Discipline Specific Courses Applicable Specifically for B.Sc. Life Sciences

DISCIPLINE SPECIFIC ELECTIVE COURSE – 18 LS (DSE-18 LS): Nanomedicine and Nanosensing

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Nanomedicine and Nanosensing **(DSE-18 LS)**	**04**	**02**	**--**	**02**	**Class 12th with Physics, Chemistry**	**--**

Course Objectives

The objectives of this course are as follows:

- To discuss the various nanomaterials to be used as drug delivery systems.
- To develop an understanding of living system interaction of nanomaterials
- To enable learners to have an insight into the field of nanodiagnostics.
- To explain nature of nanomaterials as nanosensors.

Learning outcomes

By studying this course, the students will be able to:

- Demonstrate understanding of the concept of nanomaterial as efficient drug delivery systems.
- Evaluate Living System Interaction of Nanomaterials, thereby, exhibit foray into field of nanodiagnostics.
- Understand basic principle of gas sensing, chemosensing, biosensing, Optical, electrochemical, magnetic sensing using various nanoparticles.
- Perform hands-on laboratory exercise aimed at designing a variety of nanomaterials and their subsequent application in nanomedicine and nanosensing.

Unit 1: Nanomaterial and Drug Delivery - (8 Hours)

Nanomaterials of biological interest: Lipid-, polymer-(PLGA, PVP), inorganic-based (Gold, iron-oxide and silica) and hybrid nanomaterials. Nanomaterials as drug delivery systems. Encapsulation and release of drugs, photosensitizers (porphyrins), DNA, and other active agents i.e. coumarin dyes. Stimuli-responsive drug release.

Unit 2: Living System Interaction of Nanomaterials (7 Hours)

Interaction of nanomaterials with mammalian cells; Endocytosis, phagocytosis, pinocytosis, and other cell-entry mechanisms. Fate of nanoparticles inside cells. In vitro assays: cell viability, ROS determination, biochemical assays, etc.

Unit 3: Nanodiagnostics **(7 Hours)**

Nanodiagnostics: Basics of optical imaging, MRI, CT imaging, radioimaging. Nanomaterials (gold nanospheres and nanorods, dye-doped silica nanoparticles) for optical imaging, magnetic resonance imaging, CT imaging, radio-imaging, etc. Structural and Functional imaging. Image-guided drug delivery.

Unit 4: Nanosensing **(8 Hours)**

Basic principle of gas sensing, chemosensing, biosensing, Optical, electrochemical, magnetic sensing using various nanoparticles (gold nanospheres and nanorods, iron-oxide nanoparticles, nanographene and nanographene oxide). In vitro diagnostics from simple body fluids such as blood and urine. Microfluidic technology for low volume and high throughput sensing.

Practicals: **Credits: 02**

(Laboratory periods:15 classes of 4 hours each)

Hands-on/Demonstration/ Instruction Mode: Demonstration/ Discussion of working principle/ Hands-on with substantial literature analysis/ Laboratory exercise.

1. (i) Synthesis of nanoparticles: Gold nanospheres and nanorods, nanographene, iron-oxide nanoparticles.
   (ii) Characterization and differentiation of Gold nanospheres and nanorods using spectrophotometric analysis.
2. Preparation of PLGA nanoparticles.
3. Preparation of liposomes, solid-lipid nanoparticles (SLNs),
4. Synthesis of silica and organically modified silica (ormosil) nanoparticles,
5. Estimation of loading capacity of Drug/dye and release kinetics study in liposomes, PLGA nanoparticles, SLNs, ormosil nanoparticles, and ZIF-8 nanoscale frameworks (Any one system).
6. Comparative reaction kinetics study of dye-degradation (rhodamine-B) using Au/ Ag/ Au-Ag nanoparticles.
7. Colorimetric determination of trace amount of metal ions *(Iron or copper)* using gold nanospheres/nanorods.
8. LED-light-activated photothermal experiments using gold nanospheres/nanorods using temperature change measurements.
9. Determination of protein binding capacity of gold nanoparticles using NMR study.

Essential/recommended readings

Theory:

1. Prasad 1. P. N.. Introduction to Nanomedicine and Nanobioengineering. Wiley, 2012.
2. Webster. T. J. Nanomedicine Technologies and Application (2 nd Edition) ScienceDirect, 2023.
3. Jain. K. K. The Handbook of Nanomedicine. Springer, 2017
4. Kulkarni S. K., Nanotechnology: Principles and Practices, Springer Cham, 2014 (978-3-319-09171-6).
5. Singh K., Nanoparticle Therapeutics, Academic Press Elsevier, 2021 (978-0-12-820757-4).

6. Ratner B. D., Hoffman A. S., Schoen F. J., Lemons J. E., Biomaterials Science, Press Elsevier, 2013 (978-0-12-374626-9)
7. Nelson D. L., Cox M., Principles of Biochemistry, WH Freeman, 7th ed. 2017 (978-1319108243)
8. Alberts B., Johnson A., Lewis J., Raff M., Roberts K., Walter P., Molecular Biology of the Cell, 4th ed., Garland Science, 2002, 10: 0-8153-3218-1

Practical:

1. Prasad P. N.. Introduction to Nanomedicine and Nano-bioengineering. Wiley, 2012.
2. Webster. T. J. Nanomedicine Technologies and Application (2 nd Edition) Science Direct, 2023.
3. Jain. K. K. The Handbook of Nanomedicine. Springer, 2017
4. Kumar C., Hormes J., Leuschner C., Nanofabrication Towards Biomedical Applications, Wiley Vch,, 2005 (9783527311156)
5. Greco R. S., Prinz F. B., Smith R. L., Nanoscale Technology in Biological Systems, CRC Press, 2004 (9780849319402).
6. Perera Y. R., South T.M., Hughes A. C., Parkhurst A. N., Williams O.C., Davidson M. B., Wilks C. A., Misna D. A., Fitzkee N.C., Using NMR spectroscopy to measure protein binding capacity on gold nanoparticles, *J. Chem. Educ.* 2020, *97, 3, 820-824*.
7. Bentley A. K., Farhoud M, Ellis A. B., Lisensky G.C., Nickel A-Marie L, Crone W. C., Template Synthesis and Magnetic Manipulation of Nickel Nanowires, *J. Chem. Educ.* 2005, *82, 5, 765-768*.
8. Oliveira M. L., Pagung E., Lorenzini L., Neves T.R., Pereira J.R.P., Ferreira S. A. D., Freitas M. B. J.G. de, Moura P. R.G., Lelis M. F. F., Synthesis of Iron Oxide Nanoparticles and their Application in Photo-Fenton Process: An Undergraduate Experiment in Chemistry, *J. Chem. Educ.* 2025, *102, 1590-1597*.
9. How to Characterize 4−90nm Size Gold Nanospheres with Experimental and Simulated UV−Vis and a Single SEM Image, *J. Chem. Educ.* 2023, *100, 1589-1596*.
10. Nedrygailov I, Brien D. O., Monaghan S., Hurley P, Biswas S., Holmes J.D., Nanowood: A Unique Natural Nanomaterial That Can Be Obtained Using Household Chemicals, *J. Chem. Educ.* 2024, *101, 11, 4931-4936*.

Assessment Methods: All examination and assessments methods shall be in line with the University of Delhi guidelines issued from time to time.