Biomimetic formation of hexagonal prism-like vaterite and relevance to biomineralization

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Biomineralization is a common phenomenon in nature. Living organisms can employ some of biological/organic macromolecules to produce crystals with one special mineral type and a uniform morphology at the particular tissue sites. At present, an accepted consensus is that polyanionic macromolecules, such as proteins, can induce the nucleation of the special polymorph and the uniform morphogenesis of biogenic minerals with their carboxylate, sulfate and/or sulfonic groups, phosphate. Vaterite, the least stable polymorph of $CaCO_3$, has been of great interest because its crystallization and stabilization are strongly associated with biological activities. Therefore, investigating the effect of structure-specific organic/biological model additives on crystallization and morphogenesis of vaterite is important to understanding both the unique morphogenesis and the biomineralization mechanism. Here, the biomimetic growth of $CaCO_3$ was carried out by a CO_2 gas diffusion technique, and sodium citrate (SC) with three carboxyl groups and sodium dodecyl benzene sulfonate (SDBS) with a headgroup of sulfonic group were selected as model additives to influence the crystallization and growth of $CaCO_3$. Our results show that the well-defined hexagonal prism-like vaterite mesocrystals can be achieved in the presence of SC and SDBS. However, no the hexagonal prisms of vaterite can be produced only with sodium citrate or SDBS, indicating that the synergistic interactions between SC and SDBS control the formation of the prism-like vaterite mesocrystals. Because of the remarkable resemblance of the vaterite prism-like mesocrystals to the nacreous layers of vatreite in freshwater cultured pearls or to the columns/lamellae of vaterite in bivalve, current study of biomimetic mineralization may prove useful for a deeper insight into the biomineralization of vaterite.