Engineering Nanomaterial Surfaces for Biomedical Applications

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- ***Introduction***
  - Nanomaterials possess unique physical and chemical properties
  - Functionalized nanomaterials & synthetic ligands
  - Applications in:
    - Bio-molecular sensing
    - Biological imaging
    - Drug delivery vehicles
    - Disease therapy
    - Scaffolds in tissue engineering
  - Surfaces play a critical role in function

- ***Biomedically Important Materials***
  - Metal nanoparticles, eg. Au and Ag NPs
    - Easy to prepare, stable, unique optoelectronic properties
  - Quantum dots
    - Immunoassays for proteins and other analyses
  - Magnetic nanoparticles
    - Eg. Iron oxides. Motion through external *B* field
  - CNTs
    - Good electrical and thermal conductivity, mechanical strength and chemical stability

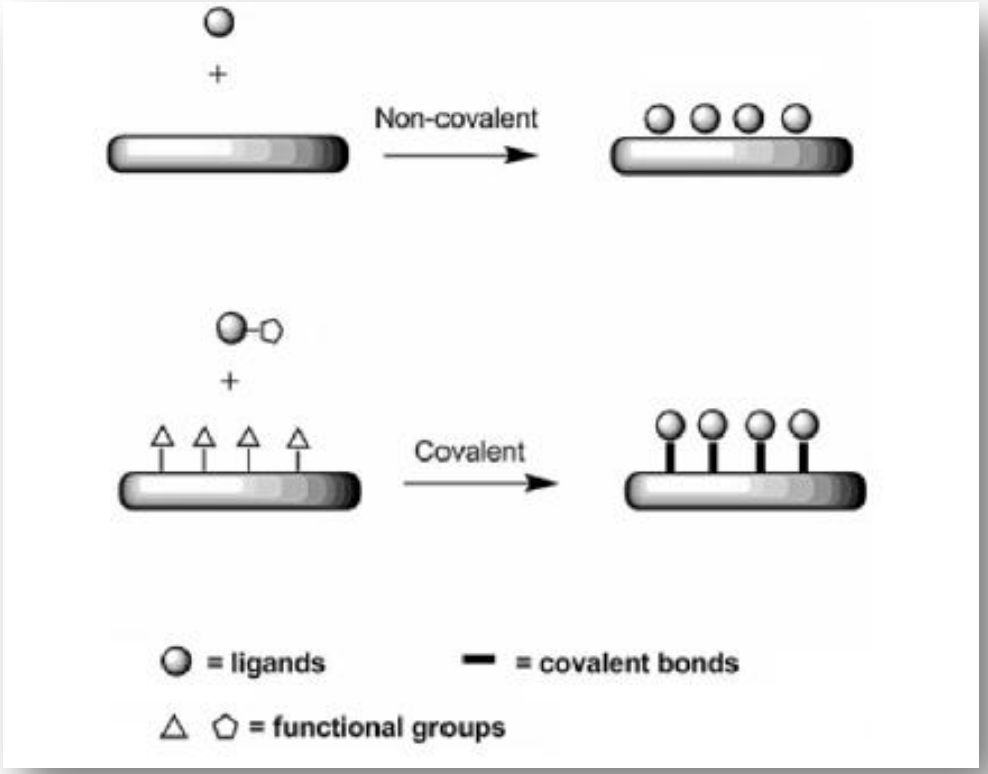
- ***Typical Nanomaterials***

Table 1. Properties of Typical Nanomaterials and Biomedical Applications

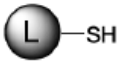
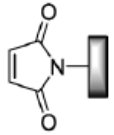
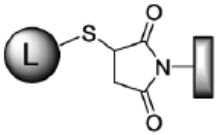
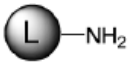
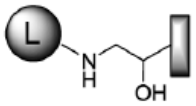
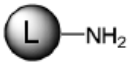
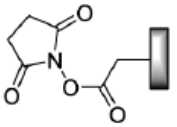
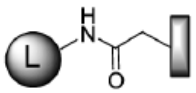
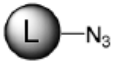
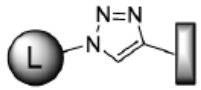
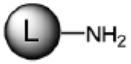
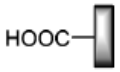
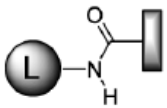
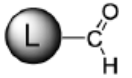
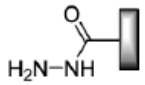
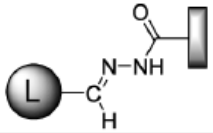
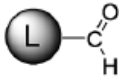
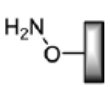
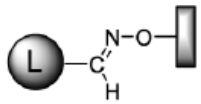
Nanomaterials			
Category	Examples	Intrinsic properties	Biomedical applications
Metallic	Au, Ag	SPR	Biosensing, drug delivery, bioimaging
Semiconductor	CdS, CdSe	Fluorescence, luminescence	Immunoassays, bioimaging, biosensing
Magnetic	Fe_3O_4	Magnetism	MRI, drug delivery
Carbon-based	CNTs, Fullerene	Electronic and mechanical properties, conductivity	Drug and gene delivery, therapy, biosensing

- ***Nanomaterial Surface Functionalization***
  - Non covalent: Physisorption
    - Bonding through electrostatic interactions, hydrogen bonding, and hydrophobic interactions
    - Surface coating for stabilizing individual NPs
    - Steric repulsion inhibits agglomeration
  - Covalent: Chemisorption

- ***Modification of nanomaterial surfaces***

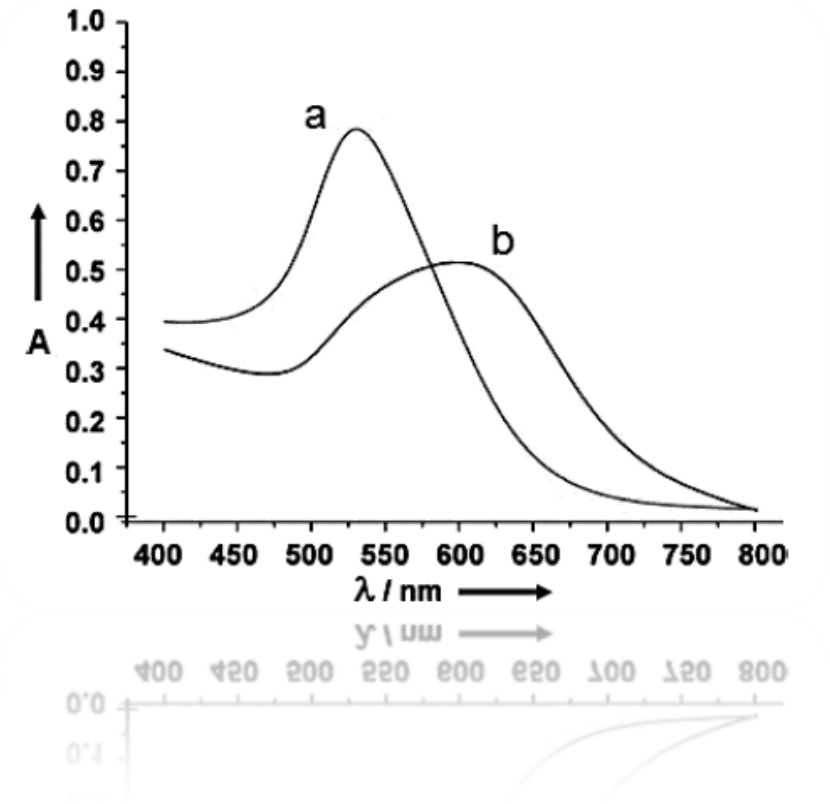


- ***Typical Complementary Functional Groups***

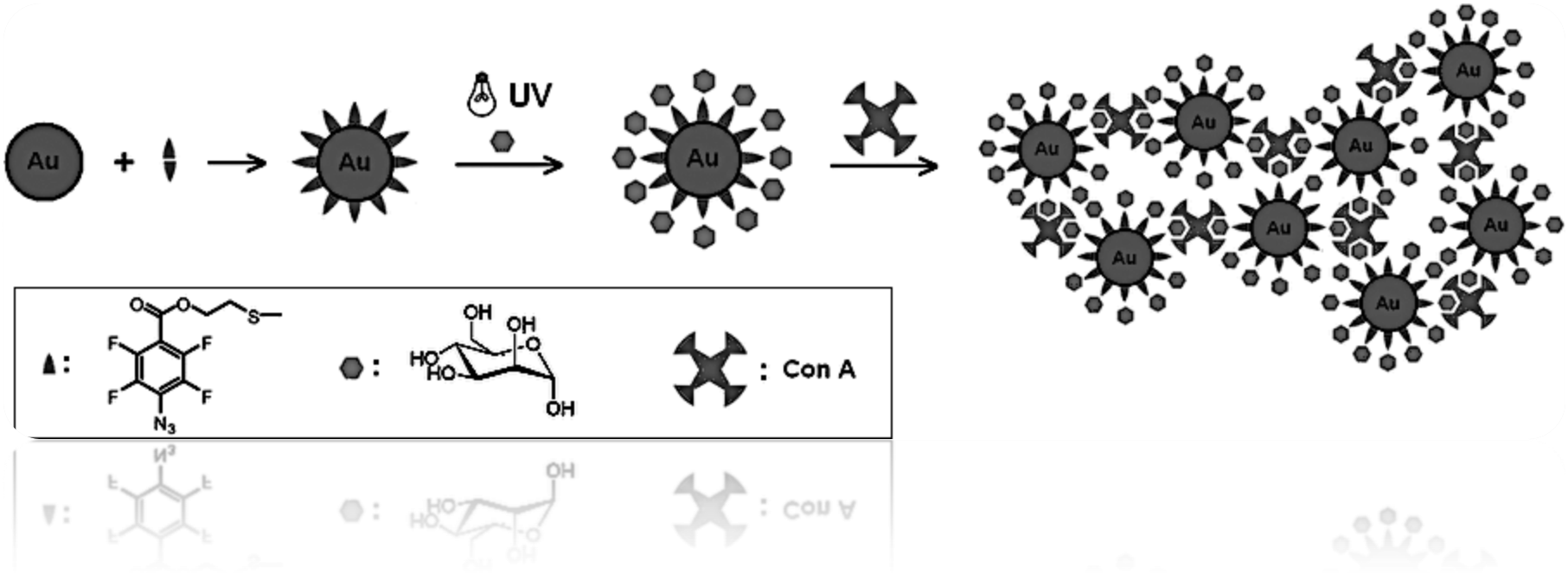
Ligand	Substrate	Ligand decorated surface	Ref.
			(76, 77)
			(78, 79)
			(80)
			(81, 82)
			(83)
			(84)
			(84, 85)

- ***Photoinitiated Coupling Chemistry***
  - Carbohydrates are complex in structure
    - Hard to chemically derivatize
    - But still important class of biomolecules
  - Hence, use PFPA-functionalized NPs
  - Then use them to covalently couple carbohydrates using UV
  - Synthesize by adding PFPA directly to NP solution
  - Coated NPs are stable and homogenous in solution
  - Can use same process for attaching polymers

- ***Gold Nanoparticles***
  - PFPA-functionalized Au NPs of 20nm in diameter
  - Covalent attachment of carbohydrate ligand using UV activation (80% surface coverage using TGA)
  - Developed into a calorimetric biosensor for probing carbohydrate-protein interactions
  - Treated with *Con A* target protein



- ***Gold Nanoparticles Before/After Coupling***



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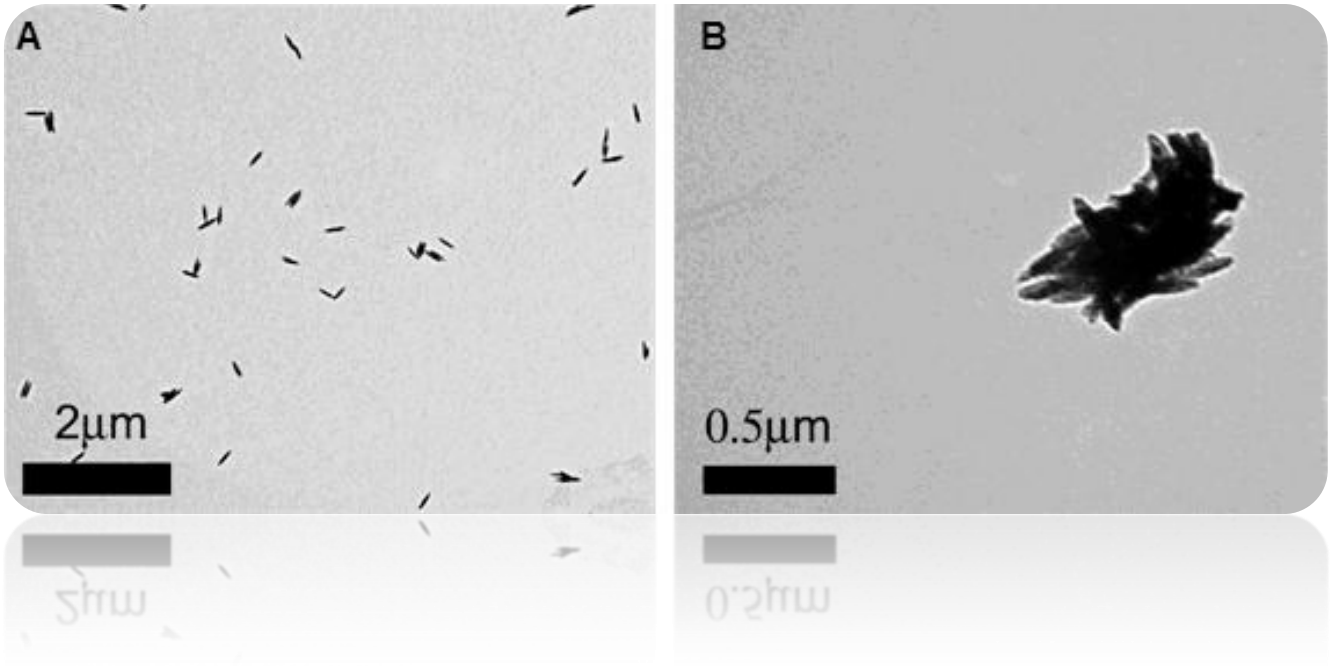

- ***Conclusions***
  - Nanomaterials and surface treatment are widely useful
  - Applications in analysis, sensing, imaging, and diagnostics
  - Careful choice of ligands
    - To prevent agglomeration
    - For molecular recognition
    - Defining molecular properties of NMs
    - For ligand coupling
    - For fixing polarity and solubility

Thank You

Questions?