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Nucleic Acid–Mineral Interactions: Implications for Bone Regeneration

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Nucleic acid–mineral interactions, observed in various natural environments, are increasingly recognized for their role in molecular preservation and geobiological processes1–3. These interactions offer a promising avenue for biomedical applications, particularly in the design of biomaterials for regenerative medicine.

In this study, the adsorption mechanisms of therapeutic oligonucleotides on biomimetic apatite, a calcium phosphate material analogous to native bone mineral4, were investigated. A broad panel of oligonucleotides with diverse chemistries was examined.

Employing adsorption methods, and surface characterization, the aim was to elucidate the key physicochemical parameters that govern nucleic acid interaction to mineral substrates. The results reveal that the backbone chemistry of the oligonucleotide sequences exhibit enhanced affinity for apatite surfaces compared to other chemical modifications such as lipid moieties5 . This could lead to improved molecular stability and preserved biological activity.

To translate these insights into practical applications, a physicochemical study on an antibacterial phosphocalcic cement formulation was set up. This cement integrates both antibiotics and oligonucleotides to achieve localized antimicrobial activity while simultaneously promoting osteogenesis. The formulation is designed to address the two challenges of infection control and bone reconstruction in orthopedic and maxillofacial applications6. Moreover, in light of increasing antibiotic resistance, the use of oligonucleotides, able to target the precise resistance of a bacteria in addition with conventional antimicrobials, offers a promising strategy to reduce the required antibiotic dose and mitigate resistance development7. Preliminary results showed a significant impact of the oligonucleotide on the cement microstructure and setting time.

Overall, this work not only enhances the fundamental understanding of nucleic acid–mineral interactions but also demonstrates their potential in engineering advanced biomaterials for regenerative medicine.

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