



Study of Cu-MOF-based Chemodynamic Therapy in Tumor Cell Therapy Application

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DOI: 10.32629/jcmr.v5i1.1801

Abstract: Cu-MOF, as a novel metal-organic framework material, shows great potential in many fields by virtue of its unique physical and chemical properties. Especially in tumor cell therapy, the application of Cu-MOF has become a hot research topic in recent years. The present study will explore the application of Cu-MOF-based chemodynamic therapy in tumor cell therapy, which will provide a good impetus for the subsequent development.

Keywords: Cu-MOF, chemodynamic therapy, tumor cell therapy, application research

1. Research background

Cu-MOF is a crystalline porous material formed by self-assembly of copper ions and organic ligands. This material has a high specific surface area, high pore volume, and tunable pore size and structure, which makes Cu-MOF have a wide range of applications in biomedical fields such as drug delivery and release, bioimaging, and photothermal therapy.

Chemodynamic therapy (CDT) is a novel therapeutic approach that utilizes the endogenous microenvironment in the tumor focal area to achieve specific activation and generate hydroxyl radicals (-OH) to kill tumor cells. This therapeutic method has the advantages of avoiding the toxic side effects of chemotherapeutic drugs and killing tumor cells efficiently, and thus has a broad application prospect in tumor treatment. However, CDT also has some limitations, such as the short half-life and small range of action of -OH, which makes the deep tumor cells often able to escape the killing of CDT and metastasize. To solve this problem, the research team began to explore carriers that can precisely deliver drugs to deep tumors.

RT uses radiation to kill localized tumor tissue. Surgery directly removes the tumor entity or the entire tissue. Chemotherapy kills cells by non-specifically interfering with cell division by inhibiting DNA replication or separating newly formed chromosomes. These traditional cancer treatments have limitations or shortcomings in actual clinical application. Surgery is difficult to avoid tumor residue, while radiotherapy and chemotherapy have systemic toxicity and different degrees of side effects on normal tissues, which limits their clinical application. Therefore, many new therapeutic methods have been developed, such as photodynamic therapy (PDT), photothermal therapy (PTT), chemodynamic therapy (CDT), acoustic-dynamic therapy (SDT), and radiation-dynamic therapy (RDT). etc. On the basis of this combination of multiple therapies is conducive to addressing the side effects of traditional treatments in order to improve therapeutic efficacy and to reduce the adverse damage to normal tissues.

The mechanisms of chemodynamic therapy include simple tumor microenvironment-mediated Fenton and Fenton-like reactions. The Fenton reaction has been described as the production of highly cytotoxic hydroxyl radicals from H_2O_2 catalyzed by Fe^{2+} . radicals catalyzed by Fe^{2+} . It has been widely used in the environment. For chemodynamic therapy, Fe-based materials produce Fe^{2+} in the microacidic environment of tumor tissues. environment of tumor tissues, then Fe^{2+} is treated with H_2O_2 to generate highly cytotoxic -OH, which subsequently triggers cellular The efficiency of the Fenton reaction is directly related to the therapeutic effect of CDT. The amount of catalyst and The amount of catalyst and the reaction conditions (e.g. pH, H_2O_2 , GSH, etc.) affect the Fenton reaction.

2. Research status

In contemporary medicine, the treatment of tumors has become the focus and difficulty of research. In order to seek more effective tumor treatments, researchers are constantly exploring various novel strategies. Among them, the research on the application of Cu-MOF-based chemokinetics in tumor cell therapy is gradually gaining attention. Cu-MOF, or metal-organic framework, is a novel material with highly porous and tunable properties, and its unique structure makes it have great potential for drug delivery and release, chemokinetic therapy, and so on.

As an alternative strategy to conventional cancer treatment regimens, chemodynamic therapy (CDT) has received

increasing attention for its generation of reactive oxygen species (ROS) in a manner that does not rely on local oxygen, which mainly utilizes the Fenton or Fenton-like reaction to generate highly cytotoxic $\cdot\text{OH}$ for killing tumor cells. Compared with conventional therapies, CDT can generate spatiotemporally controlled and tissue-depth-independent reactive oxygen species (ROS) and oxygen (O_2), to respond to the high levels of hydrogen peroxide (H_2O_2) in the tumor microenvironment (TME). ROS and oxygen (O_2) in response to high levels of hydrogen peroxide (H_2O_2) in the tumor microenvironment (TME). Although Fenton and Fenton-like reactions are usually inhibited by unstable H_2O_2 and slightly alkaline conditions in normal microenvironments, ions can be solubilized from iron or other nanomaterials based on transition metal ions to activate the Fenton and Fenton-like reactions in acidic TME. Recently, nanotechnology has played an important role in the development of new targeted tumor diagnostics and therapeutics. Emerging nanomaterials based on Fenton and Fenton-like reactions are predominantly iron-based, followed by other metal-based nanoparticles (NPs) (including Mn^{2+} , Cu^{2+} , and Ti^{3+} ions, among others) and several organic NPs². Due to the properties of these nanomaterials, including tumor-targeting ability, large specific surface area, and high reactivity, they are powerful tools for the production of $\cdot\text{OH}$ and O_2 via Fenton and Fenton-like reactions. With the tumor-targeting ability of these nanomaterials, NPs based on Fenton and Fenton-like reactions can improve therapeutic efficiency and reduce material side effects.

Currently, research on the application of Cu-MOF-based chemokinetics in tumor cell therapy has made some progress. Due to the specificity of the tumor microenvironment, Cu-MOF can intelligently respond to environmental changes and achieve rapid drug release. This not only improves drug utilization, but also reduces damage to normal cells.

3. Research applications

In the applied research case, researchers skillfully utilized the properties of Cu-MOF as a drug carrier for tumor therapy. They first synthesized a Cu-MOF with tumor-targeting function, which is a material capable of releasing drugs in a low pH environment (similar to that of tumor tissue). This property allows the drug to act precisely on the tumor site, reducing damage to the surrounding normal tissue. The researchers then used this Cu-MOF as a carrier for carrying anti-tumor drugs, which were delivered to the tumor site by intravenous injection. The drugs were gradually released under the regulation of Cu-MOF to achieve a sustained blow to the tumor.

It is worth mentioning that this Cu-MOF-based chemokinetic therapy has demonstrated impressive efficacy in experiments. In the animal model, the tumor growth of the group treated with Cu-MOF was effectively inhibited, and the survival period was significantly prolonged. In addition, this therapeutic approach has the advantages of low toxicity and low immunogenicity, which can reduce side effects and immune responses during treatment.

However, despite the exciting results of the research on the application of Cu-MOF-based chemodynamic therapy in tumor therapy, there are still many challenges to overcome. For example, how to further improve the drug loading and release efficiency, and how to optimize the biocompatibility and targeting of the material. In order to solve these problems, researchers are continuously exploring and innovating with the aim of bringing better therapeutic effects to tumor patients.

Through continuous in-depth research and improvement of the technology, Cu-MOF-based chemodynamic therapy is expected to become a highly efficient, safe and widely used tumor treatment method, bringing life hope to patients.

As an emerging material, Cu-MOF (metal-organic framework) shows great potential in the fields of drug delivery, bioimaging, and chemodynamic therapy due to its unique physicochemical properties. Especially in chemodynamic therapy, the properties of Cu-MOF enable it to precisely control the rate and process of chemical reactions, which provides a brand new idea for tumor therapy.

In traditional chemotherapy, the release of drugs often cannot be precisely controlled, thus affecting the therapeutic effect and even producing side effects. The chemical kinetic method based on Cu-MOF can realize the slow and controlled release of drugs by adjusting the characteristics of Cu-MOF, such as pore size and stability, to improve the precision and effect of treatment.

By studying the chemical reaction process of Cu-MOF in tumor cells, we can gain a deeper understanding of the process of tumor cell growth, division, and death, and provide theoretical support for the development of more effective therapeutic means.

Cu-MOF has excellent biocompatibility and low toxicity, which makes its application in tumor therapy safer and more reliable. Compared with traditional chemotherapeutic drugs, Cu-MOF-based therapies can reduce damage to normal cells, minimize side effects, and improve the quality of patient survival.

In summary, the study of Cu-MOF-based chemodynamic therapy in tumor cell therapy not only helps to promote the cross development of chemodynamic therapy and biomedicine and provide new strategies and methods for tumor therapy, but also has a broad clinical application prospect and economic benefits. Therefore, the study has important theoretical and

practical significance.

4. Summary

Compared with traditional tumor therapies, Cu-MOF-based therapies have many advantages. Firstly, Cu-MOF can realize precise delivery and release of drugs through specific ligand design to improve the targeting and effect of treatment. Second, Cu-MOF can be used as a photothermal converter to achieve efficient ablation of tumors through near-infrared light irradiation. In addition, Cu-MOF can also be used as a drug carrier for chemical kinetic therapy to achieve the killing of tumor cells by controlling drug release.

Chemokinetic therapy is a new type of treatment method, which utilizes the chemical reaction of drugs in tumor cells to achieve the killing of tumor cells. And Cu-MOF can be used as the carrier of this treatment method, which realizes the targeted strike on tumor cells by loading drugs. In addition, Cu-MOF can also increase the local temperature of the tumor through the photothermal effect to promote the release and diffusion of the drug, further improving the therapeutic effect.

Although Cu-MOF-based chemodynamic therapy shows great potential in the treatment of tumors, there are still many problems to be solved. For example, how to further improve the biocompatibility and stability of Cu-MOF, how to realize long-term storage and controlled release of drugs, and how to improve the targeting and effectiveness of treatment. In the future, more research is needed to address these issues and explore more possibilities of Cu-MOF-based chemodynamic therapy in the treatment of tumors.

Cu-MOF-based chemodynamic therapy has a huge application landscape in the treatment of tumors. With deeper research and technological advancement, we expect that this therapeutic approach will play a greater role in future clinical practice and bring better therapeutic experience and results to tumor patients.

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