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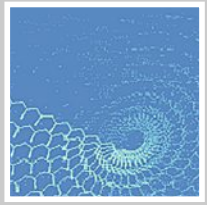

Polymer and Colloid Highlights

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Diatoms Knit together Biopolymers and Silica

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Diatoms are single-celled organisms with a cell wall made of amorphous silica, called the frustule. The silica structure is formed at ambient conditions, using photosynthesis as the cell's energy source. The frustule has an intricate multi-scale pattern of pores. It is formed by co-precipitating silica with biopolymers (Fig. 1A), such as frustulins, pleuralins, silaffins and long-chain polyamines;[1] the exact composition is species-dependent.[2] Some diatoms have been shown to also contain chitin.[3] There is evidence that the presence of polymers can either accelerate or inhibit silic acid precipitation.[4] Biopolymers could provide control over silica deposition in the cell, however, the mechanism of morphogenesis of the intricate patterns of pores remains unclear.

It has been proposed that the frustule pattern is templated by phase-separated protein droplets.[5] To date there is no direct evidence of templating in living cells. In our recent work, we used a top-down approach to investigate whether self-assembly could produce micro-patterns similar to those observed in *Coscinodiscus granii*.

We analyzed the flat central part of the C. granii valve[6] (Fig. 1B). The micro-pores are arranged in an unusual radially aligned hexagonal crystal. Even though the structure is flat, there are defect pairs of pores with 5 and 7 neighbours (Fig. 1C) scattered around the structure. Through simulations, we show that diatom-like patterns can be achieved by introducing a radial alignment to a system of diffusive and repulsive particles, which could assemble to template the silica structure. To make sense of the defect distribution in the structure we turn to crocheting, a yarn art, where rows of stitches loop into each other to make up a crystalline arrangement. In order for a circular crochet to stay flat (Fig. 1C), each row requires the right number of additional stitches (defects). The number of necessary defects depends on the radius of the row, leading to a linear defect insertion rate. This geometrical argument also holds for the diatom (Fig. 1D). Regardless of the origin of the radial alignment, it frustrates the crystal and leads to defect insertion.

The next step to deciphering the valve formation process is live-cell imaging. Observing diatom cells during division will give further insight into the cell wall formation process. Understanding diatom frustule formation could lead to a low-energy way of making patterned amorphous silica materials. Such materials could be used as physical and optical filters.

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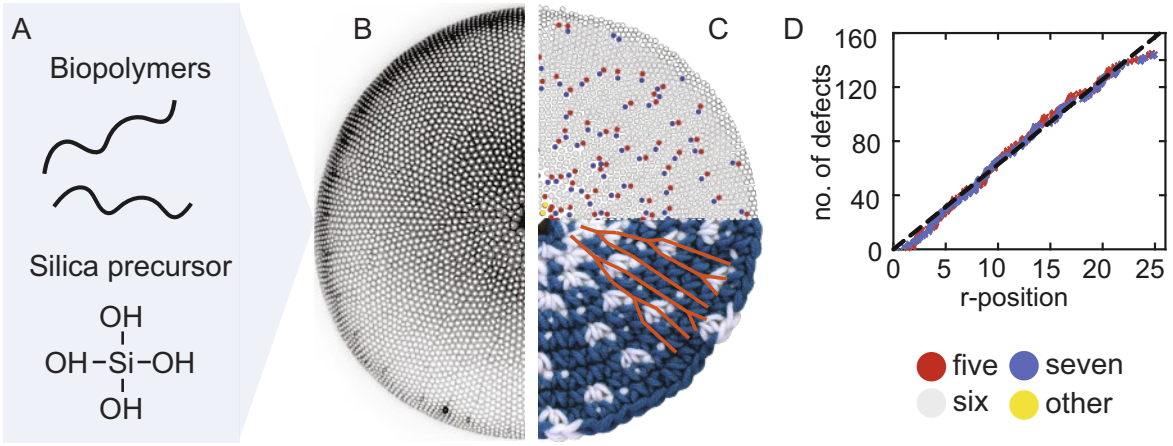

Fig. 1. A: The diatom cell wall is made up of silica and biopolymers. B: A confocal stack projection of a *Coscinodiscus granii* valve. C: (top) Located pores, color-coded by number of neighbors; (bottom) a flat crochet circle with single stitches made with blue and double stitches with white yarn. Orange radial lines drawn to highlight radial alignment. D: Cumulative number of defects plotted against the radius for 5 and 7 connected defects.

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