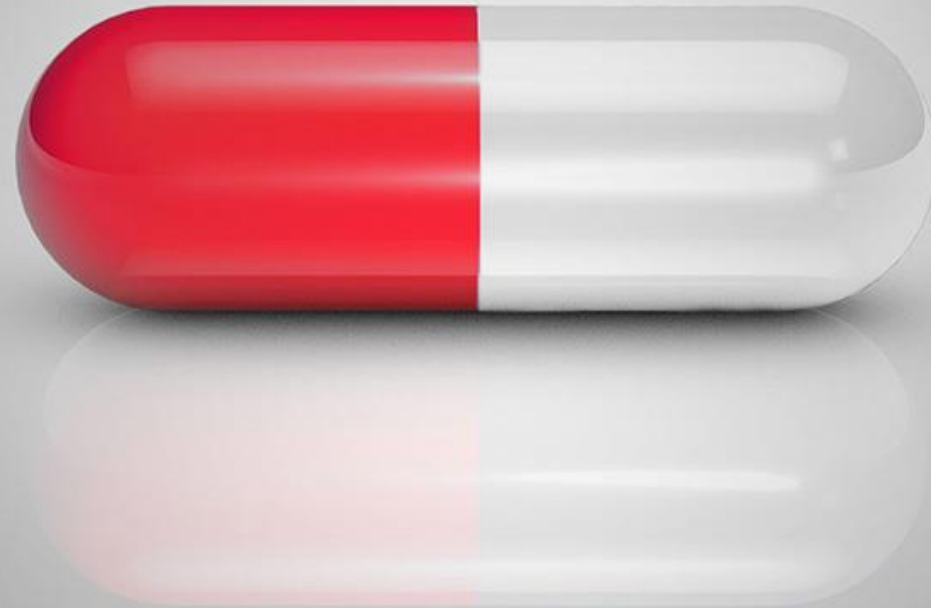




Smart Hydrogels for Controlled Drug Delivery



Biomaterials Project

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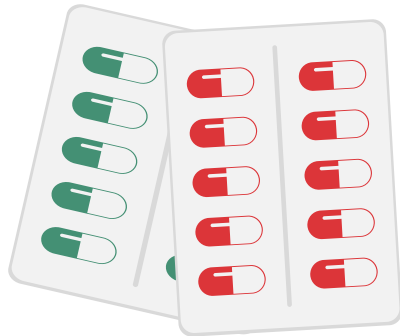
What Are Smart Hydrogels?

- Responsive materials for precise drug release
- Triggered by stimuli like pH, enzymes, or temperature
- Core role in targeted and personalized therapy



What Is Targeted Drug Delivery?

- Localized treatment with minimal side effects
- Enhanced efficacy via site-specific drug action
- Smart hydrogels as innovative carriers





Inflammatory Bowel Disease (IBD)



- Chronic inflammation of the digestive tract causing pain and discomfort
- Two main types: Crohn's disease (any GI tract) and ulcerative colitis (colon only)
- Symptoms include diarrhea, abdominal pain, and weight loss
- Existing treatments often fail to target inflammation precisely



Case Study Overview

01

Three advanced hydrogel systems for targeted IBD treatment.

02

Matrix metalloproteinase-responsive hydrogels for enzyme-specific action.

03

Starch-based hydrogels for pH-sensitive colonic delivery.

04

Composite HA/GE hydrogels combining microspheres and hydrogels for sustained release.





Case Study 1 – MMP-Responsive Hydrogels

A

Uses enzyme sensitivity to target inflamed tissues

B

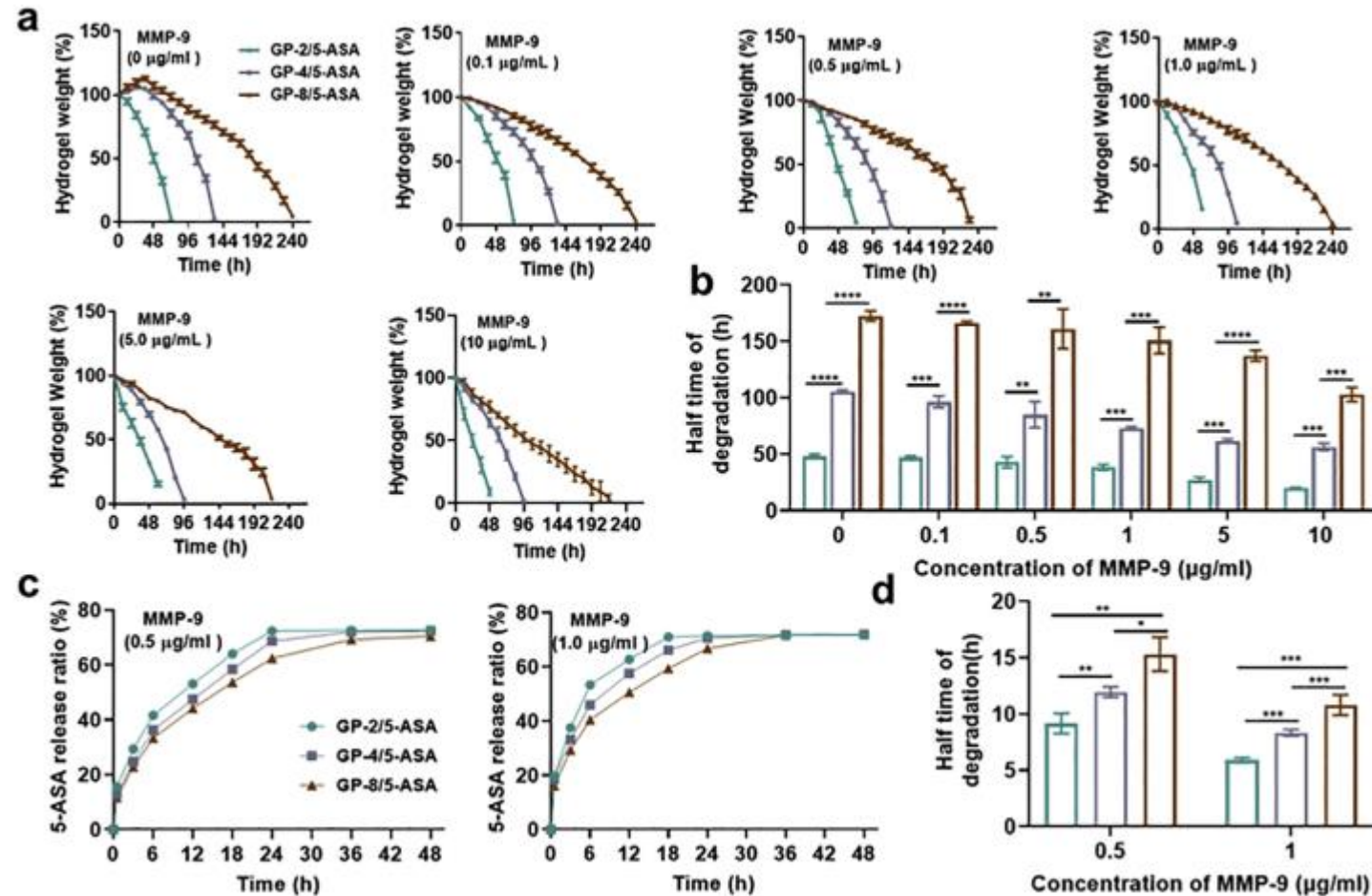
Releases drugs on-demand when MMP levels rise

C

Enhances localization and reduces off-target effects

D

Ideal for personalized and site-specific therapies

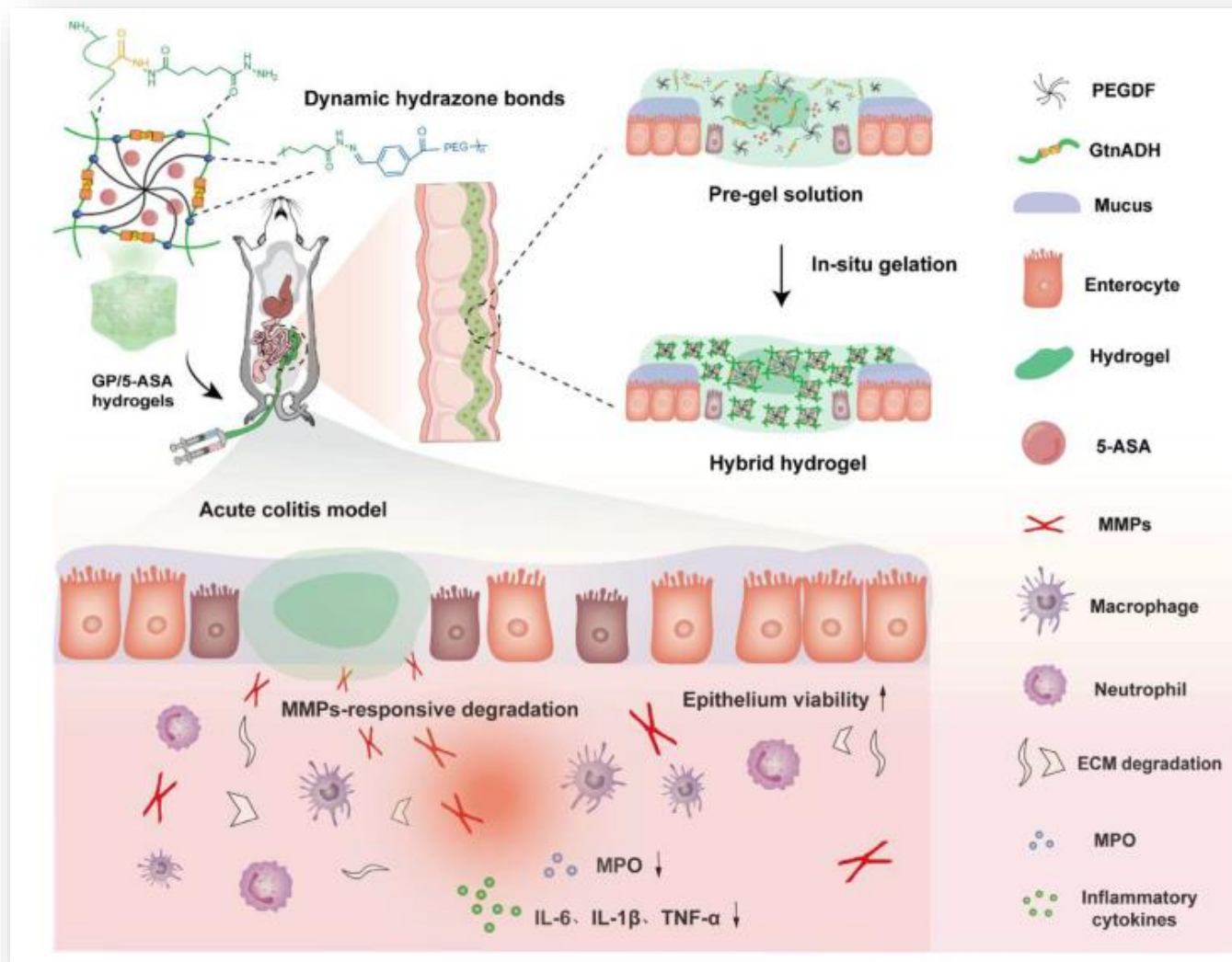


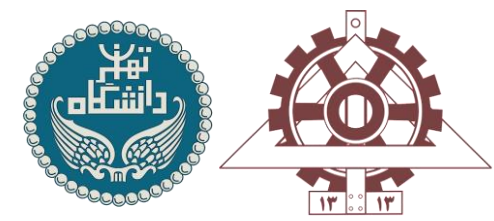


Case Study 1 – MMP-Responsive Hydrogels

MMP-responsive GP hydrogels with tunable retention for on-demand therapy of inflammatory bowel disease. The hydrogels could be injected and strongly adhered to the intestinal epithelium, with variable retention times dependent on hydrogel formulation. These hydrogels were subsequently degraded by MMPs and released 5-ASA into the intestinal microenvironment. The hydrogels facilitated the repair of the damaged mucosa and restored intestinal barrier functions for improving the treatment of IBD. The hydrogel therapeutics were effective in reducing the number of macrophages and the inflammatory markers included IL-6, TNF-

α , and IFN γ and the expression of MPO to ultimately promoted the repair of damaged mucosa and restored intestinal barrier function.





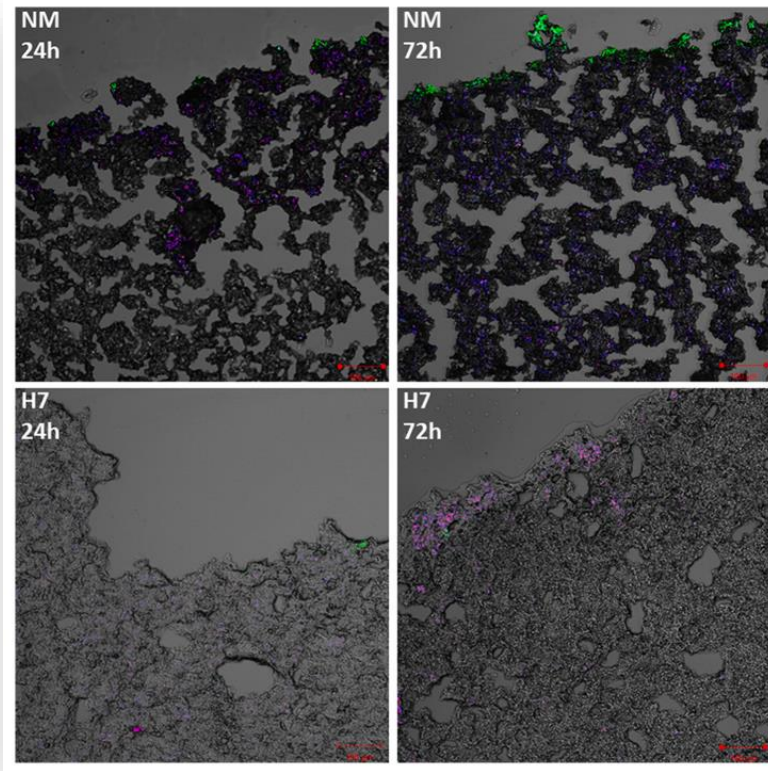
Case Study 2 – Starch-Based Hydrogels

A
Made from biodegradable, cost-effective natural polymers

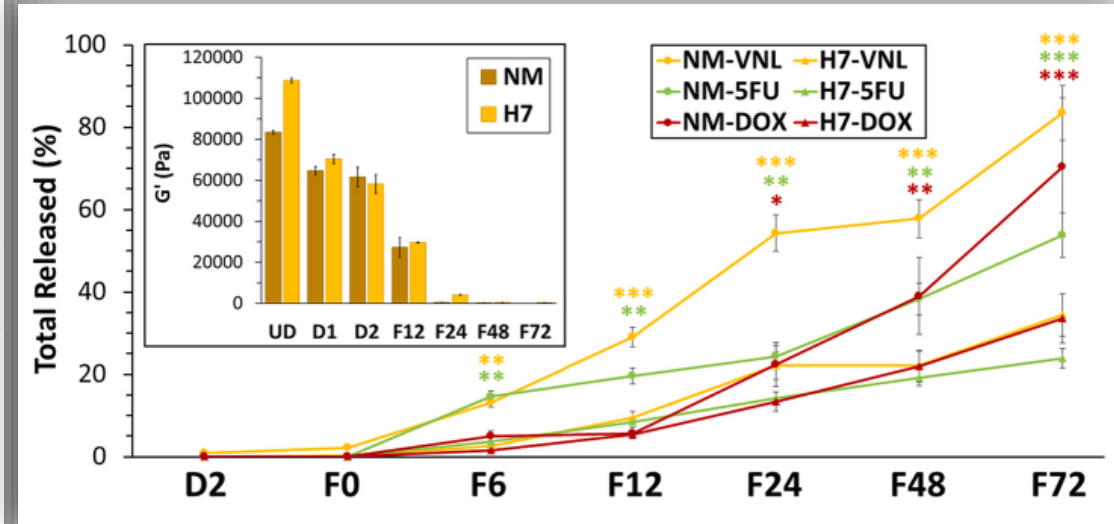
B
pH-sensitive design ensures colon-specific drug release

C
Stable in acidic stomach conditions for oral administration

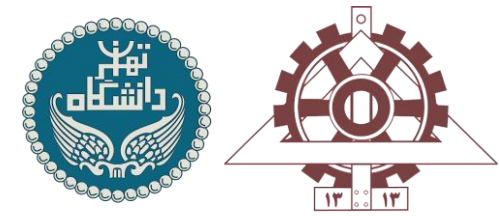
D
Focused on sustainability and low-cost scalability



Peripheral image of normal maize (NM) and Hylon VII® (H7) starch hydrogels



Release profiles of 5FU, VNL and DOX



Case Study 3 – Carboxymethyl Chitosan Microspheres

A

Composite system with HA/GE hydrogels and CC microspheres

B

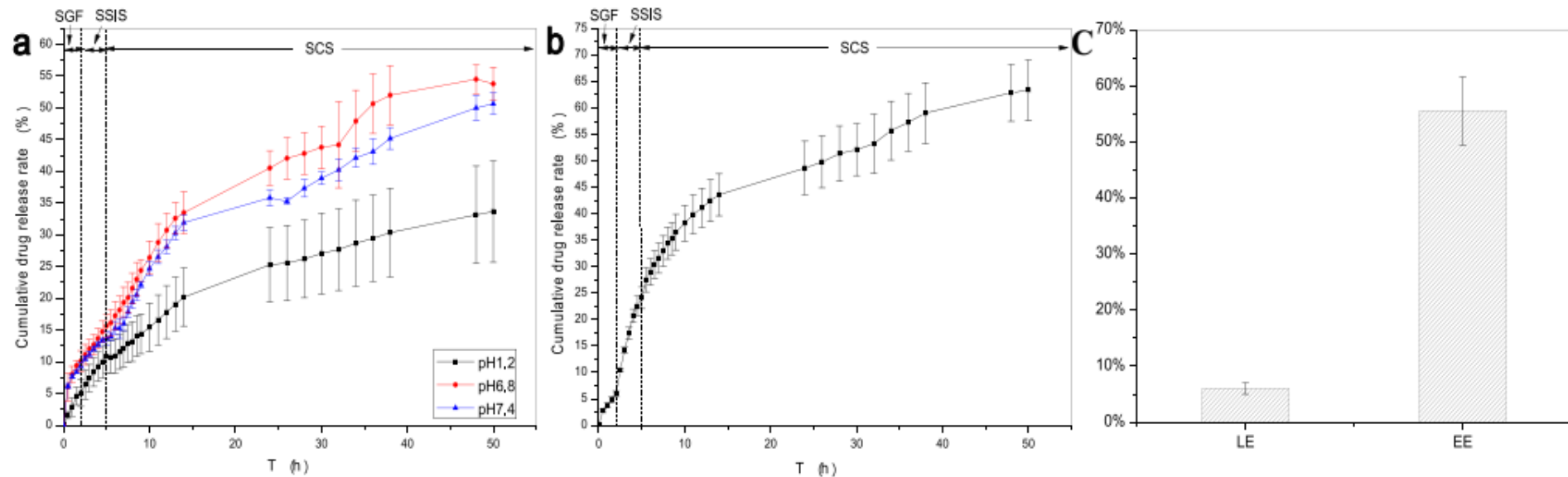
pH-sensitive mechanism for colon-targeted delivery

C

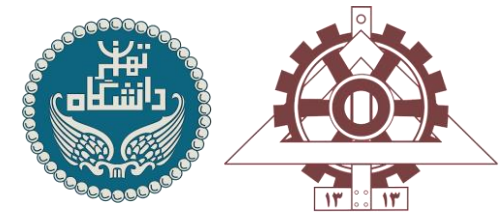
Sustained release of curcumin over 50 hours

D

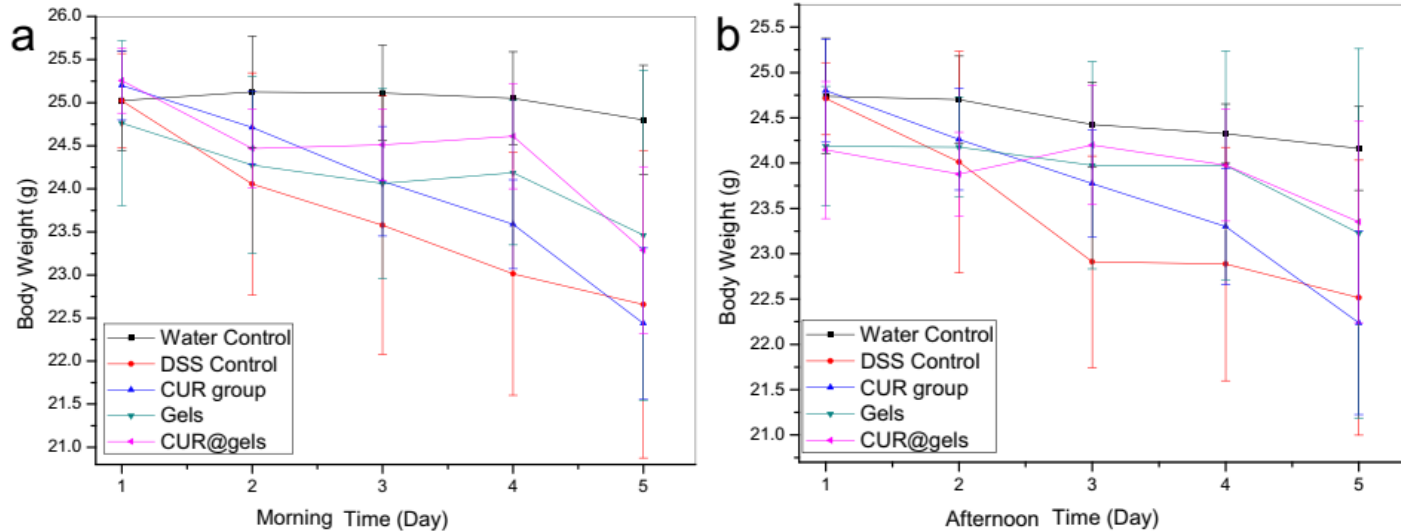
Significant reduction in pro-inflammatory cytokines



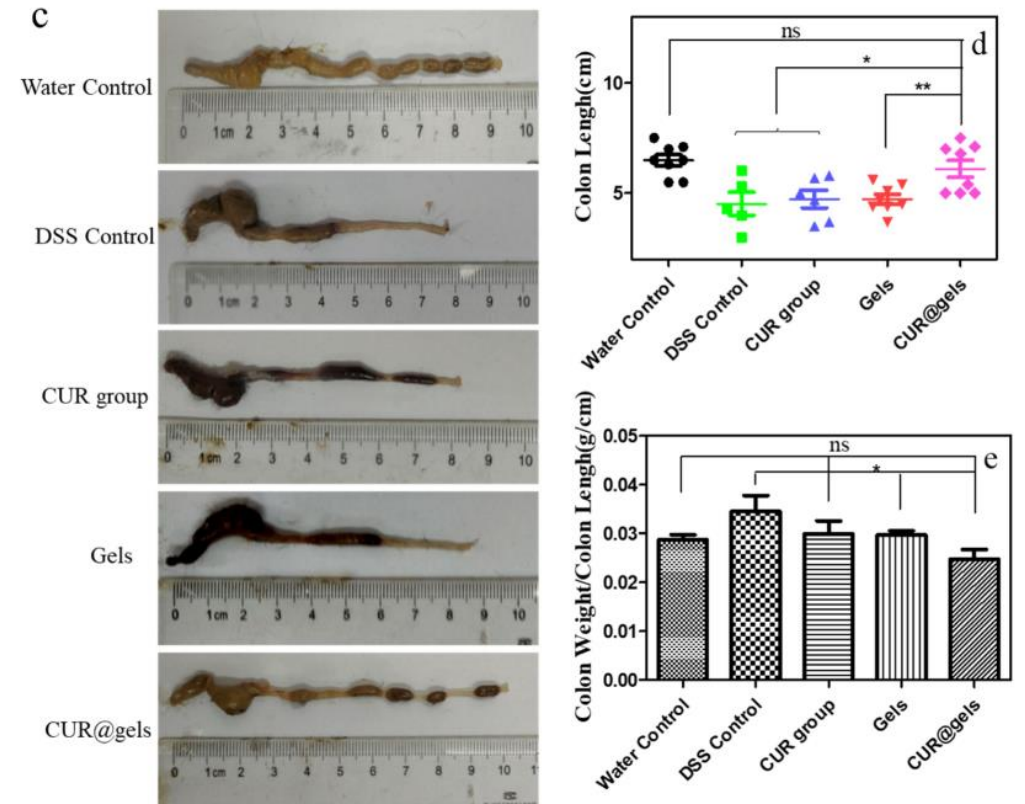
Cumulative release of CUR from composite hydrogels



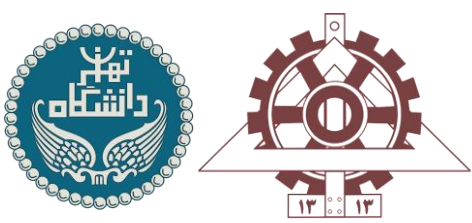
Case Study 3 – Carboxymethyl Chitosan Microspheres



Effects of orally administered CUR@gels on variations of mice body weight in DSS-induced mice colitis



Photographs of colons (c), scatter diagram of colon length (d) and histogram of colon weight/colon length (e)



Comparing the Three Approaches

Stimuli

enzyme-responsive, pH-sensitive, and dual-material systems



Materials

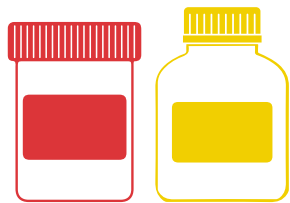
synthetic polymers vs. natural starch vs. composite hydrogels

Outcomes

all approaches show localized delivery with varying release times

Practicality

biocompatibility and scalability vary across systems





Benefits and Challenges

Benefits



localized treatment, reduced side effects, biocompatibility.

Challenges



production cost, stability, and regulatory hurdles.

Opportunities

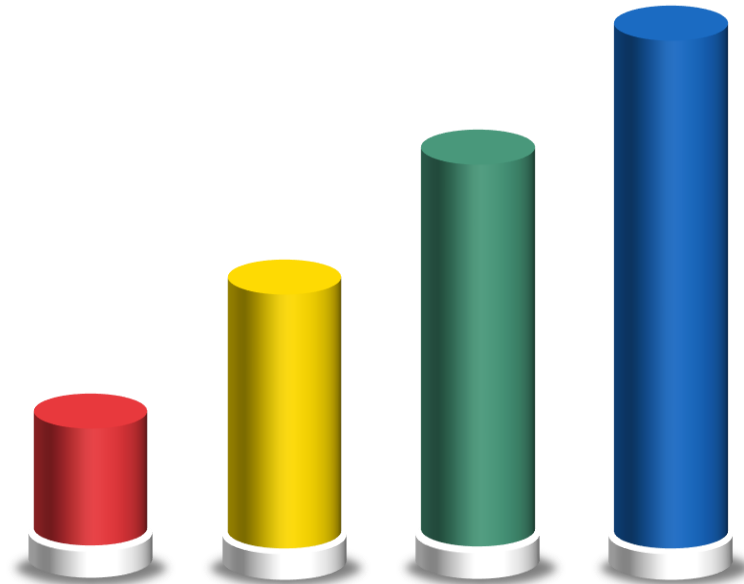


improved materials and advanced targeting.

Future Outlook



broad applications in personalized medicine.





Conclusion



Smart hydrogels revolutionize drug delivery in IBD treatment

Controlled release mechanisms enhance therapeutic outcomes

Current innovations point to a future of precision medicine

Bridging research to clinical use remains a key challenge



THANK YOU