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Antimicrobial nanobiomaterials for scaffolds and medical devices

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Tissue engineering and medical implants hold great potential to restore lost tissue functions in the human body. In tissue engineering, biomaterial constructs may play many important roles, including providing space for tissue growth, acting as scaffolding for cell attachment and migration, mimicking native tissue microenvironments and delivering bioactive signals. However, one significant challenge in using biomaterials in the body is the potential for formation of drug-resistant infections and biofilms on implant surfaces, which lead to device failures, multi-billion dollar costs to the health system and adversely affect the lives of millions of patients. Antimicrobial inorganic nanomaterials are an attractive alternative to antibiotic drugs as they can attack microbes via multiple mechanisms, limiting the microbes' ability to develop resistance. We have thus investigated the potential of selenium nanoparticles as antibacterial biomaterials with much lower cytotoxicity than the commonly used silver nanoparticles. The nanoparticles' antibacterial properties depend strongly on their size, and an optimal size range exists for low cytotoxicity and strong antibacterial properties. Hydrogel scaffolds with tailored interconnected porous architectures and mechanical properties are produced through combinations of gas foaming and thermally induced phase separation. Scaffolds decorated by in situ selenium nanoparticle formation from solution impact both Gram-positive (drug sensitive and drug resistant) and Gram-negative bacteria, causing cell damage including membrane permeabilisation. Selenium-based nanomaterials are shown to be promising agents for a range of antibacterial biomaterial applications, including in chitosan scaffolds, which show potential as scaffolds to aid wound healing.

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