MBT-403D
Paper Third
Nanobiotechnology (Max. marks: 100)

Unit I: Introduction to Nanobiotechnology; Concepts, historical perspective; Different formats of nanomaterials and applications with example for specific cases; Cellular Nanostructures; Nanopores; Biomolecular motors; Bio-inspired Nanostructures, Synthesis and characterization of different nanomaterials. Thin films; Colloidal nanostructures; Self Assembly, Nanovesicles; Nanospheres; Nanocapsules and their characterisation.

Unit II: Nanoparticles for drug delivery, concepts, optimization of nanoparticle properties for suitability of administration through various routes of delivery, advantages, strategies for cellular internalization and long circulation, strategies for enhanced permeation through various anatomical barriers.
Nanoparticles for diagnostics and imaging (theranostics); concepts of smart stimuli responsive nanoparticles, implications in cancer therapy, nanodevices for biosensor development.

Unit III: Nanomaterials for catalysis, development and characterization of nanobiocatalysts, application of nanoscaffolds in sythesis, applications of nanobiocatalysis in the production of drugs and drug intermediates.

Unit IV: Introduction to Safety of nanomaterials, Basics of nanotoxicity, Models and assays for Nanotoxicity assessment; Fate of nanomaterials in different stratas of environment; Ecotoxicity models and assays; Life Cycle Assessment, containment.

Textbooks and References:

1. GeroDecher, Joseph B. Schlenoff, (2003); Multilayer Thin Films: Sequential Assembly of Nanocomposite Materials, Wiley-VCH Verlag GmbH & Co. KGaA
2. David S. Goodsell, (2004); Bionanotechnology: Lessons from Nature; Wiley-Liss
3. Neelina H. Malsch (2005), Biomedical Nanotechnology, CRC Press
4. Greg T. Hermanson, (2013); Bioconjugate Techniques, (3rd Edition); Elsevier
5. Recent review papers in the area of Nanomedicine.

Nanomaterials for Biocatalysis

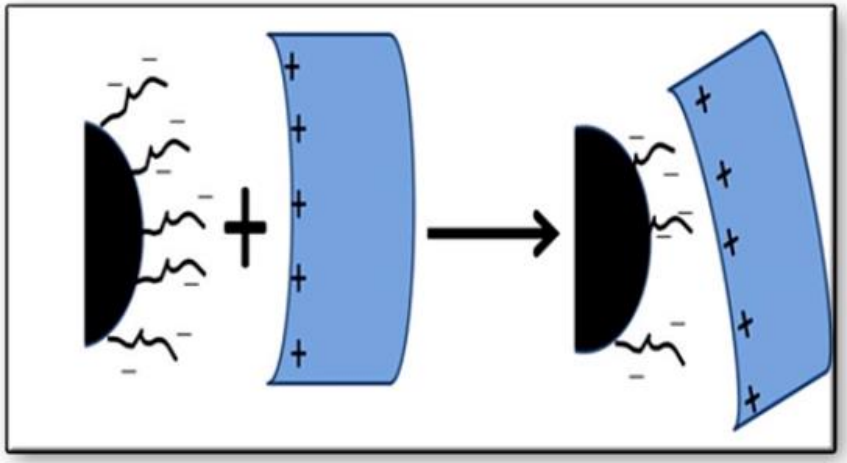
- Nanomaterials are ideal matrix for protein / enzyme immobilization because they possess large surface area, hence large amount of protein can be loaded.
- Smaller particle size reduces the size of the bioreactor.
- Large size matrices generally have diffusion limitations, this problem is also overcome using nanomaterials.
- When dispersed in aqueous solutions they show Brownian movement which increases the rate of reaction.

Enzymatic Immobilisation Strategy

- Broadly there are four main approaches to link a protein or enzyme to the nanomaterials
  - Electrostatic adsorption
  - Covalent attachment to the surface modified nanomaterials
  - Conjugation using specific affinity of protein
  - Direct conjugation to the nanomaterials surface

Electrostatic Adsorption

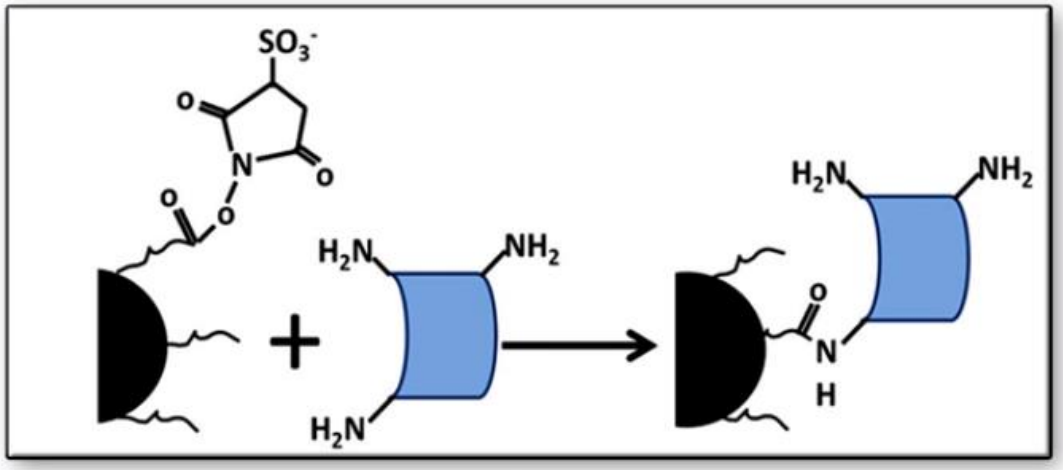
- Enzyme is attached to the matrix by ionic interactions, e.g positively charged nano-materials can interact with the negatively charged enzymes or proteins.



Electrostatic Adsorption

Covalent Attachment to the Nanomaterials

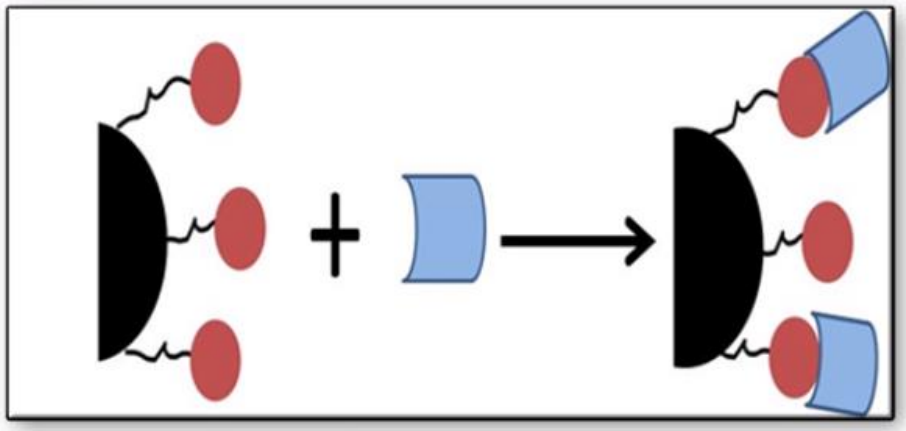
- Protein/ Enzyme bind with the surface modied nanomaterials like nanoparticles modified with the silane groups or sodium-1-3-2-5-azido-2-nitro-benzoylaminoethyldisulfanylpropanoyloxy-25-diketo-pyrrolidine-3-sulfonate .



Covalent Attachment to the Nanoparticle Ligand

Conjugation using Specific Affinity of Protein

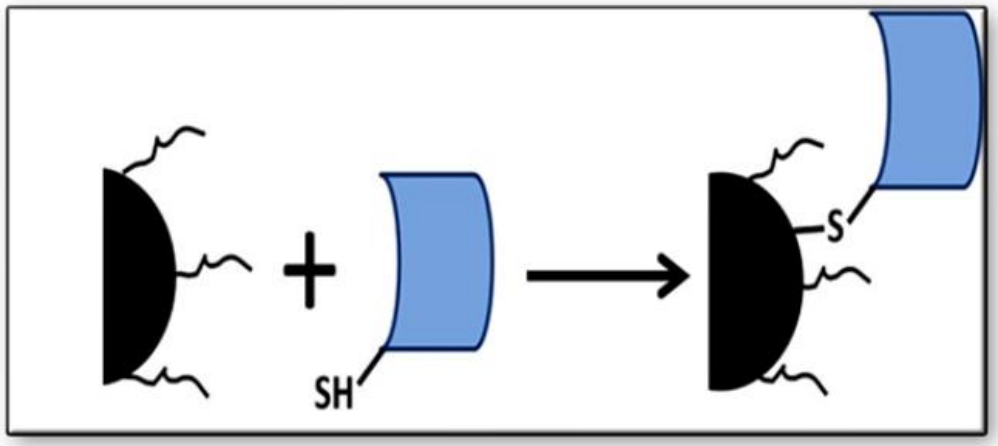
- Affinity ligands is introduced on the surface of the nanoparticles which specifically bind the protein/Enzyme.



Conjugation using specific affinity of protein

Direct Conjugation to the Nanoparticles Surface

- Some nanomaterials like silver and gold nanoparticles interact with the thiol group of the protein without the use of a linker.



Direct conjugation to the nanoparticles surface

Advantages and disadvantages of using nanoparticles for enzyme immobilization

Advantages	Disadvantages
Mass transfer resistance	Cost of fabricational process
Effective enzyme loading	Large scale application
High surface area	Separation of the reaction medium (except magnetic nanoparticles)
High mechanical strength	
Diffusional problems minimization	