Nanocatalysts-Based Chemodynamic Cancer Therapy

Govind Chate, Shashwat Banerjee

Central Research Laboratory, MIMER Medical College and Dr. BSTR Hospital, Pune, Maharashtra, India

Cancer has remained a significant global health challenge wherein there is a need for an innovative therapeutic strategy that is more effective, yet lacks side effects. Even though therapy options have grown from surgical procedures and chemotherapy to targeted treatments and immunotherapy, cancer remains a priority for global health, underscoring the need for continued research into comprehensive strategies for prevention, early detection, and improvement in the outcomes of patients' care.[1] The established therapy modalities for this disease are surgical intervention, chemotherapy, radiotherapy, targeted therapy, and immunotherapy.[2] Surgery removes the tumor and the surrounding tissue physically; it is effective for local cancers. Among these options, wherein fast-dividing cancer cells are killed by applying cytotoxic chemicals throughout the body, chemotherapy is highly promiscuous in its targets and thus causes a set of side effects.[3] Radiation therapy uses high-energy radiation to destroy cancer cells and shrink tumors but is impeded by both tumor resistance and damage to surrounding healthy tissues. Targeted therapies zero in on specific molecular abnormalities that propel the growth of cancers and thus bring more precise treatments with fewer side effects,[4] one such example is targeted therapeutic agents, which target molecules involved in the biology of tumor/cancerous cells. Immunotherapy works to heighten the body's immune response to recognize and dispose of cancer cells. It has shown promising results in some cancers, but not all. It is apparent that, even with these advances, there still exist the problems of drug resistance and treatment toxicity and differences in treatment outcomes among patients; further research remains necessary to find new therapies and strategies for personalized treatments.[5]

Unlike traditional therapies, the newly developed chemodynamic therapy (CDT) offers the potential for targeted eradication of tumors through *in situ* generation of $^{\bullet}OH$. CDT explores high levels of H_2O_2 within the tumor microenvironments as a switch to cytotoxic effects, therefore shielding from damage to healthy tissues.[6] CDT has drawn wide attention because of its noninvasiveness, negligible side effects compared with traditional strategies such as surgery and radiation therapy, and the potential to overcome chemotherapy resistance and reduce systemic side effects.[7] In CDT, catalytic nanomaterials with enzyme-like activity (nanozymes) are used to produce reactive oxygen species (ROS) for tumor suppression.

Although the CDT field has been largely enriched over the past couple of years, it is still in its infancy, and many challenges still persist. Further research is underway in perfecting nanocatalyst design, improving biocompatibility, and exploring synergies between treatments such as immunotherapy. As CDT moves forward, proof from its pre-clinical studies right up to its early clinical trials holds much promise for it to become a viable therapeutic option in oncology.[8] Some of the strategies or nanomaterials being explored by scientist for developing next-generation CDT are: (1) Delivering H_2O_2 directly or indirectly to cancer cells as for increasing the efficacy of CDT, H_2O_2 concentration during Fenton/Fenton-like reactions is crucial.[9] (2) Modulating the reaction environment in the cancer cells to produce a more sensitive ROS level.[10] (3) Application of single-

Access this article online	
Website: themmj.in	Quick Response Code
DOI: 10.15713/ins.mmj.89	

Address for correspondence:
Govind Chate, Patent Attorney, Central Research Lab, Central Research Lab, MIMER Medical College and Dr. BSTR Hospital, Talegaon Dabhade, Pune, Maharashtra, India. E-mail: govindrajchate@gmail.com

atom catalysis, which is the cutting-edge direction in the field of catalysis, can help in highly CDT efficiency and selectivity.[11] (4) Enhancing the targeting efficiency of the nanocatalyst.[8] (5) Designing highly efficient CDT nanomaterials by computational field.[8]

REFERENCES

1. Xia QH, Cai YF, Zhang KX. Theranostic strategies based on iron oxide and gold nanoparticles: Photoacoustic imaging for monitoring and reactive oxygen species for cancer therapy. J Biomed Nanotechnol 2021;17:1131-45.
2. Chen Q, Feng L, Liu J, Zhu W, Dong Z, Wu Y, *et al*. Intelligent albumin-MnO_2 nanoparticles as pH-/$H2O_2$-responsive dissociable nanocarriers to modulate tumor hypoxia for effective combination therapy. Adv Mater 2016;28:7129-36.
3. Wang Z, Ju Y, Ali Z, Yin H, Sheng F, Lin J. Gold nanorods/hemin@PCN-224 nanocomposite as an enzyme mimic for synergistic catalysis-enhanced chemodynamic therapy. J Mater Chem B 2021;9:728-38.
4. Liu T, Wang C, Gu X, Gong H, Cheng L, Shi X, *et al*. PEGylated MoS2 nano-sheets for biomedical applications: Combined photothermal and chemotherapy of cancer. Adv Mater 2014;26:3433-40.
5. Zhang W, Guo Z, Huang D. An intelligent H_2O_2-driven nanosystem for effective chemodynamic and photodynamic combination therapy. Adv Sci 2020;7:1903293.
6. Jin Z, Wen Y, Hu Y. Fenton response-free ferroptosis therapy via sequential glutathione and iron redox-couple triggered lipid peroxide generator. Biomaterials 2021;271:120705.
7. Zhang Y, Liu Y, Zang J. Cascade amplifying synergistic effects of chemo-photodynamic and chemodynamic therapy mediated by copper peroxide nanoparticles for cancer treatment. Biomaterials 2021;276:121058.
8. Tang Z, Zhao P, Wang H, Liu Y, Bu W. Biomedicine meets fenton chemistry. Chem Rev 2021;121:1981-2019.
9. Wang Y, Zhang W, Sun P. Enhanced chemodynamic therapy via a hybrid metal-organic framework with *in situ* generated H_2O_2. Chem Commun 2020;56:3868-71.
10. Perillo B, Di Donato M, Pezone A, Di Zazzo E, Giovannelli P, Galasso G, *et al*. ROS in cancer therapy: The bright side of the moon. Exp Mol Med 2020;52:192-203.
11. Cao C, Wang X, Yang N, Song X, Dong X. Recent advances of cancer chemodynamic therapy based on Fenton/Fenton-like chemistry. Chem Sci 2022;13: 863-89.

How to cite: Chate G, Banerjee S. Nanocatalysts-Based Chemodynamic Cancer Therapy. MIMER Med J 2023;7(2):14-15.

Source of Support: Nil. **Conflict of Interest:** None declared.