Antibacterial synthetic polymers

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The increasing occurrence of microbial infections has stimulated the development of new antibacterial materials for medical applications. The challenge is to develop novel medical polymers that have an intrinsic antibacterial functionality. In the design of innovative materials, scientists are increasing taking inspiration by Nature, developing biomimetic polymers, which contain building blocks that mimes part or whole natural antibacterial materials. To this aim, the development of different polymers, which mimic respectively honey and antimicrobial peptides have been explored in the Hymedpoly project.

A honey-like hydrogel was prepared via thiol-ene click chemistry of hyperbranched polyethylene glycol diacrylate (HB-PEGDA, 10 w/w%) and thiolated hyaluronic acid (HA-SH). The hydrogel produced antibacterial reactive oxygen species (ROS) in the form of hydrogen peroxide (H2O2), through the two components found in honey: glucose oxidase (GO) enzyme within HB PEGDA and glucose (G) in HA-SH. The hydrogel was able to produce 9.11 mmol H2O2 ROS after 24 hours with 250 U/L GO and 25 g/L G. This concentration demonstrated zone of inhibition as a measure of antibacterial activity against several bacterial strands. An electrospun polyurethane patch was prepared and surface modified with polydopamine for the immobilization of GO enzyme, to be used in combination with the above-described hydrogel.

Antimicrobial peptides (AMPs) are essential components of immune system forming the first line of defense against pathogenic bacteria[1]. AMPs consist of amphipathic structures in which clusters of hydrophobic and hydrophilic amino acids segregate, enables them in selective disruption of the bacterial cytoplasmic membrane[1]. In order to mimick the structural organization of AMPs, a novel polyurethane grafted polyionic liquid based patchy colloidal particles was developed. A hydrophobic liquid monomer was grafted from the polyurethane backbone by redox initiated aqueous heterophase polymerization. Subsequently, the hydrophobic anion was exchanged with a hydrophilic one. Chemical structure was elucidated by NMR analysis. Cryo-TEM images confirmed the formation of patchy colloidal particles consisting of the self-organized mesophases. The strong bactericidal effect is summarised in table 1.

Table 1. MIC and MBC values among non- and resistant Gram-positive bacteria.

Most relevant clinical Gram-positive bacterial strains in chronic wounds and medical device-related infections	Polyurethane-based Patchy Colloidal Particles (μg/mL)	
	MIC	MBC
Staphylococcus aureus ATCC 29213	10.4 ± 3.7	10.4 ± 3.7
Methicillin-Resistant Staphylococcus aureus (MRSA)	13 ± 3.7	13 ± 3.7
Staphylococcus epidermidis ATCC 12228	6.5 ± 1.8	6.5 ± 1.8
Macrolide-lincosamide-streptogramin B resistance in Methicillin Resistant *Staphylococcus epidermidis* (MRSE)	13 ± 3.7	18.2 ± 9.7
Enterococcus faecalis ATCC 29212	31.2 ± 0	46.85 ± 15.6
Vancomycin - resistant enterococci (VRE)	31.2 ± 0	62.5 ± 0

1. M. Zasloff, Nature, 415, 389-395,2002

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