VIDWAN Journal of Medical and Pharmaceutical Sciences

OPEN ACCESS

PEER-REVIEWED - OPEN ACCESS Vol. 01 · Issue 01 · 2026 · pp. 44-51 | ISSN: APPLIED (Online) | INAGURAL EDITION

TRIPTOLIDE LOADED ORAL NANOZYME FOR TARGETED COLITIS THERAPY

Mr. V. J. Krishna, *Assistant Professor*,
Srinivasa Rao College of Pharmacy, Andra Pradesh.

ABSTRACT

Ulcerative colitis (UC) is a chronic inflammatory bowel illness that requires targeted and efficient treatments due to its symptoms, which include inflammation, increased production of reactive oxygen species (ROS), and damage to the intestinal epithelial barrier. For the purpose of treating colitis, a nanoplatform that possesses a wide range of activities was designed. The implementation of triptolide-encased oral nanozymes is carried out. The reactive oxygen species-scavenging characteristics of nanozymes, in conjunction with the substantial anti-inflammatory actions of triptolide, have the potential to reduce inflammatory responses and oxidative stress. The protection of the nanozyme and the limitation of its dispersion are both accomplished by the utilization of pH- and enzyme-responsive approaches in an oral medication delivery system that is designed to target the inflammatory colon. A quick elimination of reactive oxygen species (ROS) in the affected region is achieved by the nanozyme. Additionally, the nanozyme inhibits the NF-κB signaling pathway, decreases the levels of pro-inflammatory cytokines, and activates macrophages, which are immune cells that fight inflammation. Through the enhancement of mucosal healing and tight junction protein synthesis, the formulation is able to reestablish the intestinal barrier and lower the systemic toxicity of triptolide. Immunological regulation, antioxidants, and the delivery of medication in a targeted manner all contribute to improved treatment outcomes and a reduced severity of the disease. Ulcerative colitis can be effectively treated with a nanozyme that contains triptolide and is delivered orally. This treatment is both safe and effective. The effectiveness of treatment is improved when medications are given in a localized manner and when the condition is controlled using a collection of different approaches.

Keywords: *Triptolide; Oral nanozyme; Ulcerative colitis; Targeted drug delivery; Reactive oxygen species (ROS); Colon-targeted therapy; Nanozyme; Anti-inflammatory therapy; Oxidative stress; Nanomedicine.*

Article history: Received 8 July 2026 · Revised 17 July 2026 · Accepted 29 July 2026 · Published 7 August 2026

1. INTRODUCTION

The inflammatory bowel disease (IBD), which includes ulcerative colitis and Crohn's disease, is characterized by inflammation of the mucosal lining, oxidative stress, breakdown of the epithelial barrier, and compromised immunological responses. IBD is a disorder that is both persistent and recurrent. The colon and the rectum are the primary organs affected by ulcerative colitis. There are a number of potential adverse effects, including increased risk of rectal bleeding, abdominal pain, diarrhea, weight loss, and a decrease in quality of life. Recent discoveries imply that immune system dysfunction, dysbiosis of the gut microbiota, environmental variables, and genetic predisposition may be potential contributors to the condition, despite the fact that research has not yet found a single cause. Pharmacological drugs that are considered to be traditional, such as biologics, immunosuppressants, corticosteroids, and aminosalicylates, are helpful in the therapy of diseases. Inconsistent treatment efficacy, systemic adverse effects, inadequate patient adherence, and incorrect targeting of inflammatory regions are all potential outcomes of prolonged usage of the medication. In response to these concerns, researchers have created cutting-edge drug delivery methods that reduce the risk of systemic toxicity and provide individualized, localized therapy options.

Tripterygium wilfordii Hook F. is the fungus that is responsible for producing the well-known diterpenoid triepoxide triptolide. Fibrosis, inflammation, antioxidants, and immune system function are all significantly impacted by the consequences. For therapeutic purposes, it is feasible to decrease the levels of pro-

inflammatory cytokines, modify the activation of T-cells, suppress the activation of NF-κB, and decrease the amount of oxidative damage that occurs in tissues that are inflammatory.

2. MODEL DEVELOPMENT

Synthesis and Characterization of T-C

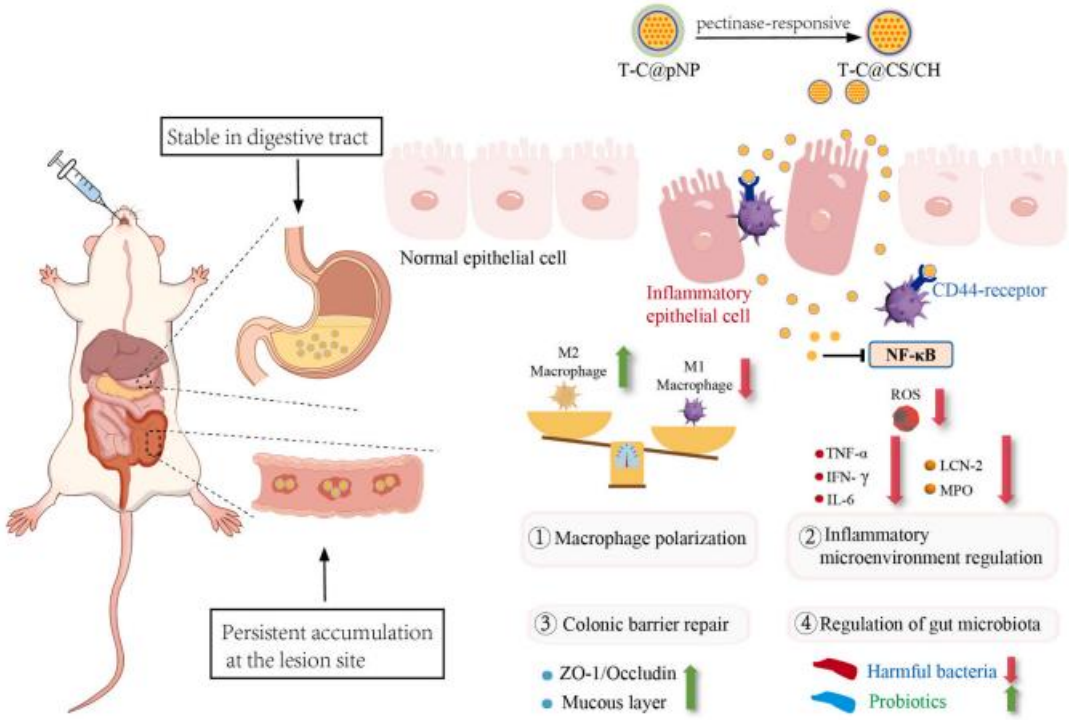
Following the synthesis of CeO2 nanozymes using chemical methods, the nanozymes were then exposed to a triptolide (TP) treatment. Characterization of the T-C nanozymes was accomplished through the utilization of antioxidant tests, DLS, TEM, XRD, EDS, XPS, and DSC.

Preparation and Characterization of the Nanoplatform

It was determined that chitosan (CS), chondroitin sulfate (CH), and pectin (PC) should be combined in a particular combination in order to create the oral nanoplatform known as T-C@pNP. The researchers investigated the zeta potential, size, and form of the particles, as well as the drug encapsulation capacity of the particles.

Storage Stability of T-C@pNP

The course of eight days at a temperature of four degrees Celsius, we measured the zeta potential and particle size of T-C@pNP in order to evaluate its stability.



Scheme 1. Preliminary study on the mechanism of oral treatment of T-C@pNP in colonic inflamed mice

In Vitro Release of T-C@pNP

The dialysis bag technique was utilized in order to explore the release of medication in the stomach, which has a pH of 1.2, and the intestines, which have a pH of 6.8 with pectinase.

Degradation Study of T-C@pNP

For the purpose of evaluating the acid resistance and pectinase-mediated disintegration of the nanoparticle shell, the particle size, zeta potential, and polydispersity index (PDI) were all modified.

In Vitro Cytotoxicity of T-C@pNP

In order to determine the effect that the combination had on the viability of RAW 264.7 and IEC-6 cells, the CCK-8 test was utilized.

In Vitro Cellular Uptake

An examination of the uptake of FITC-labeled nanoparticles by inflammatory RAW 264.7 and IEC-6 cells was carried out with the assistance of confocal laser scanning microscopy.

In Vitro Anti-inflammatory Capacity

When it comes to reducing inflammation, the effectiveness of TNF-α, IL-6, and IFN-γ was evaluated through the utilization of ELISA.

In Vitro Cell Scratch Assay

For the purpose of determining whether or not nanoparticles are effective in augmenting wound healing, the IEC-6 cell contact assay was utilized.

In Vivo Biodistribution Measurement

Through the use of intravital ultrasound (IVUS), ICG-labeled nanoparticles were utilized in order to study participants who were suffering from DSS-colitis.

In Vivo Anti-colitis Efficiency

We monitored the mice's weight, disease activity index, colon length, inflammation, splenic index, and histological examination in order to determine whether or not the medicine was effective in treating DSS-induced colitis in mice.

Histochemical Analysis

In order to evaluate the integrity of mucus layers, tight junction proteins, collagen deposition, reactive oxygen species (ROS) generation, MPO activity, macrophage polarization, and histology, immunofluorescence labeling was utilized.

Western Blot

For the purpose of determining the amounts of NF-κB p-p65 and Beclin-1 proteins in colon samples, Western blot analysis was utilized.

Gut Microbiota Analysis

For the purpose of investigating the microbiota of the intestinal tract, 16S rRNA sequencing and analytics were utilized.

Statistical Analysis

In order to examine the mean ± standard deviation data, we utilized a one-way analysis of variance (ANOVA). It was determined that a p-value that was lower than 0.05 was considered to be statistically significant.

3. EXPERIMENTAL RESULTS

Characterization of T-C

A homogenous particle size was demonstrated by TP-loaded cerium oxide nanozymes (T-C), which exhibited an outstanding drug-loading efficiency. TEM, XRD, EDS, XPS, and DSC experiments were conducted to verify the addition of triptolide to hollow CeO_2 nanozymes while maintaining the Ce2+/Ce2+ redox system. The antioxidant T-C is capable of eliminating a significant quantity of reactive oxygen species (ROS) and is also advantageous in the treatment of inflammatory bowel disease.

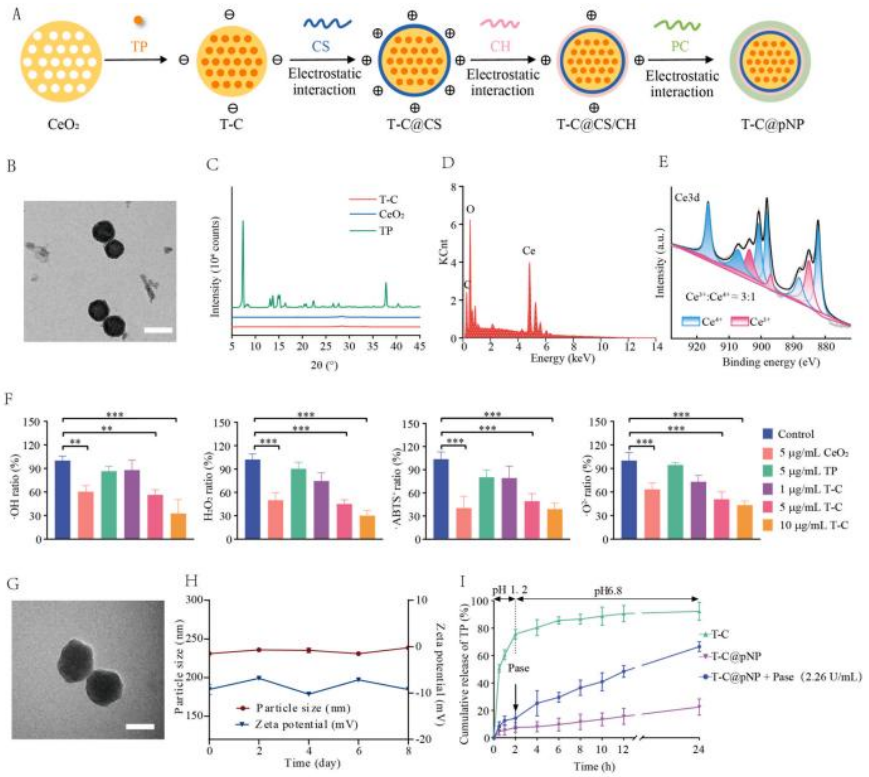


Fig. 1. Synthesis and characterization of T-C and T-C@pNP.

Characterization of T-C@pNP

Chitosan, chondroitin sulfate, and pectin were coated on T-C to create the oral nanoplatform, which is represented by the acronym T-C@pNP. The nanoparticles maintained their stability during storage due to their homogeneous sphere shape, appropriate particle size, and negative surface charge. Due to its resistance to acid and rapid degradation upon the addition of pectinase, the pectin coating was an exceptional candidate for medication delivery to the colon.

In Vitro Release of T-C@pNP

T-C@pNP stabilized the release of medication under stomach conditions (pH 1.2), thereby preventing its premature release. The shell was completely decomposed in an intestinal environment with a pH of 6.8 when pectinase was present. The triptolide was gradually discharged as a consequence. The nanoplatform delivers the drug to the colon in a specific manner, and it subsequently releases the drug in response to enzymes.

In Vitro Cytological Assessment of T-C@pNP

Inflammatory RAW 264.7 macrophages and IEC-6 gut epithelial cells are capable of effectively absorbing T-C@CS/CH nanoparticles, as indicated by scientific research. Chondroitin sulfate, which targets the CD44 receptor, and electrostatic interactions may facilitate the drug's rapid penetration of inflammatory cells.

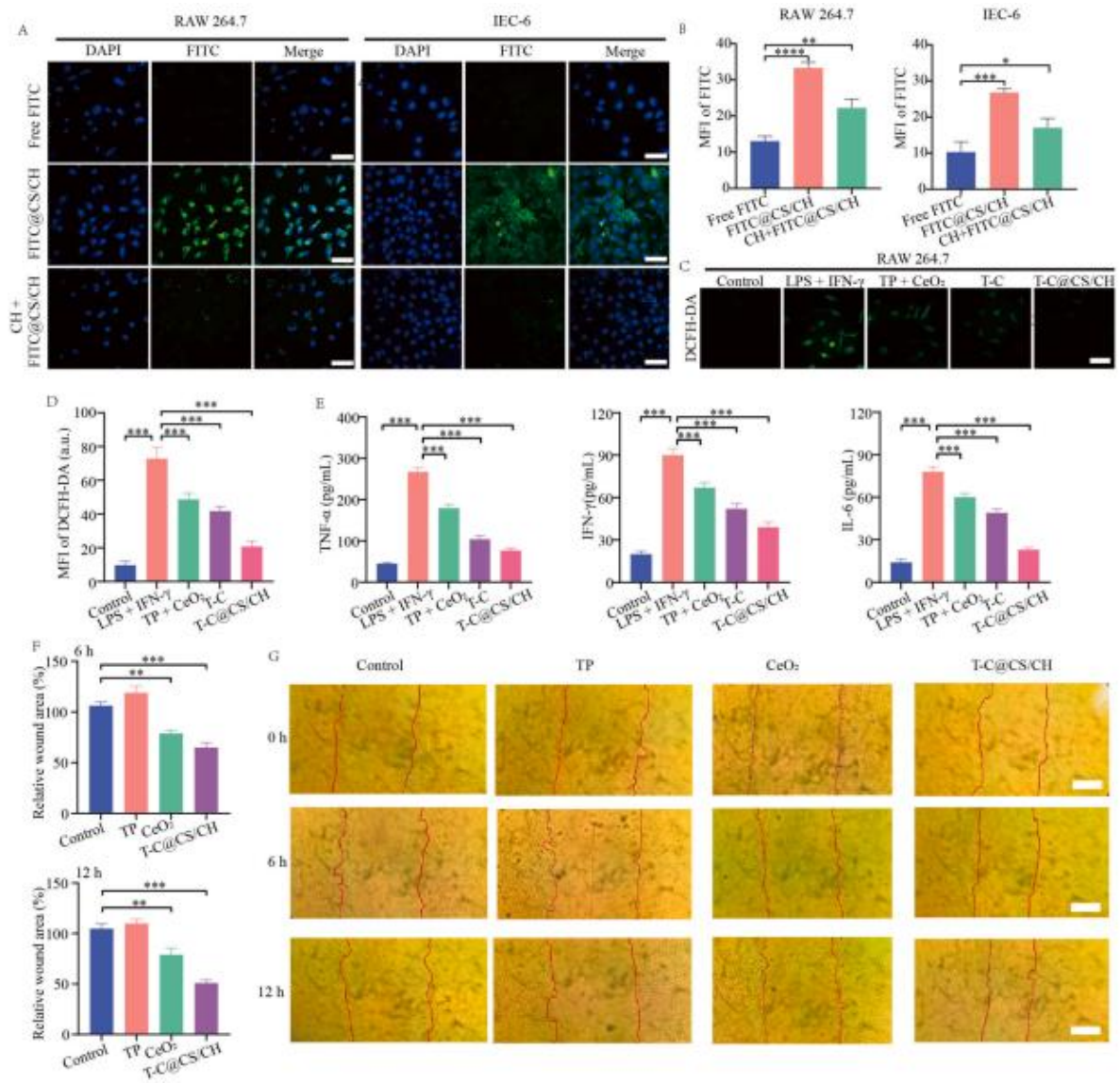


Fig. 2. In vitro assessment of uptake and therapeutic effects of T-C@pNP.

In Vitro Anti-ROS and Anti-inflammatory Capacity

In comparison to free TP and CeO_2, T-C@CS/CH demonstrated a substantial decrease in reactive oxygen species (ROS) levels and inhibited the production of inflammatory cytokines, including TNF-α, IL-6, and IFN-γ. The therapy's efficacy was enhanced by the combination of the antioxidant activity of CeO2 nanozymes and the anti-inflammatory effects of triptolide.

Wound Healing Capacity

Scratch testing demonstrated that the nanoparticle mixture accelerated the healing process of wounds and directed IEC-6 intestinal epithelial cells toward movement. The recipe's capacity to facilitate cellular absorption and reduce inflammation facilitated epithelial regeneration, which implies that it could be employed to reconstruct the intestinal barrier.

In Vivo Biodistribution

Fluorescence imaging demonstrated that T-C@pNP remained in the inflamed intestines for an extended period following oral administration. The pectin coating impeded the degradation of the nanoparticles in the digestive tract, thereby facilitating the transportation of drugs to the stomach. Furthermore, the medications were delivered by the chondroitin sulfate, which adhered to the inflammatory regions.

In Vivo Therapeutic Effects

The administration of T-C@pNP led to a reduction in splenic enlargement, a restoration of colon length, an improvement in colon histology, a decrease in the disease activity index (DAI), and an increase in body weight. These effects alleviated the symptoms of colitis in mice produced by DSS. In comparison to free TP or CeO2 therapy, the nanoplatform was shown to have a higher therapeutic efficacy and to protect intestinal tissues from inflammation.

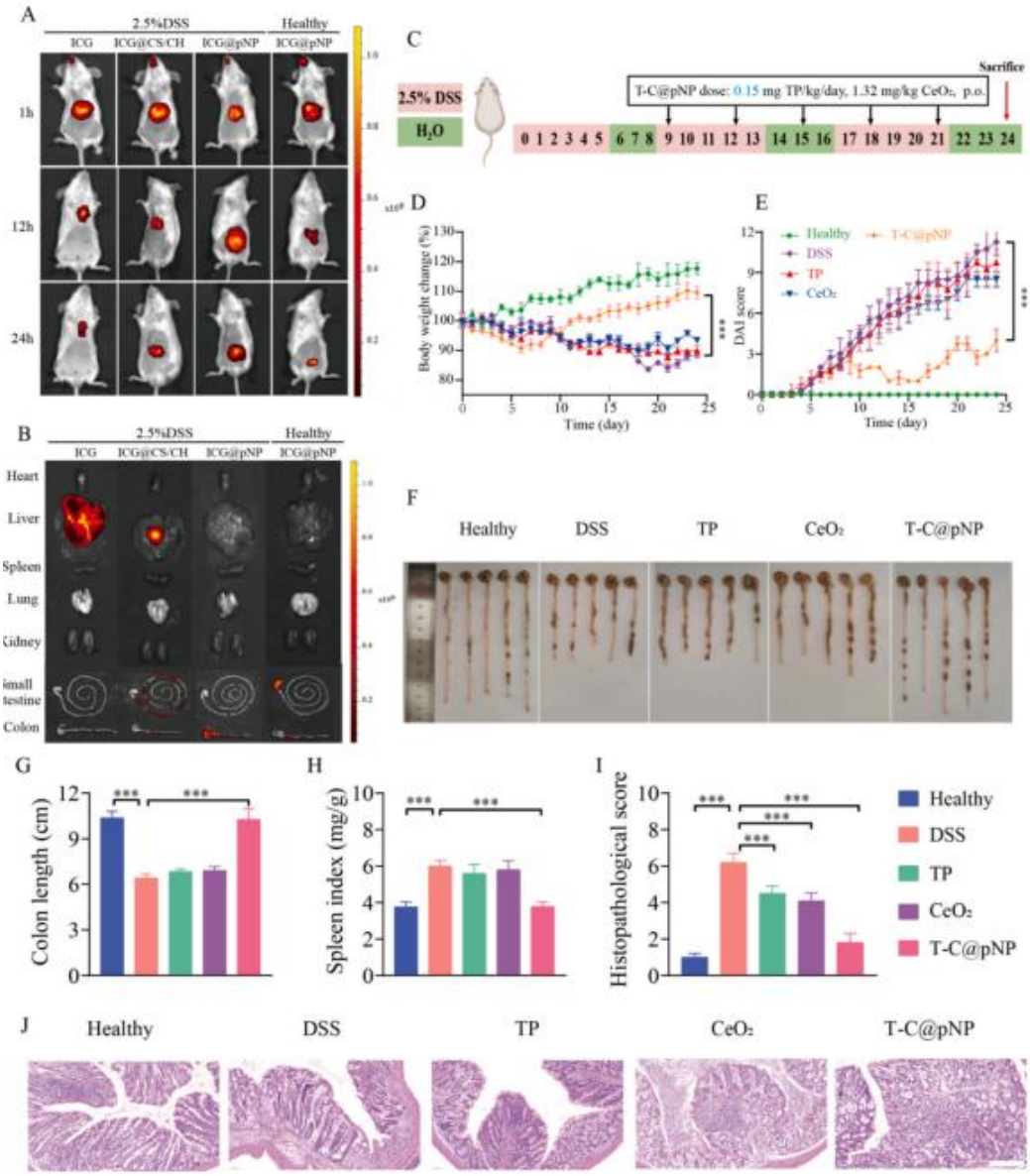


Fig. 3. In vivo distribution and therapeutic effects.

In Vivo Therapeutic Mechanism of T-C@pNP

Research has demonstrated that the following outcomes can be achieved: reducing oxidative stress, preventing neutrophil infiltration, promoting anti-inflammatory M2 macrophages, restoring intestinal tight junction proteins (ZO-1 and occludin), blocking the NF-κB signaling pathway, boosting autophagy, reducing fibrosis, and partially restoring gut microbiota composition. The combination further improved the therapy of ulcerative colitis and the mending of the intestinal barrier.

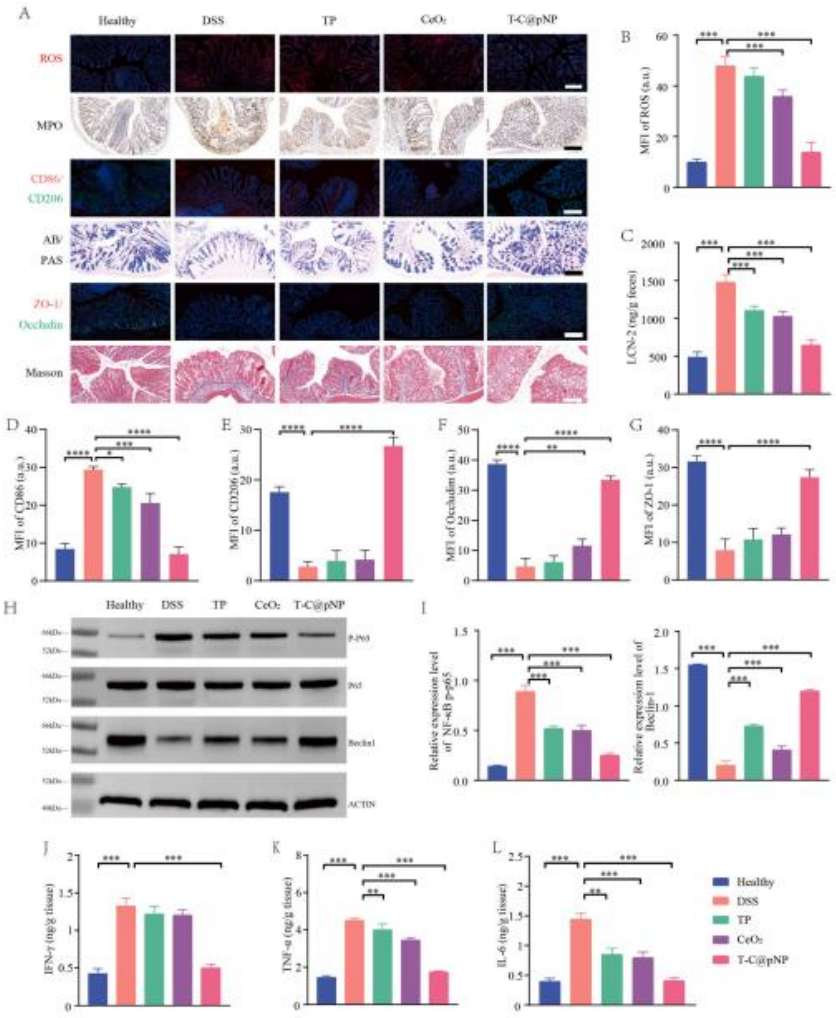


Fig. 4. In vivo therapeutic mechanism of T-C@pNP.

4. CONCLUSION

Triptolide-loaded oral nanozymes are a novel and potentially effective treatment for colitis. The potent anti-inflammatory effects of triptolide are combined with the ability of nanozymes to combat reactive oxygen species (ROS). These nanoplatforms accumulate in the tissues of the colon that are exhibiting inflammation when they are ingested. The systemic toxicity and adverse effects on the gastrointestinal tract are reduced as a result of the increased local absorption of the medicine. They prevent inflammation of the digestive tract in numerous ways. Some of these therapies include the modulation of macrophage polarization, the restoration of the intestinal epithelial barrier, the inhibition of pro-inflammatory signaling pathways, the reduction of oxidative stress, and the management of gut flora. Oral nanozymes that are loaded with triptolide have the potential to treat ulcerative colitis and other inflammatory bowel diseases, as indicated by preclinical research. These nanozymes have been identified as safe for human consumption, have the potential to reduce the severity of disease, and expedite the healing process of the gut mucosa.

REFERENCES

[1] Annangi, B., Lu, Z., Bruniaux, J., Ridoux, A., Da Silva, V.M., Vantelon, D., Boczkowski, J.,

[2] Lanone, S., 2021. Macrophage autophagy protects mice from cerium oxide nanoparticle-induced lung fibrosis. Part. Fibre Toxicol. 18, 6. https://doi.org/ 10.1186/s12989-021-00398-y.

[3] Bao, M., Wang, Keyi, Li, J., Li, Y., Zhu, H., Lu, M., Zhang, Y., Fan, Q., Han, L., Wang, Kesheng, Wang, D., Gao, Y., Peng, B., Ming, Z., Liu, W., 2023. ROS scavenging and inflammation-directed polydopamine

nanoparticles regulate gut immunity and flora therapy in inflammatory bowel disease. Acta Biomater. 161, 250–264. https:// doi.org/10.1016/j.actbio.2023.02.026.

[4] Bora, A., Mishra, P., 2016. Characterization of casein and casein-silver conjugated nanoparticle containing multifunctional (pectin–sodium alginate/casein) bilayer film. J. Food Sci. Technol. 53, 3704–3714. https://doi.org/10.1007/s13197-016- 2343-4.

[5] Cao, Y., Cheng, K., Yang, M., Deng, Z., Ma, Y., Yan, X., Zhang, Y., Jia, Z., Wang, J., Tu, K., Liang, J., Zhang, M., 2023. Orally administration of cerium oxide nanozyme for computed tomography imaging and anti-inflammatory/anti-fibrotic therapy of inflammatory bowel disease. J. Nanobiotechnol. 21, 21. https://doi.org/10.1186/ s12951-023-01770-0.

[6] Cao, X., Tao, S., Wang, W., Wu, S., Hong, Y., Wang, X., Ma, Y., Qian, H., Zha, Z., 2024.

[7] Ternary inulin hydrogel with long-term intestinal retention for simultaneously reversing IBD and its fibrotic complication. Nat. Commun. 15. https://doi.org/ 10.1038/s41467-024-52722-7.

[8] Chen, You, Feng, J., Chen, Yang, Xia, C., Yao, M., Ding, W., Li, X., Fu, X., Zheng, S., Ma, Y., Zou, J., Lan, M., Gao, F., 2024. ROS-responsive nano-medicine for navigating autophagy to enhance targeted therapy of inflammatory bowel disease. Int. J. Pharmaceut. 659, 124117. https://doi.org/10.1016/j.ijpharm.2024.124117.

[9] Chen, X., Feng, Y., Zhang, D., Zhou, S., Liu, X., Luo, B., Zhou, C., Liu, M., 2025. Orally

[10] administered hydrogel containing polyphenol@halloysite clay for probiotic delivery and treatment of inflammatory bowel disease. Nano Today 62, 102669. https://doi. org/10.1016/j.nantod.2025.102669.

[11] Cui, T., Li, B., Lou, Z., Yang, K., Yan, K., Ding, D., Ge, H., 2025. Oral administration of nanozyme-armed probiotic Escherichia coli Nissle 1917 with ROS scavenging for inflammatory bowel disease therapy. Chem. Eng. J. 519, 164949. https://doi.org/ 10.1016/j.cej.2025.164949.

[12] Dhall, A., Self, W., 2018. Cerium oxide nanoparticles: a brief review of their synthesis methods and biomedical applications. Antioxidants 7, 97. https://doi.org/10.3390/ antiox7080097.

