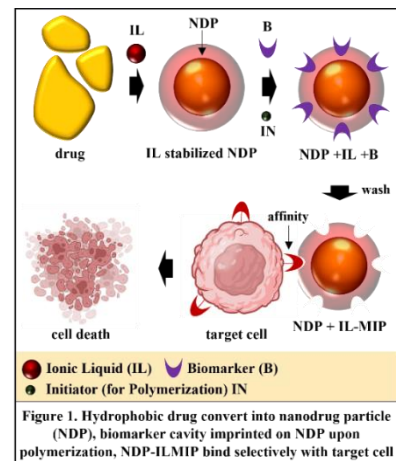


Ionic Liquid-Based Nanomedicine and Drug Delivery: The Singh Lab

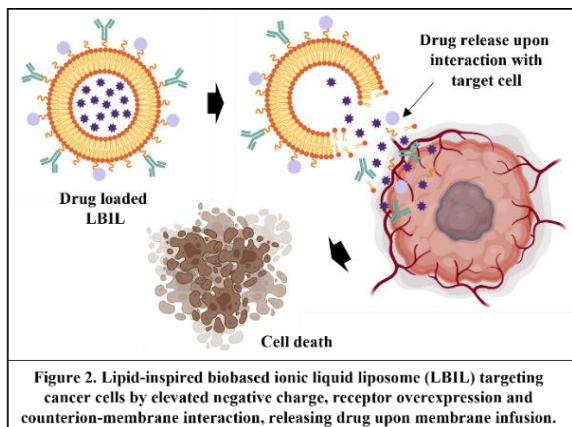
Ionic liquids are salts that remain liquid at or near room temperature and possess highly tunable chemical and physical properties. By combining ionic liquid chemistry with nanotechnology, researchers can develop innovative drug delivery systems that improve drug stability, targeting, and therapeutic effectiveness. The Singh Lab focuses on designing biocompatible ionic liquid-based nanocarriers that interact with biological systems in a controlled manner to address challenges in modern medicine.

Project 1: Ionic Liquid-Coated Nanoparticles for Targeted Drug Delivery

Nanoparticles offer unique advantages for drug delivery because of their small size and large surface-area-to-volume ratio. However, many current nanoparticle systems experience rapid clearance from the body, poor targeting efficiency, and limited therapeutic effectiveness. Ionic liquids provide a versatile platform for modifying nanoparticle surfaces to improve their interactions with biological tissues. In this project, students will prepare drug-loaded nanoparticles coated with biocompatible ionic liquids and evaluate their stability, drug release behavior, and cellular interactions. Particle size and surface charge will be characterized using Dynamic Light Scattering (DLS), while drug loading and release will be quantified using HPLC and UV-Visible spectroscopy. Students will gain hands-on experience in nanoparticle synthesis, analytical characterization, and pharmaceutical research.



Project 2: Ionic Liquid-Based Liposomes for Precision Medicine



Liposomes are among the most successful drug delivery technologies because they can encapsulate a wide variety of therapeutic agents. Despite their success, conventional liposomes often suffer from limited stability and undesired immune responses. This project seeks to develop next-generation liposomes using lipid-inspired ionic liquids that provide improved stability and enhanced targeting capabilities. Students will synthesize ionic liquid-based lipids, formulate liposomal carriers, and investigate their physical and biological properties. Spectroscopic techniques, fluorescence measurements, and cell-based studies will be used to evaluate carrier performance. Through this work, students will develop skills in synthetic chemistry, formulation science, and biological evaluation of nanomedicines.

Project 3: Poly(Ionic Liquid) Materials for Controlled Drug Release

Polymeric drug delivery systems have been widely explored because of their biodegradability and ability to provide sustained drug release. However, conventional polymers often lack precise control over drug loading and release kinetics. This project utilizes poly(ionic liquid) materials derived from biocompatible polymers and pharmaceutical compounds to create multifunctional drug delivery platforms. Students will prepare polymer-based ionic liquid materials and evaluate their ability to form nanoparticles and nanogels for therapeutic applications. Chemical characterization will be performed using NMR and FT-IR spectroscopy, while particle properties and drug release behavior will be analyzed using DLS and HPLC. Students will learn modern techniques in polymer chemistry, nanotechnology, and biomaterials engineering while contributing to the development of advanced therapeutic systems.

