IOCG 2025 Conference

The 1st International Online Conference on Gels

03–05 December 2025 | Online

MDPI

Minimalistic Tryptophan-Based Supramolecular Hydrogel as a Versatile Catalytic Scaffold.

Ipsita Sahu, Priyadarshi Chakraborty*

Department of Chemistry,Indian Institute of Technology Hyderabad, Sangareddy, Telangana, India

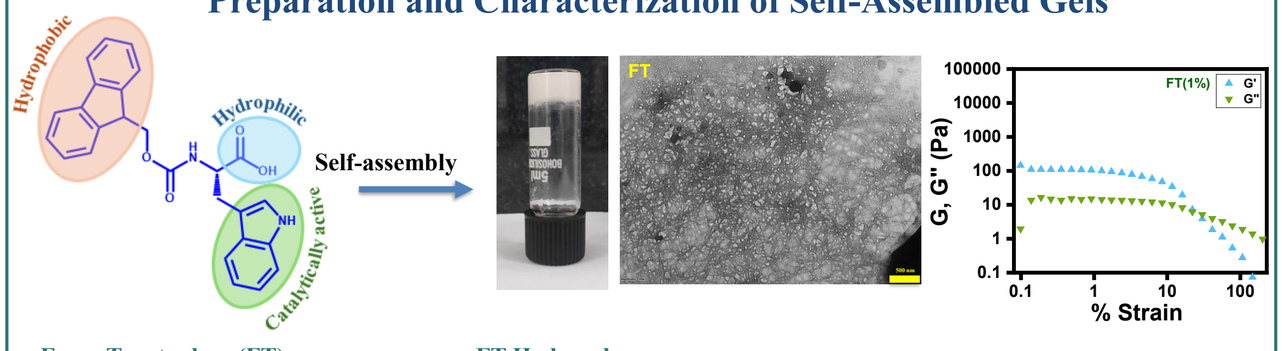
Email: cy23resch01002@iith.ac.in, priyadarshi@chy.iith.ac.in

Introduction

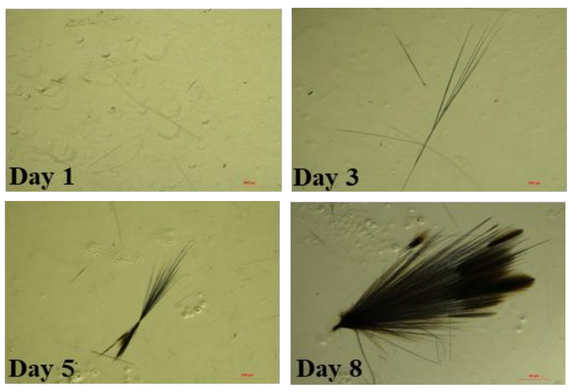
- *Amino acids, believed to be among the earliest biomolecules, are essential to biological systems where they govern structural organization, metabolism, and signaling.[1] Beyond protein synthesis, amino acids exhibit the ability to self-assemble into ordered supramolecular structures through diverse noncovalent interactions.[2]*
- *Compared to peptide-based gels, the functional and catalytic potential of single amino acid hydrogels remains largely unexplored, despite their ease of design and relevance to prebiotic chemistry.[3] Supramolecular hydrogels create confined, heterogeneous microenvironments that enhance substrate binding, diffusion, and reaction selectivity. Their reversible assembly and capacity for chemical or nanomaterial integration enable stimuli-responsive, recyclable, and multifunctional catalytic platforms.[4]*
- *Incorporation of functional moieties or nanomaterials (e.g., GO, GQDs, metal nanoparticles) can significantly improve catalytic performance by increasing active-site density and promoting electron transfer. Additionally, the semisolid nature of these hydrogels enables straightforward recovery and reuse, supporting sustainable and economical catalytic operation.[5]*

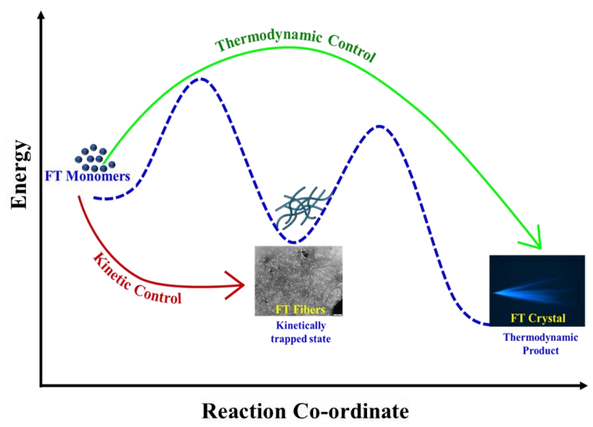
Results & Discussion

Preparation and Characterization of Self-Assembled Gels

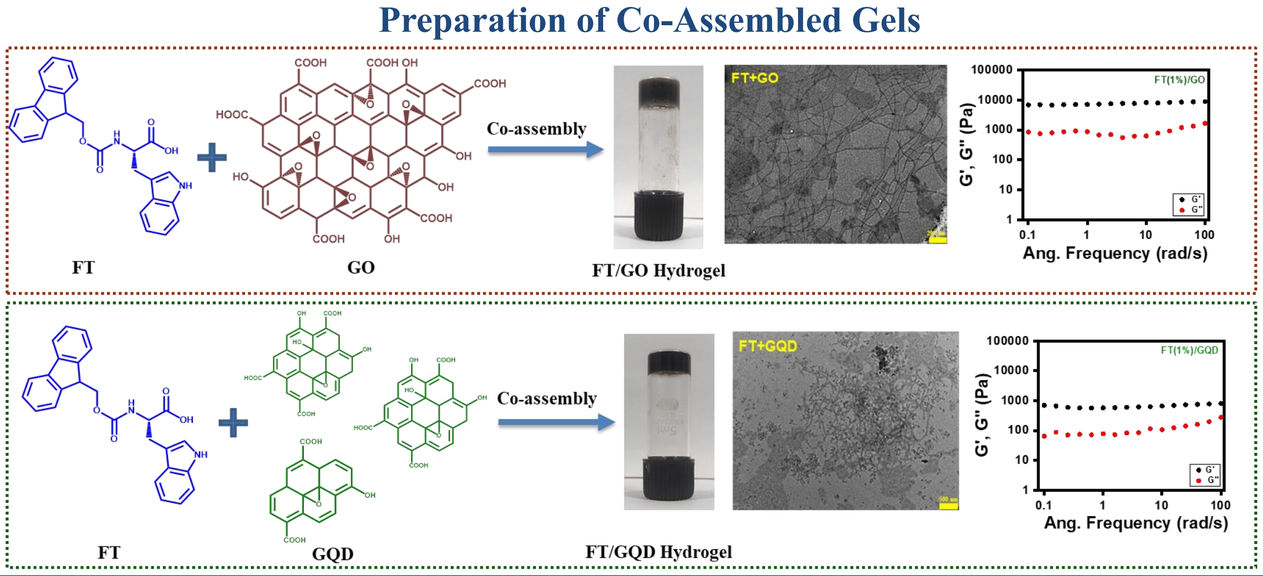


Fmoc-Tryptophan (FT) — FT Hydrogel



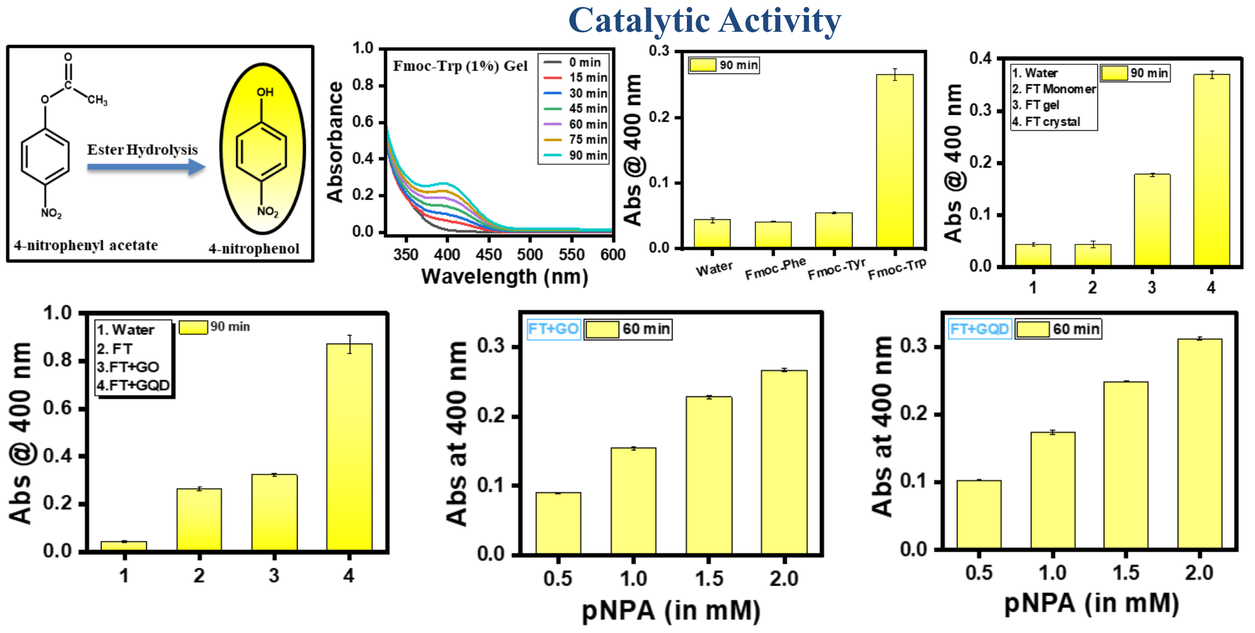


Preparation of Co-Assembled Gels

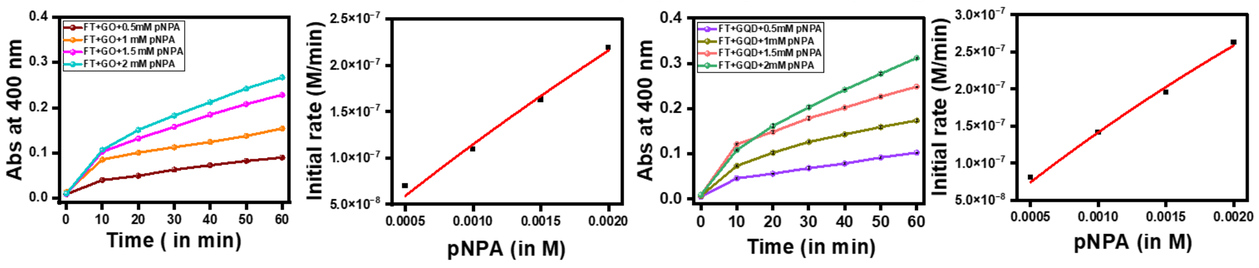


Results & Discussion

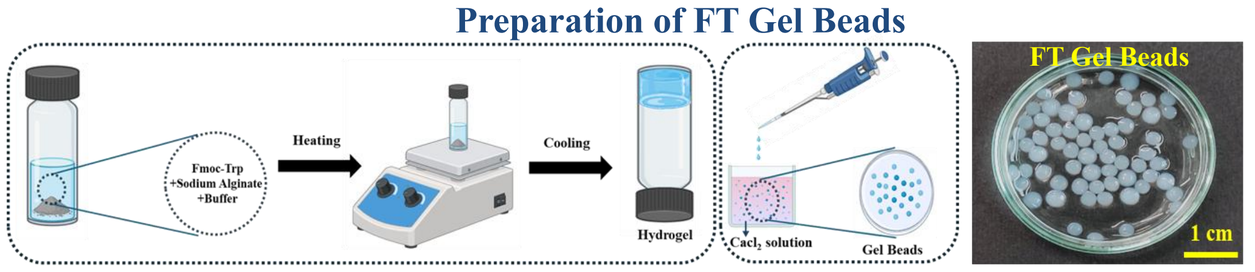
Catalytic Activity



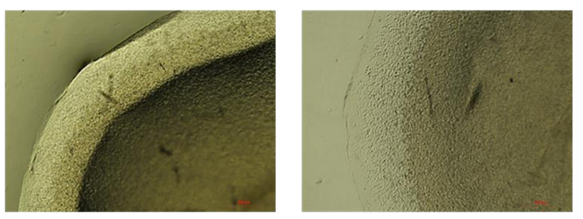
Esterase Activity by Composite Hydrogels



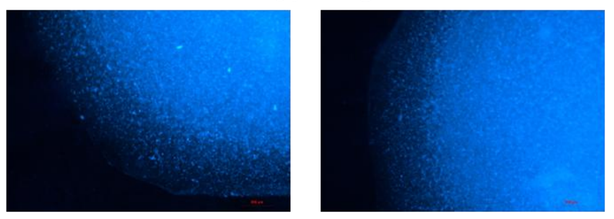
Preparation of FT Gel Beads



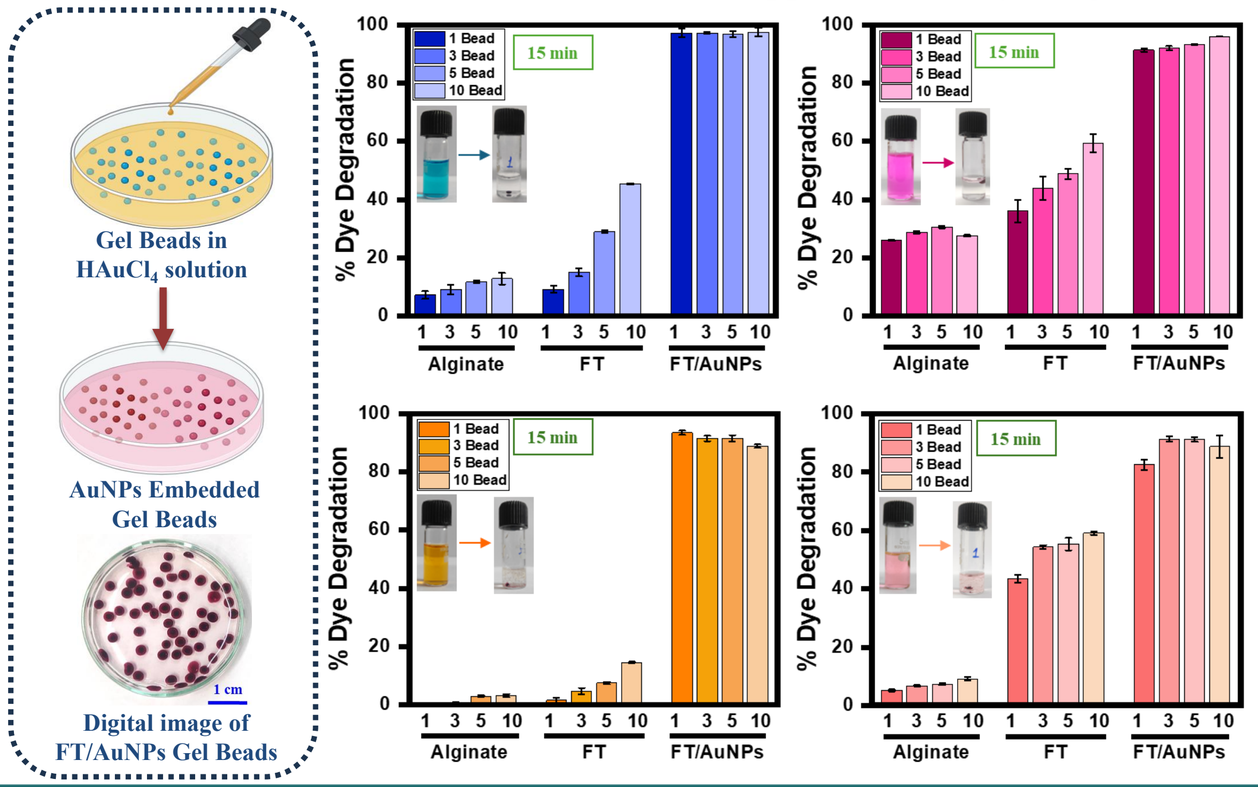
Bright Field Microscopy images of FT Gel Beads



Fluorescence Microscopy Images of FT Gel Beads



Preparation of FT/AuNPs Gel Beads and its Application in Dye Degradation



References

1. Miller, S. L. *Science* **1953**, *117* (3046), 528-529
2. Ren, H.; Wu, L.; Tan, L.; Bao, Y.; Ma, Y.; Jin, Y.; Zou, Q. *Beilstein J. Nanotechnol.* **2021**, *12*, 1140-1150,
3. Rizzo, C.; Marullo, S.; Billeci, F.; D'Anna, F. *Eur. J. Org. Chem.* **2021**, *2021* (22), 3148 - 3169
4. Das, N.; Maity, C. *ACS Catal.* **2023**, *13* (8), 5544 -5570
5. Sahu, I.; Saha, D.; Pande, S.; Verma, J.; Chakraborty, P. *ACS Applied Materials & Interfaces*, **2025**, *17*(34), 48240 - 48256.

Acknowledgements

भारतीय प्रौद्योगिकी संस्थान हैदराबाद
Indian Institute of Technology Hyderabad

सत्यमेव जयते
Ministry of Education
Government of India

Summary

- *A minimalistic supramolecular hydrogel derived from the single amino acid Fmoc-Tryptophan (FT) exhibited intrinsic catalytic activity toward ester hydrolysis.*
- *The semicrystalline, thermodynamically stable FT phase showed higher catalytic efficiency than the kinetically trapped gel and monomeric state, highlighting the role of molecular packing in catalysis. Hybridization of the FT network with nanomaterials such as graphene oxide and graphene quantum dots enhanced mechanical integrity and catalytic output, with the FT/GQD system showing enzyme-like catalytic efficiency and recyclability.*
- *To facilitate practical deployment, FT-based catalytic systems were incorporated into alginate core-shell beads, improving handling and reuse while preserving catalytic functionality.*
- *These findings demonstrate that single amino acid-based supramolecular hydrogels and their nanocomposites represent a promising class of tunable, reusable, and sustainable catalytic soft materials for both synthetic chemistry and environmental remediation.*