Asian Journal of Chemistry Vol. 21, No. 10 (2009), S167-171

Application of Nanostructures and New Nano particles as Advanced Biomaterials

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The new nanomaterials have a much larger contact surface area than the existing micro materials by using the nanoparticle control technology. The recently developed nanostructures include nanoparticles, nanofibres and other nanomaterials like single enzyme nanoparticles (SEN) used for various applications in bioscience research from biosensors to new drug development, food, environmental monitoring, proteomics, and bio-marker analysis and in virus detection. Biological signal transducers are widely used for the manufacture of nanobiosensors. This paper briefly describes the various nanotechnologies developed and untied in the areas of bioscience research and environmental applications and regulations to be adopted for future nanocompanies.

Key Words: Single Enzyme Nanoparticles, Nanoparticle Control Technology, Nanobiosensors.

INTRODUCTION

Recent breakthroughs in nanotechnology have made various nanostructured materials more affordable for a broader range of applications. Although we are still at the beginning of exploring the use of these materials for biocatalysts, various nanostructures have been examined as hosts for enzyme immobilization via approaches including enzyme adsorption, covalent attachment, enzyme encapsulation and sophisticated combination of these methods. This paper discusses the stabilization mechanisms behind these diverse approaches; such as confinement, pore size and volume, charge interaction, hydrophobic interaction, and multipoint attachment. In particular, we will discuss recently reported approaches to improve the enzyme stability in various nanostructures such as nanoparticles, nanofibers, mesoporous materials, and single enzyme nanoparticles (SENs). In the form of SENs, each enzyme molecule is surrounded with a nanometer scale network, resulting in stabilization of enzyme activity without any serious limitation for the substrate transfer from solution to the active site. SENs can be further immobilized into mesoporous silica with a large surface area, providing a hierarchical approach for stable immobilized enzyme systems for various applications such as bioconversion, bioremediation and biosensors.

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EXPERIMENTAL NANOPARTICLES

Most of the studies with nanoparticles have been dedicated to the improvement of enzyme activity and loading, rather than enzyme stabilization. In this regard , a recent report using magnetic nanoparticles for the enzyme immobilization is intriguing since a good enzyme stabilization was demonstrated with covalently attached lipase on the magnetic γ Fe_2O_3 nanoparticles (Dyal *et al.*, 2003). The final immobilization exhibited high stability for a month, and can be easily separated from the reaction medium by using a magnetic field. Interestingly, the specific activity (representing enzyme activity per unit mass of enzymes) of covalent-attached lipase on magnetic nanoparticles was lower than that reported for adsorbed enzymes on micrometer-sized polymeric beads.

Nanoparticles are desirable from several perspectives. However, their dispersion in reaction solutions and the subsequent recovery for reuse becomes often a difficult task. It appeared that the use of nanofibers would overcome this limitation while providing the advantageous features of nanosize materials. For example, electrospun nanofibers provide a large surface area for the attachment or entrapment of enzymes and the enzyme reaction. In the case of porous nanofibers, they can still reduce the diffusional path of substrate from the reaction medium to the enzyme active sites due to the reduced dimension in size. Electrospun nanofiber mats are durable and easily separable, and can also be processed in a highly porous form.

DISCUSSION ON SEN APPROACH

Single enzyme Nanoparticles: In SENs' Technique each enzyme molecule is surrounded with a porous composite organic/inorganic network of less than a few nanometers thick. The preparation of SENs represents a new approach that is distinct from immobilizing enzymes into mesoporous materials or encapsulating them in sol–gels,

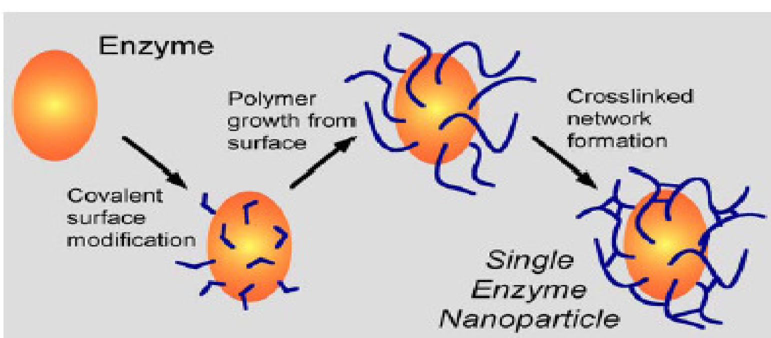

Fig 1. Schematic for SEN synthesis

polymers, or bulk composite structures Fig 2 (Kim *et al.*, 2006). The preparation of SENs begins from the enzyme surface, with covalent reactions to anchor, grow, and crosslink a composite organic/inorganic network around each enzyme molecule.The schematic for SEN synthesis is shown in Fig.1 above. A vinyl-group functionality is grafted onto the enzyme surface by covalently modifying the amino groups of lysines on the enzyme surface with acryloyl chloride. Using a tiny amount of surfactant, these modified enzymes are solubilised into hexane as ion-pair form.

This solubilisation process is different from the conventional reverse micelle approach since the surface of solubilised enzyme molecules is well exposed to the hexane phase while enzyme molecules in reverse micelles are surrounded by water molecules. By this way, this approach enables the next polymerization step to start from the surfaces of the enzyme molecules. This silicate polymerization consisting of hydrolysis and silanol condensation represents the second, orthogonal polymerization step. The reaction conditions are carefully controlled so that cross-linking is largely confined to individual enzyme surfaces, yielding discrete nanoparticles rather than the bulk solids resulting from interparticle aggregation. These nanostructures containing each enzyme molecule are known as SENs (Kim *et al.*, 2006). Using MAPS as the vinyl monomer, SENs containing a protease called SEN-CT have been prepared in synthetic yields of 38–73%. This yield is fairly high, and would make this approach more feasible in the broader range of applications. (Kim *et al.* 2006) In this unique structure of SENs, the enzyme is attached to the hybrid polymer network by multiple covalent attachment points. The thickness of the network around each enzyme molecule is less than a few nanometers. The network is sufficiently porous to allow substrates to have an easy access to the enzyme active site.

Latest Nanotechnologies Upcoming in the Market

Firing up Fuel Cells: A nanoparticle-based catalyst can speed the room temperature oxidation of ethanol, making it suitable for fuel cells. Formed of rhodium and platinum atoms deposited on nanoparticles of carbon-supported tin dioxide, the ternary electro catalyst splits the ethanol's carbon bonds. These technologies are being testing in a real fuel cell.

Fine Emulsion Fights Superbugs: A non-toxic, nanoscale emulsion of oil and water can combat the respiratory infections that claim the lives of the majority of cystic fibrosis sufferers. The surfactant-stabilized emulsion appears to disrupt the outer membranes of bacteria, killing strains that have proven to be drug-resistant. The discovery is also being investigated for treatment of cold sores and toenail fungus.

Nano-tetherballs Sensors: Cubes of gold-coated palladium tethered by single-walled carbon nanotube (CNT) conductors can form electrochemical biosensors. Grown vertically from a porous alumina substrate, the CNTs allow the functionalized cubes to float up into the sample under test, speeding the process. The group used the "nano tetherballs" to detect glucose levels of 1.3 μM with a signal-to-noise ratios of three. The cubes can be functionalized with a variety of tags to detect many different materials.

Nanoparticles Fight Plaque: Lipid-based nanoparticles functionalized with peptides can attack arterial plaque, say researchers. The peptides bind with the plaque and deliver anticoagulant drugs. Particularly encouraging is the fact that the particles appear to target the regions where the plaque deposits meet tissue, the areas most prone to ruptures.

Graphene, CNTs, for Commercial Production: Graphene and carbon nanotubes show enormous promise as electronics materials of the future; only the companies have to fine-tune the production process. Physicists at Rensselaer Polytechnic Institute have discovered that the surface chemistry of the substrate on which the graphene is grown determines material characteristics. Graphene grown on oxygenated surfaces behaves like a semiconductor and on a hydrogen-treated surface, it behaves as a conductor.

Conclusion

Amid global debate about the need to regulate nanotechnology, researchers, funding agencies along with their supporting governments are poised to move beyond discussion and implement policies and to hire companies based on nanotechnology to supply details such as chemical makeup, quantity, and usage of materials in their products and processes and expand the nanotechnology market. Canada is first to set Nanotech regulation by hiring nanotech companies. India should certainly come forward in this area to excel. The vast applications of nanoparticles as biomaterials in specific areas like tissue engineering, neuroscience, biocatalysts, energy production, biomedical applications, food industry and environmental monitoring requires the use of these nanostructures and nanoparticles in an efficient, advanced and target specific user applications. The companies should focus specific research and development activities in this area and come forward with new innovations and patented materials for users.

ACKNOWLEDGEMENTS

The authors acknowledge the support of the Deenbandhu Chhotu Ram University of Science and Technology and S.L.I.E.T (Deemed University) for the moral support and the encouragement for presenting this paper and sharing it with the international realm.

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