Formation of silica in biomineral-like structures and implication for biosilicification

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The cellular events leading to silica deposition in diatoms have been extensively studied from various aspects including silicification condition, silicified area, assembling process, structural feature and formation mechanism. However, there are many other complex phenomena in biosilicification, which produce intricate structures at small length scales and exceed the capabilities of updated materials engineering. Macroporous sieve plate is an important characteristic of valve structure in diatoms. It has been proposed that the involvement of organic components possessing anionic and hydroxyl groups is likely to be responsible for the generation of macroporous biosilica. Here, two kinds of opposite-charged surfactants and L-tartrate with anionic carboxy and hydroxyl groups were selected as model regulators to mimic silicification of silica. The results show that the silica plates with through-hole structures, which are the excellent counterpart of biosilica sieve plates, can be formed by a multistep assembly from 0D particles through 1D ropes to 2D sieve plates. The catanionic surfactants act as a template of the plate-like silicious structures, whereas L-tartrate can exactly control the formation of the macroporous structures. It must be highlighted that hydrogen bonding between silanol and hydroxyl group from tartrate can lead to the incorporation/adsorption of tartrate molecules on the silica structures, and thus negatively charged COO^- are introduced to the silica surfaces passively. During the formation of the sieve plate structures, tartrate exerts two seemingly contradictory capabilities: the effective connection of adjacent silica structures through H-bonding and the moderate separation of adjacent structures through electrostatic repulsion. It appears that hydroxyl and anionic groups incorporated in one organic/biological molecule play a crucial role in the formation of silica sieve plates. In this regard, our results may provide a deeper insight into biosilicification mechanism.