

Designing Antibiotics-Free Novel Biomaterials That Combat Bacterial Infections

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Abstract

The novel antimicrobial concept “bacteria starvation therapy” is developed to empower extraction of extracellular electrons from bacterial membrane respiration chain and interruption of energy metabolism of bacteria. The antimicrobial behaviours of large-area graphene film on Cu conductor, Ge semiconductor and SiO₂ insulator show a strong dependence on the band structure of substrate, in the order of graphene-Cu > graphene-Ge > graphene-SiO₂. [1] Moreover, increase of electrical conductivity of graphene-Ge heterojunction by improving graphene crystallinity can enhance the antimicrobial ability. [2] To further verify the antimicrobial correlation with band structure, cobalt doped TiO₂ coatings are designed with tunable bandgap (3.10 eV to 1.55 eV) and the results reveal that narrowing TiO₂ bandgap can remarkably boost the antimicrobial capacity. [3] Recently, through in-situ oxidation of Ti₃C₂T_x MXene, TiO₂-Ti₃C₂T_x heterojunction is fabricated to tailor the band structure (Figure 1). Under light irradiation, the heterojunction can exhibit favourable antibacterial activity. In summary, semiconductor-based materials with tailored band structure are able to act as extracellular electron acceptors, which can disturb the electron transfer and energy metabolism of bacteria, thereby leading to bacteria starvation and death. The “bacteria starvation therapy” can provide new insight into the interactions between bacteria and 2D materials and contribute to the design of novel antimicrobial agents based on 2D nanomaterials.

REFERENCES

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FIGURES

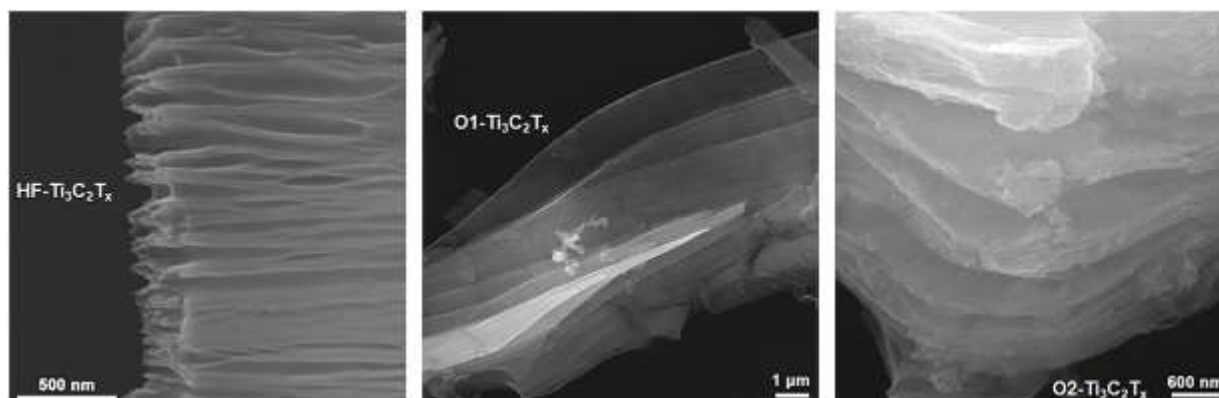


Figure 1: SEM images of pristine Ti₃C₂T_x MXene sample (left) and different oxidation degrees of TiO₂-Ti₃C₂T_x heterojunction samples including lightly oxidized O1-Ti₃C₂T_x (middle) and heavily oxidized O2-Ti₃C₂T_x (right).