nano-medicinal applications, nanomaterials should be subjected to suitable surface modifications. The aim of such surface modification strategies is to enhance the solubility and stability of nanosized materials in aqueous media as well as to impart them with biological properties and functionalities. Some applications of nanotechnology are: Applications in medicine-diagnosis and therapy, Nanomaterials for advanced implants, … .
Based on increasing development which nowadays, nanotechnology has brought for mans Society, a proper prospect for such a science in near future can be anticipated .Through applying this modern science, scientists would treat diseases such as AIDS , Parkinson and … which for years , researchers trying to find out treatments for them

1. INTRODUCTION

What qualifies as "nanotechnology" today is basic research and development that is happening in laboratories all over the world. Nanotechnology products that are on the market today are mostly gradually improved products.

The most important requirement for the nanotechnology definition is that the nano-structure has special properties that are exclusively due to its nanoscale proportions.

Nanotechnology is *the design, characterization, production, and application of structures, devices, and systems by controlled manipulation of size and shape at the nanometer scale (atomic, molecular, and macromolecular scale) that produces structures, devices, and systems with at least one novel/superior characteristic or property.*

A nanometer (nm) is one thousand millionth of a meter. People are interested in the nanoscale, because it is at this scale that the properties of materials can be very different from those at a larger scale. We define nanoscience as the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at a larger scale; and nanotechnologies as the design, characterisation, production and application of structures, devices and systems by controlling shape and size at the nanometer scale.

However, advances in the tools that now allow atoms and molecules to be examined and probed with great precision have enabled the expansion and development of nanoscience and nanotechnologies.

The properties of materials can be different at the nanoscale for two main reasons:

First, nanomaterials have a relatively larger surface area when compared to the same mass of material produced in a larger form. This can make materials more chemically reactive (in some cases materials that are inert in their larger form are reactive when produced in their nanoscale form), and affect their strength or electrical properties.

Second, quantum effects can begin to dominate the behaviour of matter at the nanoscale - particularly at the lower end - affecting the optical, electrical and magnetic behaviour of materials. Materials can be produced that are nanoscale in one dimension (for example, very thin surface coatings), in two dimensions (for example, nanowires and nanotubes) or in all three dimensions (for example, nanoparticles).

Materials that are used for biomedical or clinical applications are known as biomaterials. For any material to be classified for biomedical application three requirements must be met. The first requirement is that the material must be biocompatible; it means that the organism should not treat it as

a foreign object. Secondly, the material should be biodegradable (for in-graft only); the material should harmlessly degrade or dissolve in the body of the organism to allow it to resume natural functioning. Thirdly, the material should be mechanically sound; for the replacement of load bearing structures, the material should possess equivalent or greater mechanical stability to ensure high reliability of the graft.

2. DISCUSS

Nanotechnology is an extremely powerful emerging technology, which is expected to have a Substantial impact on medical technology now and in the future. Nanotechnology is an emerging technology seeking to exploit distinct technological advances of controlling the structure of materials at a reduced dimensional scale approaching individual molecules and their organised aggregates or supra molecular structures. The potential impact of novel nanomedical applications on disease diagnosis, therapy, and prevention is foreseen to change health care in a fundamental way. Furthermore, therapeutic selection can increasingly be tailored to each patient's profile. Many medical nanotechnology applications are still in their infancy. However, an increasing number of products is currently under clinical investigation and some products are already commercially available, such as surgical blades and suture needles, contrast-enhancing agents for magnetic resonance imaging, bone replacement materials, wound dressings, anti-microbial textiles, chips for *in vitro* molecular diagnostics, micro cantilevers, and micro needles.

A **biomaterial** is any matter, surface, or construct that interacts with biological systems.

They are bioactive and biocompatible in nature. Currently, many types of metals and alloys (stainless steel, titanium, nickel, magnesium, Co–Cr alloys, Ti alloys), ceramics (zirconia, bioglass, alumina, hydroxyapatite) and polymers (acrylic, nylon, silicone, polyurethane, polycaprolactone, polyanhydrides) are used for load bearing application. This includes dental replacement and bone joining or replacement for medical and clinical application. Therefore their mechanical properties are very important. Among them hydroxyapatite is most widely studied bioactive and biocompatible material. However, it has lower young's modulus and fracture toughness with brittle nature. Hence, it is required to produce a biomaterial with good mechanical properties. Biomaterials can be derived either from nature or synthesized in the laboratory using a variety of chemical approaches utilizing metallic components, polymers, ceramics or composite materials.

3. NANOSCIENCE AND NANOTECHNOLOGY

Nanoscience is the study of phenomena and manipulation of materials at atomic, molecular and macromolecular scales, where properties differ significantly from those at larger scale.

Nanotechnology is the design, characterisation, production and applications of structures, devices and systems by controlling shape and size at the nanometre scale**.**

4. NANOSCALE FEATURES

The prefix nano is from the Greek word nanos (νανοσ) which means dwarf. Commonly, nano is associated with the SI length unit metre and denotes one-billionth (10-9). Thus, nanomaterials are characterised at the nanometre scale in one, two or three dimensions, leading to quantum wells (e.g., thin films, layers, surface coatings), quantum wires (e.g., nanotubes, nanowires) or quantum dots (q dots), respectively. Nanoparticles with adiameter of less <100 nm are for example fullerenes, dendrimers and semiconductor quantumdots.. At the nanoscale, physics, chemistry, biology, material science, and engineering converge toward the sameprinciples and tools. As a result, progress in nanoscience will have very far-reaching impact.

The nanoscale is not just another step toward miniaturisation, but a qualitatively new scale.

The change in behaviour is dominated in the first place by quantum mechanics, as mentioned above and is additionally attributable to material confinement in small structures, and the increase in surface area per volume (or mass unit). At the larger end of the nanometre scale other phenomena are crucial, such as surface tension and Brownian motion. Nanoscience is concerned with understanding these effects and their influence on material properties. Nanotechnology aims to exploit these effects to create structures, devices, and systems with novel properties and functions due to their size.

5. COMPOSITES

An important use of nanoparticles and nanotubes is in composites, materials that combine one or more separate components and which are designed to exhibit overall the best properties of each component. This multi-functionality applies not only to mechanical properties, but extends to optical, electrical and magnetic ones. Currently, carbon fibres and bundles of multi-walled CNTs are used in polymers to control or enhance conductivity, with applications such as antistatic packaging. The use of individual CNTs in composites is a potential long-term application. A particular type of nanocomposite is where nanoparticles act as fillers in a matrix; for example, carbon black used as a filler to reinforce car tyres. However, particles of carbon black can range from tens to hundreds of nanometres in size, so not all carbon black falls within our definition of nanoparticles.

Clays

Clays containing naturally occurring nanoparticles have long been important as construction materials and are undergoing continuous improvement. Clay particle based composites –

containing plastics and nano-sized flakes of clay – are also finding applications such as use in car bumpers.

Coatings and Surfaces

Coatings with thickness controlled at the nano- or atomic scale have been in routine production for some time, for example in molecular beam epitaxy or metal oxide chemical vapor deposition for optoelectonic devices, or in catalytically active and chemically functionalized surfaces. Recently developed applications include the self-cleaning window, which is coated in highly activated titanium dioxide, engineered to be highly hydrophobic (water repellent) and antibacterial, and coatings based on nano-particulate oxides that catalytically destroy chemical agents.

Paints

Incorporating nanoparticles in paints could improve their performance, for example by making them lighter and giving them different properties. Thinner paint coatings ('light weighting'), used for example on aircraft, would reduce their weight, which could be beneficial to the environment.

6. APPLICATIONS IN MEDICINES AND MEDICAL :

In order to employ for various nano-medicinal applications, nanomaterials should be subjected to suitable surface modifications. The aim of such surface modification strategies is to enhance the solubility and stability of nanosized materials in aqueous media as well as to impart them with biological properties and functionalities.

Biomaterials must be compatible with the body, and there are often issues of biocompatibility which must be resolved before a product can be placed on the market and used in aclinical setting. Because of this, biomaterials are usually subjected to the same requirements as those undergone by new drug therapies.

7. APPLICATIONS IN MEDICINE- DIAGNOSIS AND THERAPY

Research in nanomedicine is focusing on effective use of modified and functionalised nanomaterials into biosensors, imaging agents, targeted molecular delivery vehicles, and other useful biological tools. nanoparticles, quantum dots (Qdots), carbon nanotubes/nanofibers, chitosan, dendrimers, liposomes, polymer nano capsules, nano-HA etc., are being widely investigated for various medicinal applications. It offers a promising platform for early cancer detection and treatment and has applications in both in vitro diagnostics (in intracellular molecular imaging, molecular profiling, highly sensitive solution assays) and in vivo diagnostics (magnetic nanoparticles for magnetic resonance imaging (MRI), Qdots for optical imaging, Raman active nanoparticles for Raman spectroscopy etc.).

8. NANOMATERIALS FOR ADVANCED IMPLANTS

The majority of fabrication methods used for nano topographies on planar substrates are unlikely to be capable of providing controlled topographical cues to cells seeded within three dimensional scaffolds. An alternative approach is the use of nanometric building blocks to fabricate scaffolds. Novel methods for production of high quality nanoparticles with extremely high purity and crystallinity improves the quality of the already existing hydroxyapatite based medical devices, such as bone grafts. Bio inert nano scale alumina is employed in coroneal replacements, maxillofacial reconstructions, couplings of knee prosthesis etc.

Nanotechnological modification of biomaterials surfaces

The current research in this area is to uncover novel and economic surface modification strategies for titanium based implants to achieve nanometer scale surface roughness.

These nanoscale surface modification strategies belongs to the following twogroups:

1)those which alter a surface topographically.

2)those which introduces nanoscale chemical molecules on a surface.

Those which introduces nanoscale chemical molecules on a surface: Nanoparticles can be deposited onto implant surfaces to alter their surface chemistry. For example, Ag nanoparticles can be used in coating of orthopedic pins to prevent bacterial colonisation and, dispersed silver nanoparticles can be used in polymethyl-methacrylate(PMMA) bone cement .

9. Conclusion

Nanotechnology plays a central role in the recent technological advances in the areas of disease diagnosis, drug design and drug delivery. The nano technological applications to disease treatment, diagnosis, monitoring, and to the control of biological systems have been referred to as '*nanomedicine*'.

Nanomedical approaches to drug delivery focuses on developing nanoscale particles or molecules to improve the bioavailability of a drug. Special attention has been given to bioassay applications such as biosensors, biomedical devices, and biofuel cells using nanomaterials.

Nanotechnology on a chip is a new paradigm for total chemical analysis systems. Nanorobotics and nanomanipulation technologies will eventually allow moving and manipulating nanoscale materials and assemble them into nanosytems such as nanoscale robotics.

The manipulation techniques can well be used in medicine for the investigation of structures and functioning mechanisms of living things and their interactions at the molecular level.

Based on increasing development which nowadays, nanotechnology has brought for mans Society, a proper prospect for such a science in near future can be anticipated .Through applying this modern science, scientists would treat diseases such as AIDS , Parkinson and … which for years , researchers trying to find out treatments for them .

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