Antibacterial applications of graphene oxides

(*Nanowerk News*) Bacterial infections have been considered as one of the greatest threats to human health. However, due to the increasing spread of multidrug-resistant bacteria, the current antibiotic reservoir appears to be insufficient, thereby necessitating the exploration of novel antibacterial agents.

Nano-antibacterial agents represent a novel strategy for bacterial killing. Compared with antibiotics, nano-antibacterial agents have the following two advantages: i) broad-spectrum bactericidal effects against Gram-positive and Gram-negative bacteria and ii) long-lasting bactericidal effects on the prevention of bacterial growth due to their extraordinary stability.

Significant differences exist in the antibacterial mechanisms between antibiotics and nano-antibacterial agents. Antibiotics can prevent bacterial growth by inhibiting the synthesis of target biomolecules in bacteria, including cell wall, DNA, and proteins. However, nano-antibacterial agents can kill bacteria through the mechanisms of membrane destruction and oxidative stress response and by the interactions with cytosolic molecules (lipid, proteins, DNA, etc.).

Graphene oxide (GO) has attracted extensive attention in several research fields, especially in antibacterial applications.

A review, which was published as cover article of *Science Bulletin* ("Antibacterial Applications of Graphene Oxides: Structure-Activity Relationships, Molecular Initiating Events and Biosafety"), primarily discussed about the structure-activity relationships (SARs) involved in GO-induced bacterial killing, the molecular initiating events (MIEs), and the biosafety of antibacterial applications.

The corresponding authors are Ruibin Li from the School for Radiation Medicine & Interdisciplinary Sciences in Soochow University and Lingwen Zeng from Guangzhou Institute of Biomedicine and Health in the Chinese Academy of Sciences. GO possesses a unique two-dimensional (2D) honeycombed hydrophobic plane structure and hydrophilic groups, including carboxylic (-COOH) and hydroxyl (-OH) groups on its edge, which determine its excellent antibacterial activity.

Among these antibacterial mechanisms, this review summarized the interactions between GO and bacterial membrane, especially the significant role of MIEs, including redox reaction with biomolecules, mechanical destruction of membranes, and catalysis of extracellular metabolites.

The review also discussed in detail about the physicochemical effect of GO on the bacterial membrane, such as phospholipid peroxidation, insertion, wrapping and trapping effect, lipid extraction, and free radicals induced by GO.

Furthermore, this review not only discussed about the effect of size, shape, and surface functionality on the antibacterial activity to elaborate the SARs but also summarized the antibacterial nanoproducts that can be used for biomedical, environmental, and food engineering applications.

Emphasis was also made on the biosafety of GO when used in the biomedical field, considering that direct exposure of GO-based antibacterial agents to human cells may induce undesirable hazardous effects. Therefore, we must pay close attention to the leakage and release of GO into blood while using GO-coated biomedical devices.

Finally, the review has put forward the future perspective and mentioned the challenges of using GO as a novel nano-antibacterial agent, such as understanding the interactions occurring at GO-bacteria interfaces, the exploration of GO-based nanocomposites to achieve synergistic antibacterial effects, and the immobilization of GO for antibacterial use.

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