Meet Dr. Ritika Gautam Singh, Thieme Chemistry Journals Awardee 2026!



Dr. Ritika Gautam Singh *is an associate professor at the Indian Institute of Technology Kanpur (India). She received her PhD from the University of Arizona (USA) then pursued postdoctoral research at Scripps Research, La Jolla (USA). In the fall of 2019, Ritika returned to India to establish her independent research group at IIT Kanpur.*

Thieme: Which field of organic chemistry are you interested in the most and why?

Dr. Singh: I am most deeply interested in the interface of organic chemistry with medicinal and inorganic chemistry, particularly in the design of functionally sophisticated therapeutic systems. What excites me about this area is its ongoing evolution — from traditional small-molecule frameworks toward dynamic, stimuli-responsive, and multifunctional architectures that can operate with high precision in complex biological environments. Today, medicinal inorganic chemistry is moving beyond classical DNA-targeting approaches toward redox-active, photoactivatable, and immune-modulating metallodrugs. This shift aligns strongly with my research interests, where we leverage principles of organic chemistry — molecular design, ligand architecture, and supramolecular interactions — to build advanced metal-based systems. At IIT Kanpur, our work focuses on developing self-assembled metal-based nanoaggregates with multimodal therapeutic and diagnostic potential. This approach allows us to integrate targeting, imaging, and therapy within a single platform, opening new avenues for precision medicine. The organic framework plays a crucial role in dictating assembly behavior, stability, and biological function, making it central to the success of these systems.
What draws me most to this field is its translational potential — the ability to move from molecular design to tangible biomedical applications. I am particularly motivated by the prospect that this research can advance translational medicinal chemistry in India while contributing globally to innovative metal-based diagnostics and therapeutics that address pressing health challenges.

Thieme: Following that, what is the focus of your current research activity?

Dr. Singh: My current research activity is centered on the rational design and development of metal-based therapeutics and theragnostic platforms that address two of the most pressing challenges in human health: antimicrobial resistance and cancer. Broadly, my group integrates inorganic chemistry, organic ligand design, and supramolecular self-assembly to create multifunctional systems capable of precise biological intervention.

A major focus of our work is the development of next-generation metalloantibiotics to combat multidrug-resistant pathogens. For instance, we have designed iridium(III) nanoaggregates that function as photodynamic antimicrobial agents, demonstrating potent activity against resistant *Staphylococcus aureus* in a wound-healing mouse model. Complementing this, our discovery of ruthenium(arene)-based metalloantibiotics has enabled selective and effective targeting of Gram-negative pathogens such as *Acinetobacter baumannii*, a notoriously difficult organism due to its impermeable membrane and resistance mechanisms. We have also developed water-soluble ruthenium(II) *p*-cymene complexes capable of mitigating intracellular *S. aureus* infections, thereby bridging antibacterial defense with anticancer potential — an important step toward treating infections associated with malignancies or immunocompromised states.

In parallel, we are deeply engaged in designing metal-based anticancer agents that operate through non-conventional cell death pathways. Our gold(I)-NHC complexes are engineered to induce necroptosis and paraptosis in lung adenocarcinoma, offering alternatives to apoptosis-resistant cancers. Similarly, we have developed a redox-active iron complex that triggers immunogenic cell death while exhibiting NIR-II photoacoustic properties, positioning it as a promising theragnostic agent for immunologically "cold" tumors. Extending this paradigm, our copper(II)–dipyridophenazine complex targets metastatic triple-negative breast cancer by inducing synergistic cuproptosis and chemodynamic therapy through disruption of the tricarboxylic acid (TCA) cycle.

Another key theme in our research is self-assembly-driven therapeutics. We have reported imidazolium-based nanoaggregates that trigger a unique dynamin-dependent cell death pathway characterized by cytoplasmic vacuolization and mitochondrial dysfunction in lung adenocarcinoma cells. These systems highlight how controlled nanoassembly can unlock entirely new biological mechanisms that are inaccessible to conventional small molecules.

Importantly, we are also advancing theragnostic platforms, exemplified by ruthenium *p*-cymene-derived systems that combine antimicrobial activity with NIR-II photoacoustic imaging capabilities. This dual-action approach enables not only treatment but also real-time monitoring of therapeutic response. In addition, our work on *de novo* 3-(phenylcarbamoyl) benzoate analogues demonstrates efficacy against multidrug-resistant *S. aureus* while providing insights into biodistribution, an essential step toward clinical translation.

Overall, my research is driven by the goal of creating mechanistically novel, multimodal, and translatable metal-based systems. By integrating antimicrobial and anticancer strategies with imaging and immune modulation, we aim to contribute to a new generation of precision therapeutics that can effectively tackle complex and evolving disease landscapes.

Thieme: What do you think about the modern role and prospects of organic chemistry?

Dr. Singh: Organic chemistry today occupies a central and evolving role in modern science, not as an isolated discipline, but as a foundational language that enables innovation across chemistry, biology, materials science, and medicine. Its modern identity is defined by integration — particularly in fields such as *metals in medicine*, where organic molecules are no longer merely end products, but essential design elements that dictate function, selectivity, and biological response. In this context, organic chemistry provides the structural and conceptual framework for engineering complex systems. The design of ligands, control over molecular architecture, and understanding of reactivity are critical for tuning the behavior of transition-metal complexes and guiding their interactions in biological environments. Today, the field extends beyond static molecules to dynamic, stimuli-responsive, and self-assembling systems, enabling the creation of multifunctional platforms for therapy and diagnostics. As a result, organic chemistry is increasingly positioned not just as a tool for synthesis, but as a driver of impactful, translational science. Its future lies in its ability to adapt, integrate, and innovate — continuing to shape next-generation solutions in medicine, sustainability, and technology.

Thieme: Which difficulties are there for young upcoming chemists in your field? Do you have any tips?

Dr. Singh: Young chemists entering the field of metals in medicine face a unique set of challenges arising from its inherently interdisciplinary and translational nature. Mastery is expected not only in synthetic organic and inorganic chemistry, but also in biological evaluation, mechanistic understanding, and advanced analytical techniques. This breadth can be overwhelming, particularly when coupled with the need to navigate sophisticated instrumentation, access central facilities, and work within regulatory frameworks such as ethical approvals for in vitro and in vivo studies, which can significantly affect timelines. Another key difficulty is the dependence on effective collaboration. Progress often relies on strong partnerships across disciplines — biology, medicine, materials science — and while such collaborations can accelerate innovation, misalignment or inefficiencies can slow research. Additionally, the pressure to demonstrate translational relevance early on can be demanding for young researchers still building foundational expertise. My advice would be: first, build a strong core in chemical fundamentals — this remains your most reliable tool. Second, actively seek interdisciplinary exposure, but do so strategically rather than trying to master everything at once. Third, choose collaborators carefully and communicate clearly; good collaborations are as important as good ideas. Finally, be patient with the process — delays due to infrastructure or regulatory requirements are part of rigorous science. If approached thoughtfully, these challenges ultimately strengthen both the science and the scientist.

Thieme: What is your most important scientific achievement to date and why?

Dr. Singh: My most significant scientific achievement to date has been the development of a multidisciplinary research program at the interface of medicinal inorganic chemistry, chemical biology, and immunotherapeutic metallodrug design, aimed at addressing two of the most pressing global health challenges: cancer and antimicrobial resistance. Through the rational design of metal-based complexes, supramolecular nanoaggregates, and lipophilic cationic ligands, my research has established innovative therapeutic platforms that combine precise molecular engineering with mechanistic biological insight. A major outcome of this work has been the development of next-generation NIR-II photoactive and redox-active metallotherapeutics exhibiting nanomolar anticancer potency. These systems not only demonstrate exceptional efficacy against highly aggressive and treatment-resistant malignancies, but have also provided fundamental insights into metal-mediated biological pathways, redox regulation, mitochondrial targeting, and immunogenic mechanisms of cell death. Importantly, these discoveries have advanced beyond proof-of-concept studies, with translational evaluation progressing from in vitro investigations to in vivo validation (TRL-1 to TRL-3) in clinically relevant models of glioblastoma, head and neck squamous cell carcinoma (HNSCC), and triple-negative breast cancer (TNBC). In parallel, my research has expanded the frontiers of metalloantibiotic development by creating metal-based antimicrobial agents effective against multidrug-resistant Gram-negative pathogens, particularly Acinetobacter baumannii. These compounds have demonstrated antibacterial activities comparable to FDA-approved therapeutics, highlighting their potential as alternative strategies to combat the escalating crisis of antimicrobial resistance. I consider this my most important scientific achievement because it bridges fundamental coordination chemistry with translational biomedical innovation, generating mechanistically informed therapeutic candidates with the potential to impact both oncology and infectious disease treatment. Beyond producing high-impact scientific advances, this work establishes a platform for the development of clinically relevant metallodrugs capable of addressing urgent unmet medical needs.

Thieme: Could you tell us something about yourself outside the lab, such as your hobbies or extra-work interests?

Dr. Singh: Outside the lab, I value spending meaningful, grounding time with my family. Much of my free time revolves around playing with my 5-year-old son — those moments bring a refreshing sense of curiosity, creativity, and perspective that often contrasts with the structured nature of scientific work. I also enjoy simply being present with family, whether through small everyday activities or relaxing together. These experiences provide balance, helping me return to research with renewed energy and clarity.