Engineering size-controlled amorphous magnesium calcium phosphate nanoparticles via molecular and polymeric stabilization for drug delivery applications

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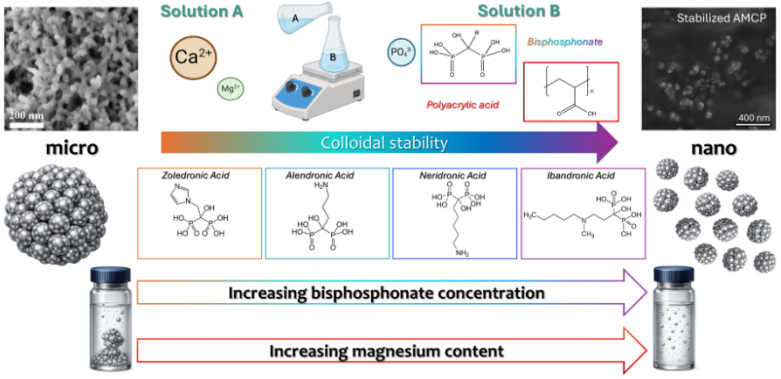
Calcium phosphate particles are attractive materials for biomedical applications because of their biocompatibility, pH-responsive behavior, and compositional similarity to mineralized tissues [1]. However, controlling particle size, colloidal stability, and crystallinity remains a major challenge, especially when targeting amorphous magnesium calcium phosphate (AMCP)-based systems, which tend to aggregate and evolve toward more crystalline phases. To address this bottleneck, we developed a molecular and polymeric stabilization route to engineer AMCP-based nanometric particles by acting directly on nucleation and early growth, where size and phase evolution are determined. Molecular or polymeric stabilizers enable fine control over both colloidal behaviour and amorphous-phase persistence. In this framework, bisphosphonates bind calcium species in solution and interact with the forming calcium phosphate clusters, regulating growth pathways and shifting the resulting particle size distributions. Beyond size control, this systematic study shows that colloidal stability can be tuned as a function of bisphosphonate chain length, identifying molecular architecture as a practical design parameter. Polyacrylate provides a complementary strategy by strongly limiting irreversible clustering and yielding AMCP-based dispersions with excellent redispersibility upon handling and storage [2]. Particle dimensions can be further adjusted through composition: varying magnesium content offers an additional, independent strategy to regulate the size of the obtained particles. To link stabilizer chemistry to particle properties, the systems were investigated through a multi-technique workflow, combining dynamic light scattering (size in suspension), electron microscopy (morphology), X-ray diffraction together with IR spectroscopy (phase/crystallinity), and thermal analysis (amorphous-to-crystalline conversion). Overall, these results outline a simple and experimentally grounded approach to obtain AMCP-based sub-micron particles with tunable size and controllable stability, supporting their development as formulation-ready platforms for nanomedicine.

Keywords:
Amorphous magnesium calcium phosphate, bisphosphonates, polyacrylate, stability, particle size control



Graphical overview of the molecular and polymeric stabilization strategy for AMCP particles, highlighting the role of bisphosphonates, polyacrylate, and magnesium content in controlling particle size and colloidal stability.

References:

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