Biomimetic Mineralization of Acid Polysaccharide-based Hydrogels: Inspiration from Recent Findings about Organic/mineral Interface in Bone

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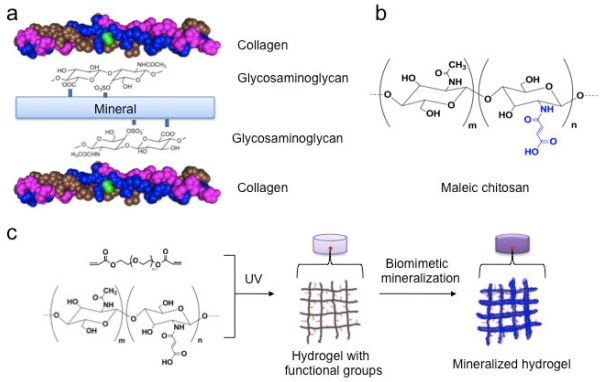
Introduction. Natural bone is an advanced composite material, comprising approximately 70% mineral and 30% organics by dry weight. The organics contain both proteins and polysaccharides, with the former being the focus of most studies and theories of bone biomineralization. The relative negligence of polysaccharides in favor of proteins has also directed the research efforts of using proteins to develop biomimetic bone-like composites.

Inspired by recent bone biomineralization discovery that glycosaminoglycans (GAGs) are intimately associated with mineral phase in bone,[1] (Scheme 1a), we report the use of maleic chitosan/PEGDA hybrid hydrogels for *in vitro* growth of carbonated apatite. We integrated maleic chitosan as a functional acidic polysaccharide within hydrogel networks, and hypothesized that the polysaccharide might mediate interactions between mineral and hydrogel surfaces, thus control both porosity and properties of the composites. Our study suggests that the mineralized hydrogel composites may serve as new scaffolds for bone engineering.

Materials & Methods. Maleic chitosan (scheme 1b), was synthesized using an previous approach.[2] Maleic chitosan-PEGDA hybrid hydrogels were prepared via photopolymerization.[2] Mineralization of maleic chitosan/PEGDA hydrogel discs were carried out in a modified simulated body fluid (SBF).



Scheme. 1. Recapitulating the synthesis of bone-like composites via a biomimetic strategy (a) Cartoon shows the predominance of polysaccharide s at the organic-mineral interface in bone (reproduced from Reference 1); (b) Structure of maleic chitosan. (c) Pathway to produce biomimetic bone-like composites.

Results & Discussion. To produce bone-like composites, hydrogels were first fabricated via photo-crosslinking, followed by biomimetic mineralization (Scheme 1 c). The transparent hydrogel before mineralization always showed interconnected porous intererior structures (Fig. 1a-1c). After mineralization, the hydrogel became opaque but still maintained a porous structure (Fig. 1d-1f). The average pore size significantly decreased due to mineral deposition onto pore walls (Fig. 1e and 1f). XRD and FTIR confirmed that mineral phase after 17 days was crystalline calcium-deficient apatite (with Ca/P ratio = 1.40 determined by EDX). However, mineral phase collected at 3-day is of spherulitic amorphous feature, as confirmed by TEM and SAED (data not shown). Mineral weight percentage increased with mineralization time. These results suggest polysacchrides can mediate mineral deposition and crystallinity within hydrogel networks and allow good interfacial interactions between organic and mineral phases.

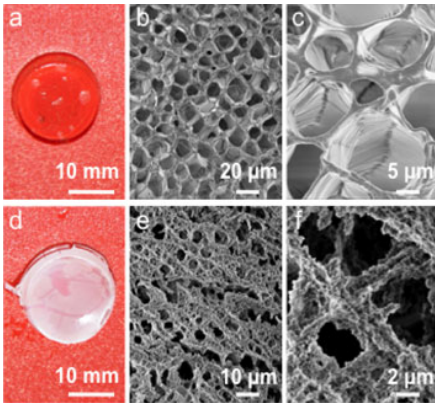


Fig 1. Hydrogel before (a-c) and after 17-day mineralization (d-f): (a) Optical image, (b-c) SEM images, c is an magnified image from b; (d) Optical image of hydrogel after mineralization (e-f) SEM images of mineralized hydrogel, f is magnified images from e.

Conclusion. Using an acidic polysaccharide hydrogel as an template coupled with biomimetic mineralization, we can produce porous bone-like composites with controlled mineral amounts and crystallinity. These studies suggest that acidic polysaccharides may be the excellent biomaterial scaffolds for the design of new useful bone-like biocomposites. Findings from this study may provide new insights into the roles of acidic polysaccharides in bone biomineralization.

References

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Abstract #370