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Silica biomineralization in the palm tree *Syagrus coronata* (Mart.) Becc.: structure, morphology and composition of silicon biocomposites

Claudia Franca Barros[1], Maura da Cunha[2], Flávio Costa Miguens[2], Ulysses Lins[3*]

[1]Jardim Botânico do Rio de Janeiro, Rio de Janeiro, RJ, Brasil.
[2]Universidade Estadual do Norte Fluminense, Campos dos Goytacazes, RJ, Brasil.
[3]Instituto de Microbiologia Professor Paulo de Góes, Universidade Federal do Rio de Janeiro, 21941-590, Rio de Janeiro, RJ, Brasil. e-mail: ulins@micro.ufrj.br

The formation of biominerals typically involves the deposition of specific inorganic minerals on or in an organic matrix in a highly controlled manner. These biomineralization processes are collectively known as biologically controlled mineralization. Control over biomineralization is one of the most striking features of biological organisms and the complexity of biomineralized structures suggests the potential of organic constituents to control energetic factors during biomineral synthesis. The presence of organic matter in biominerals can precisely direct the organization of the inorganic parts during the synthesis of a biomineral composite or a biocomposite. Thus, understanding the structural and elemental organization of a biocomposite is crucial for understanding their biophysical properties, rate of growth and stabilization. One remarkable example of biomineral is the amorphous mineral silica. Silica is the most common amorphous mineral and has a general formula $[SiO_{2n/2}(OH)_{4-n}]_m$ where n = 0-4 and m is a large number [1]. Many organisms contain the amorphous hydrate silica as intricate structures. In some plants, amorphous silicon oxide inclusions known as phytoliths are abundant in leaves and internodes. Phytoliths fill the entire lumen of the silica cells or trichomes or may be part of the outer epidermal cell walls. Most plants do not accumulate silica in large amounts, although silicon is a major inorganic constituent in plant cells. Some plants, however, absorb silicon from soil as silicic acid $[Si(OH)_4]$ and accumulate it as silica in the epidermis preferentially. The nature of plant silica and the distribution of silica bodies in different plant families are well documented [2].

Syagrus coronata is an economically important palm tree grown as an ornament, for the oil extracted from its seeds, and the wax from its leaves which has several applications in industry. Silica biocomposites were analyzed in leaves of *S. coronata*. Silica bodies were found in the hypodermal layer cell walls and in granules present in the vacuoles of palisade cells. Scanning electron microscopy of the hypodermal layer of cells showed a collection of spherical bodies embedded in enveloping cavities that outlined the general structure of the bodies. Globular subunits with sharp edges formed the spherical bodies that ranged from 6 to 10 μm (average 7.8 μm). X-ray microanalysis detected only silicon and oxygen homogeneously distributed throughout the bodies. Vacuoles of palisade cells contained a large number of granules ranging from 20 nm to 1.2 μm (average 300 nm). Transmission electron microscopy associated with electron spectroscopic imaging and electron energy loss spectroscopy were used to determine the elemental composition of the granules. Vacuolar granules were amorphous and composed of silicon and oxygen, suggesting they consist of amorphous silica biominerals. No nitrogen was detected in the granules indicating they probably do not contain proteins inside.

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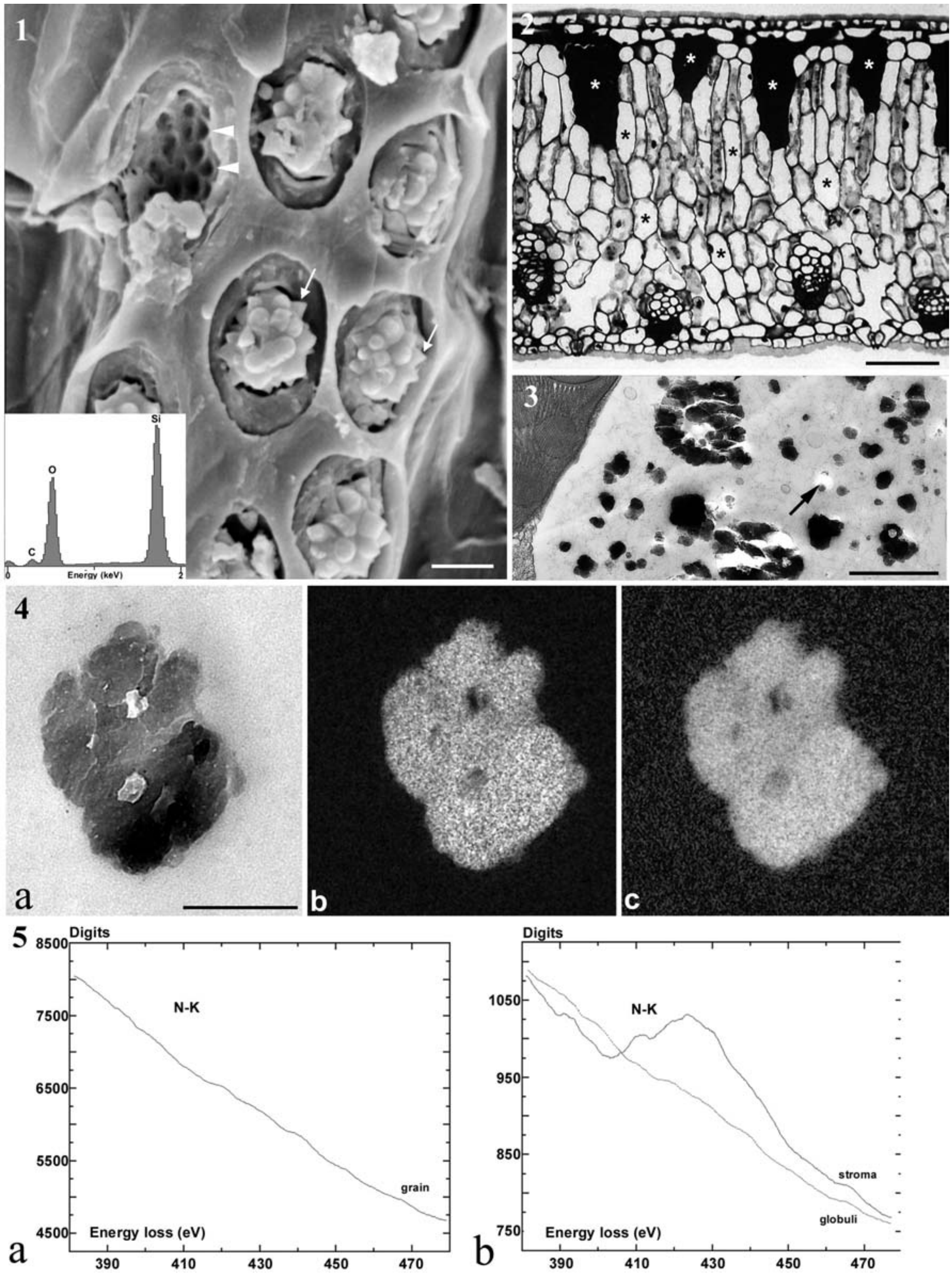

1) SEM of silica mass bodies (arrows) in *S. coronata*; inset: EDS of a mass showing Si and O; 2) LM of the pinnulae shows mesophyll cells with vacuoles (black asterisks) and fibers (white asterisks); 3) TEM of a palisade cell showing electron dense granules embedded in the vacuole. Some granules are removed during sectioning (arrow); 4) Elemental mapping of a vacuolar granule: (a) Zero loss image, (b) Si and (c) O maps show that both elements co-localize; 5) a) EELS of vacuolar granule. No nitrogen was detected, b) EELS of plastoglobulli (negative control) and cloroplast grana (positive control). Bar equals 5 μm in (1), 50 μm in (2), 300nm in (3) 200nm in (4a-c).

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