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Photothermal Conversion for Antibacterial Application

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Abstract

Antibiotics have been used in medical treatment for about a century, but with the overuse of antibiotics comes the emergence of drug-resistant bacteria, which can lead to water contamination, wound infection, and seriously affect human health. Therefore, it is urgent to develop a fast and efficient antibacterial material; Photothermal conversion is considered an effective technology to be employed in antibiotics, including wound infection and water treatment. Converting light energy into heat energy is also an efficient sterilization method. In view of the above problems, this review focuses on photothermal materials and briefly describes the application of photothermal materials such as antibacterial, water treatment, etc. In addition, we also outline the principle of photothermal materials sterilization, and how to improve the photothermal conversion efficiency of photothermal materials.

Keywords: Photothermal conversion; Photothermal materials; Antibacterial

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Photothermal conversion is a very common phenomenon but it can be applied in many fields, such as solar-driven desalination, power generation, photothermal therapy and so on [1-4]. For our healthy, photothermal therapy for killing cancer or tumor cells is emphasized and the materials for photothermal therapy have attracted lots of attention in the past decades. However, photothermal materials are used more widely in other biological fields such as wasted water treatment by removing heavy cations or killing bacteria. The applications bring new paths to obtain fresh or healthy water and new chances for poor areas.

Antibacterial is considered an important issue for our healthy lives and abusing antibiotics results in various problems. Therefore, new strategies for antibacterial with low cost were expected to be employed on large scale and photothermal materials are the candidates for the new antibacterial strategies, such as drinking water treatment and the treatment of wound infections. Employing photothermal conversion for antibacterial to treat drinking water is viewed as a cheap way to obtain fresh water. Zhao et al. [5] prepared AgBP2-Ag_2S quantum dots for antibacterial in a near-infrared II (NIR) window. They found that the antibacterial efficiency resulted from the photogenerated $\cdot O_2^-$ and h^+, but the photothermal effect enhanced the disinfection [5]. The study paves a new way for constructing photothermal agents for rapid disinfection which is expected to be used in antibacterial and water disinfection. MXenes are known as the important materials used in catalysis, and energy storage and meanwhile they also are widely used in antibacterial [2,6]. MXenes have high light absorption and fast thermal transport so that the heat generated from the photothermal conversion on MXenes can destroy the component of bacteria and consequently inhibits bacterial growth. Zhou and his coworkers constructed MXene composite hydrogel scaffolds via 3D printing and they found that the MXene composite inhibited the bacteria by destroying the membrane under the NIR irradiation [7]. The photothermal conversion for antibacterial also could be used by

combining photothermal therapy for would treatment [8,9]. Xing et al. [9] used polyvinyl alcohol/carbonized polymer dots (PVA/CPDs) hydrogel to enhance the synergy of inherent cationic antibacterial action and NIR-assisted photothermal therapy [9]. Their results show that 2% PVA@CPDs could eradicate both *S. aureus* and *E. coli* quickly and effectively, which hints at the great chance of photothermal conversion for antibacterial.

Although the photothermal materials were designed and prepared with some special structure in different fields, their photothermal conversion efficiencies depend on the speed of photons transforming into heat. Therefore, it is a key point how to construct the special structures to promote the speed by transforming phonons into thermal, including regulating the electron structure of photothermal materials. In the recently employed photothermal materials, such as metal, carbon-based materials, semiconductors, polymers and their composites or heterostructure, their electron behaviors and chemical bonding would affect the photothermal capacity.

In summary, photothermal conversion for antibacterial applications is expected to bring new chances in wound infection treatment or drinking water treatment and how to accelerate the process of photothermal conversion should be emphasized to expand the applications.

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