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Modification of collagen with proanthocyanidins by mimicking the bridging role of glycosaminoglycans for dentine remineralization

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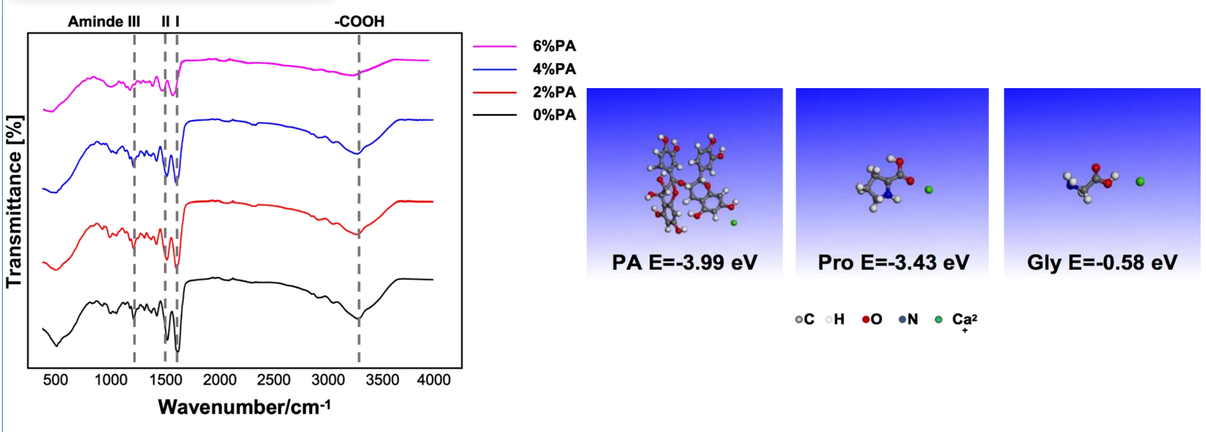
Objective

The aim of this study was to mimic the excellent bioactivities of glycosaminoglycan (GAG) by applying the natural product - proanthocyanidins (PA). At the same time, PA was used to synergistically combine with biomimetic remineralization strategies to enhance the remineralization effect on demineralized dentine. In addition, the inhibitory effect of PA on the main cariogenic bacteria was also evaluated in this study.

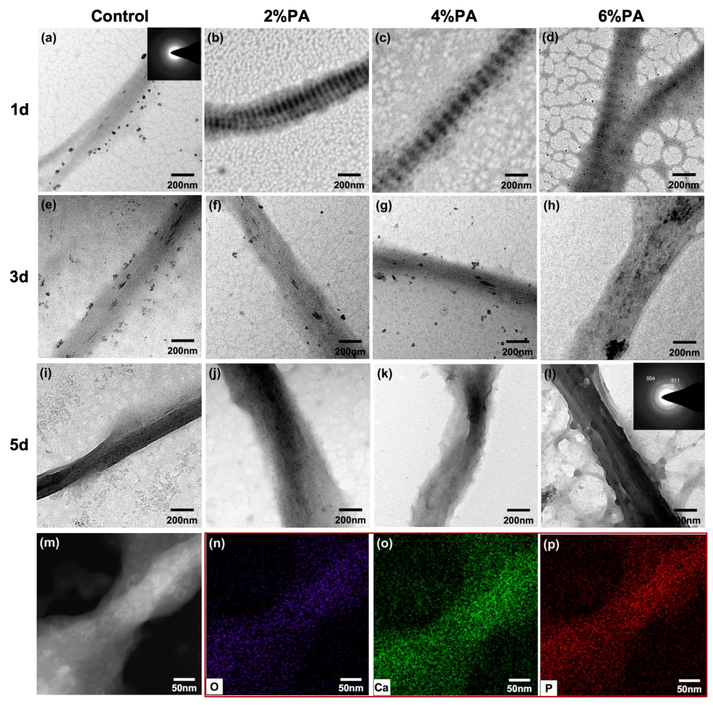
Method

The interfibrillar bridges formed by was verified by fourier transform infrared spectra. High-resolution transmission and scanning electron microscopy were used to evaluate the effect of PA in conjunction with carboxymethyl chitosan/amorphous calcium phosphate (CMC/ACP), a biomimetic mineralization agent, on the collagen mineralization and dentine restoration. The inhibitory effects of PA on various cariogenic bacteria were evaluated by anti-adhesion and anti-biofilm studies. Finally, an animal model of caries was established to evaluate the antibacterial and remineralizing effects of PA in combination with biomimetic remineralizing agents.

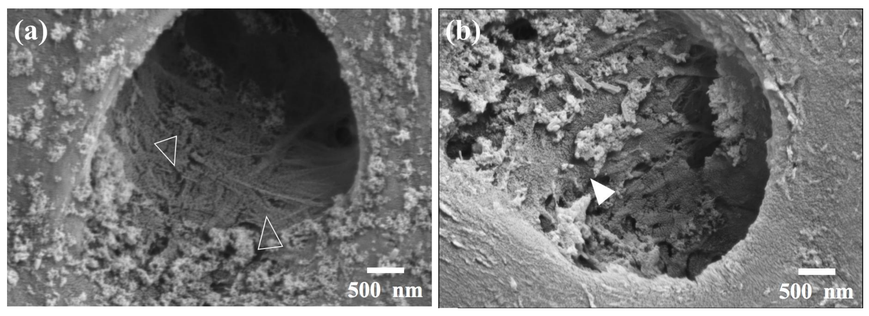
Result



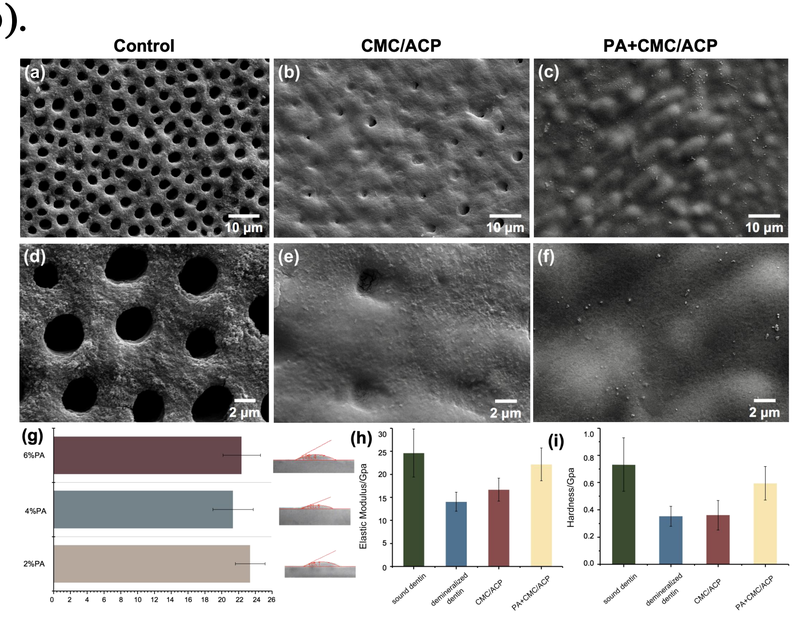
✦PA can act as a GAG analogue to form a bridging structure between fibrils and effectively reduce the bonding energy of inorganic ions.



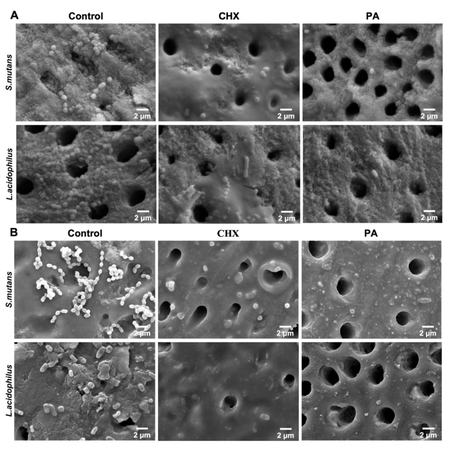
✦PA reduced the interfacial energy between the mineral-organic phases to enhance collagen hydrophilicity, subsequently facilitating the infiltration of calcium phosphate precursors and hence promoting collagen mineralization.

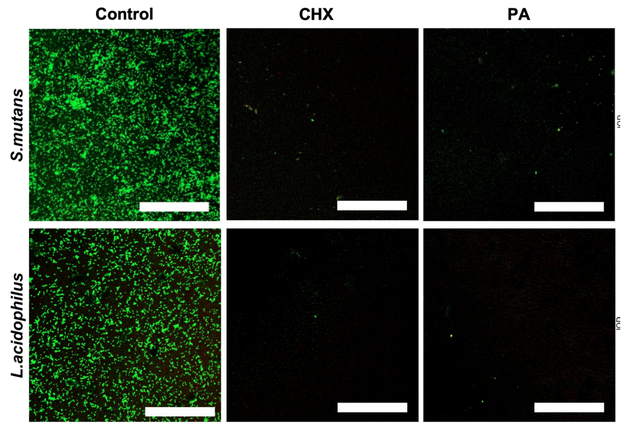


✦ PA can rebuild collapsed collagen networks by forming interfibrillar bridges (a), providing a stable template for subsequent mineral ion deposition (b).

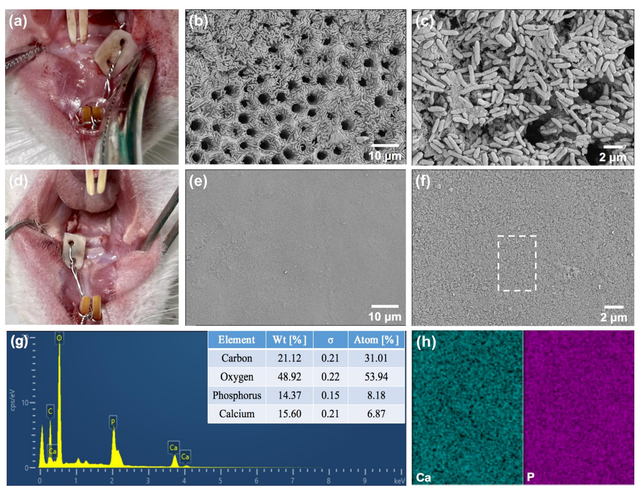


✦The combination of PA and CMC/ACP effectively promoted dentine remineralization, improving the mechanical properties close to those of natural dentin.





✦The anti-bacterial effect of PA was comparable to that of chlorhexidine, reaching more than 95% ($p < 0.05$).



✦In *ex vivo* studies, PA and CMC/ACP can form a remineralization barrier on dentine surface, effectively blocking bacterial invasion into the deeper dentinal tissues

Conclusion

This strategy highlights the importance of maintaining the structural integrity of the collagen network in dentine remineralization and offers great clinical potential for the effective treatment of dentine caries.