Nature-inspired biomaterials: from interactive coatings to granular hydrogels exhibiting specific interactions with living matter

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Biointerfaces play a key role in regulating and controlling cell-biomaterial interactions. Uncontrolled protein adsorption and cell adhesion to biomaterial surfaces can lead to adverse outcomes such as inflammatory responses, harmful immune reactions, infections, and even implant failure. A fundamental strategy to mitigate non-specific and potentially harmful interactions is to introduce selectivity at the interface. A cornerstone for this is to be able to confer the interface with a cloak of invisibility to which specific molecules can be tagged. [1] In this talk, I will first introduce our concept of the Kill&Repel coating strategy.[2] This coating system combines the synergistic action of antifouling polymer brushes assembled in situ with a bacteriophage-inspired bacteria killing mechanism. As a result, this coating specifically kills bacteria with a low risk of resistance development, while remaining completely harmless to human cells. When the coating was applied to wound dressings, it was able to specifically eradicate antibiotic resistant bacteria such as *S. agalactiae*, *S. epidermisdis*, *S. aureus* and MRSA in a simulated infection. These dressings also showed unique resistance to cellular debris adhesion, indicating a self-cleaning mechanism with inexhaustible antimicrobial activity. In the second part of my talk, I will present our latest advances on the design of stealth granular hydrogels for wound regeneration. These granular hydrogels are composed of jammed microgels based on zwitterionic poly(carboxybetaine) polymers, which renders them superhydrophilic, non-immunogenic and resistant to protein fouling. We prepared a diverse set of microgels in the scale of 60-300 µm using different fabrication techniques - batch emulsion, microfluidics, and mechanical extrusion fragmentation. Furthermore, we achieved microgels with storage moduli ranging from ~10-10,000 Pa, which span the stiffness regime of mammalian soft tissue and cartilage. The microgels were cross-linked by covalent and reversible non-covalent linkages to form interconnected porous (~8-30%) granular hydrogels that allow cell migration and proliferation, both of which are essential for wound regeneration.
We envision that our work may contribute to the next generation of specific cell-instructive biomaterials capable of directing cell behavior in a superior-manner.

References

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Figures

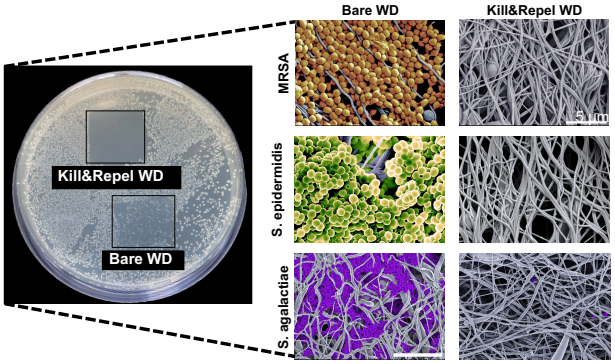

Figure 1. Kill&Repel coating was able to completely eradicate bacteria and prohibiting adhesion of residues.

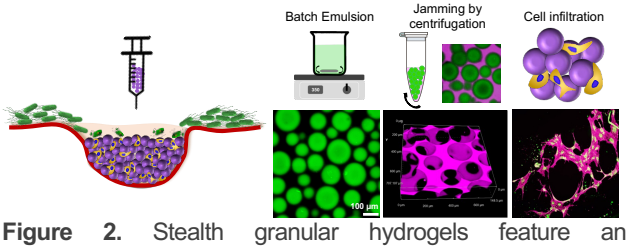

Figure 2. Stealth granular hydrogels feature an interconnected porous network that allows for cell migration, proliferation and mass transport. They also have shear-thinning and self-healing properties that make them ideal for injection, extrusion and 3D printing applications, enabling constructs that better mimic the complexity and heterogeneity of native tissues.