PANKAJ SINGH PATWAL

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RESEARCH PROFILE

PhD researcher working on active soft matter and out-of-equilibrium systems, with a focus on designing cell-like active microreactors that show life-like behaviors, including self-propelled motion, chemomechanical oscillations, chemical communication, and collective self-organization. My work explores the stimuli-responsive, membrane-bound enzyme-loaded microcompartments that produce autonomous motion through buoyancy-driven movement and reaction-induced endogenous fluid flows, leading to emergent collective behavior in synthetic systems. I have published in high-impact journals (JACS, Advanced Materials, and Chemical Science) and presented my work as a poster at the Gordon Research Conference (GRC) and an oral presentation at the Gordon Research Seminar (GRS). I expect to defend my PhD thesis in July 2026 and am seeking a postdoctoral position in active matter, systems chemistry, and soft materials.

EDUCATION

Dec 2020-Present (Expected: July 2026)	**Ph.D., Indian Institute of Technology** (Roorkee, India) Thesis Title: "*Chemically-driven Motility and Collective Dynamics in Membrane-bound Microgels*" Advisor: Prof. Pavan Kumar B.V.V.S.
2018 – 2020	**M.Sc. Chemistry, Indian Institute of Technology** (Ropar, India), **CGPA: 9.31** Dissertation Title: "*Synthesis and catalytic application of Metal oxide-MOF nanocomposites*" Advisor: **Prof. Rajendra Srivastava**
2014 – 2017	**B.Sc. Applied Physical Sciences** (Industrial Chemistry), **Percentage: 83.87%** Atma Ram Sanatan Dharma College, **University of Delhi**, India

RESEARCH EXPERIENCE

Dec 2020- Present, **Doctoral Research, IIT Roorkee**, Advisor: Prof. Pavan Kumar B.V.V.S.

- Fabricated the membrane-bound microgel compartments as a minimal cell model.
- Investigated enzymatic reaction-induced endogenous fluid flows, including Solutal and Marangoni flows, to produce autonomous motion of microgel compartments at the water-oil interface.

- Demonstrated fuel-driven self-organization, collective flow-mediated cargo transport, and enhanced chemical signaling between active microcompartments.
- Investigated design strategy to generate autonomous oscillatory Marangoni flows with synchronizing behavior that enables the oscillatory microcompartment dynamics.
- Implemented a simple and modular design for the realization of chemomechanical self-oscillations in microgel compartments using buoyant motility within stratified chemical media with antagonistic stimuli.
- Mentored seven Postgraduate students over the course of the PhD, guiding experimental design, data processing, analysis, and scientific writing.
- Worked as a Teaching Assistant for six semesters, assisting undergraduate students in laboratory sessions and coursework.

Aug 2019- Aug 2020, **M.Sc. Research Project, IIT Ropar**, Advisor: Prof. Rajendra Srivastava

- Developed metal oxide–MOF nanocomposites for catalytic biomass valorization and production of sustainable fuel precursors, and characterized using XRD, FTIR, BET, and SEM.

PUBLICATIONS

Published articles

1. **Patwal, P. S.**; Pavan Kumar, B. V. V. S. *Self-Organization of Microcompartments Powered by Enzyme-Driven Solutal Flows at the Water-Oil Interface*. **J. Am. Chem. Soc.** 2025, 147 (44), 40429 40439. https://doi.org/10.1021/jacs.5c11877
2. **Patwal, P. S.**; Mann, S.; Pavan Kumar, B. V. V. S. *Chemomechanical Self-Oscillatory Microgel Motility in Stratified Chemical Media*. **Adv. Mater.** 2025, 37 (6), 2415568. https://doi.org/10.1002/adma.202415568
3. Sharma, P.; **Patwal, P. S.**; Pavan Kumar, B. V. V. S. *pH-Responsive Regulation of Multiphase Coacervate Wetting via Phase Selective Enrichment of Fatty Acids*. **Chem. Sci.** 2026, Advance Article. https://doi.org/10.1039/D5SC07783D
4. Karoui, H.; **Patwal, P. S.**; Pavan Kumar, B. V. V. S.; Martin, N. *Chemical Communication in Artificial Cells: Basic Concepts, Design and Challenges.* **Front. Mol. Biosci.** 2022, 9, 880525. https://doi.org/10.3389/fmolb.2022.880525

Manuscript under preparation

1. **Patwal, P.S.**; Pavan Kumar, B.V.V.S. *Oscillatory Motility of Enzyme-Loaded Compartments via Marangoni Flows at Water-Oil Interface*.

TECHNICAL SKILLS

Synthesis and Fabrication

- Microgel fabrication: membrane-bound, Janus, and core-shell hydrogels with pH-, temperature-, and ion-responsive properties; enzyme-encapsulation and functional loading.

- Device fabrication: Simple PDMS-based devices and glass capillary setups for flow and motility experimental studies.

Experimental Techniques

- Optical and fluorescence microscopy (brightfield, epifluorescence); Dynamic Light Scattering (DLS) and zeta potential; UV/Vis spectroscopy; ATR-FTIR spectroscopy
- Drop Shape Analysis (interfacial tension, contact angle).

Software Proficiency

- ImageJ & Tracker for Image Analysis and Particle Tracking, PIVlab (particle image velocimetry) for flow field analysis
- MS Word/ Excel/ PowerPoint, Origin, ChemDraw, Zotero, EndNote.

HONORS AND ACHIEVEMENTS

- Prof. V.K. Gupta Memorial Impactful Young Researcher Award for the Academic Year 2025-26.
- International travel support from Pharmaffiliates Private Limited to attend the Gordon Research Conference: Oscillations and Dynamic Instabilities in Chemical Systems, Les Diablerets, Vaud, Switzerland,2026.
- Pharmaffiliates Best Publication Award 2025, awarded by Pharmaffiliates Private Limited at CHEMDAY 2025, organized by IIT Roorkee.
- Best Poster Award at the Institute Research Day 2025, organized by IIT Roorkee.
- Prof. V.K. Gupta Memorial Impactful Young Researcher Award for the Academic Year 2024-25.
- Institute Silver Medal for Master of Science (Chemistry), 2020, Indian Institute of Technology, Ropar, India.
- 2nd rank in the class of Bachelor of Science (B.Sc.), 2017, Atma Ram Sanatan Dharma College, University of Delhi, India.

National Competitive Examinations

- All India 63rd rank (among 39081 students) in Joint CSIR - UGC NET JUNE 2020 for Junior Research Fellowship.
- All India 719th rank (among 24414 students) in GATE exam 2020.
- All India 277th rank (among 12473 students) in IIT JAM exam 2018.

PRESENTATIONS AND INVITED LECTURES

Oral Presentations

- "*Solutal Buoyancy and Marangoni-Driven Dynamics at the Water-Oil Interfaces*", Gordon Research Seminar: Oscillations and Dynamic Instabilities in Chemical Systems, Les Diablerets, Vaud (fr), Switzerland, 05/2026.
- "*Buoyancy–Driven Chemomechanical Oscillator: Beating and Bouncing Dynamics",* ChemDay2023, IIT Roorkee, India, 12/2023.

Poster Presentations

- "*Fuel-Driven Self-Organization of Microcompartments at the Water-Oil Interface*," Gordon Research Conference: Oscillations and Dynamic Instabilities in Chemical Systems, Les Diablerets, Vaud (fr), Switzerland, 05/2026.
- "*Fuel-Driven Self-Organization of Microcompartments at the Water-Oil Interface*," International Winter School 2025 Frontiers in Materials Science and Satellite Conference on Computer Simulations in Chemistry, Materials and Biology", JNCASR, Bangalore, 12/2025.
- "*Buoyancy–Driven Chemomechanical Oscillator: Beating and Bouncing Dynamics*," Institute Research Day 2025, IIT Roorkee, India, 03/2025.
- "*Buoyancy–Driven Chemomechanical Oscillator: Beating and Bouncing Dynamics*," CompFlu- 2023, IIT Madras, India, 12/2023.
- "*Buoyancy–Driven Chemomechanical Oscillator: Beating and Bouncing Dynamics*," International Winter School 2023 and Recent advances in materials (RAM-90), JNCASR Bangalore, India, 12/2023.
- "*Buoyancy–Driven Chemomechanical Oscillator: Beating and Bouncing Dynamics*," Systems Chemistry Virtual Symposium 07/2023.