Antimicrobial properties of sulphur-enriched, hydrophilic MoS_2 nano/microparticles and heterostructured Pd/MoS_2/Ti coatings

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Recently, graphene-like two-dimensional molybdenum disulphide-based nanomaterials, especially their single or few-layered forms, usually named nanosheets (MoS_2-ns) or nanoknifes, have received considerable attention as a promising antimicrobial agent. However, most previous studies indicate that without functionalization with other antimicrobial agents such as Ag, Ti_3C_2MXene, graphene oxide (GO) [1, 2], etc., the antimicrobial efficiency of MoS_2 is low and needs further improvements. In this study, the MoS_2-based nano/microparticles and coatings were synthesized through a simple, one-step hydrothermal approach without any other additives. The fabricated materials exhibited relatively small ($\Delta\theta = 18.7 \pm 2.5^{o}$) contact angle, resulting in their prominent hydrophilic properties, possibly caused due to sulphur-enriched MoS_2 composite as evidenced by TG/DTA–MS analysis. Such nanostructures can exhibit a better adhesion of biomolecules, thus facilitating the interaction between them, as confirmed by highly effective antimicrobial action (Fig.1). The present study examines the antimicrobial properties of hydrophilic, sulphur-enriched MoS_2 nano/microparticles as well as MoS_2-based coatings against various humans' pathogenic bacteria such as *Salmonella enterica*, *Pseudomonas aeruginosa*, *Escherichia coli*, *Staphylococcus aureus* (MRSA), *Micrococcus luteus*, and two *Candida* fungi, in particular *C. parapsilosis*, *C. krusei*. The MoS_2-ns (40 μg mL^{-1}) showed over 90 % killing efficiency against *S. aureus* MRSA bacteria and two *Candida* fungi within 24 h of exposure. Surprisingly, the petal-like MoS_2 microstructures and heterostructured MoS_2/Ti and Pd/MoS_2/Ti coatings also possess high antimicrobial potency and could be considered a promising antimicrobial agent and thus deserve further studies. The MoS_2-induced intracellular reactive oxygen species (ROS) production was evidenced by measuring the standard DCF dye fluorescence.

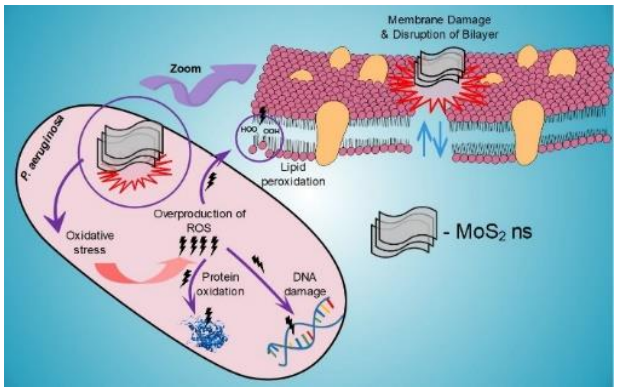

Fig. 1. Schematic illustration of various MoS_2 nanosheets antimicrobial pathways.

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References

1. S. Pandit, S. Karunakaran, S.K. Boda, B. Basu, M. De, ACS Appl. Mater. Interfaces. **8** (2016) 31567.
2. M. Zhu, X. Liu, L. Tan, Z. Cui, Y. Liang, Z. Li, K.W.K. Yeung, S. Wu, J. Hazard. Mater. **383** (2020) 121122.