# SELF-HEALING PROCESSES IN PLANTS

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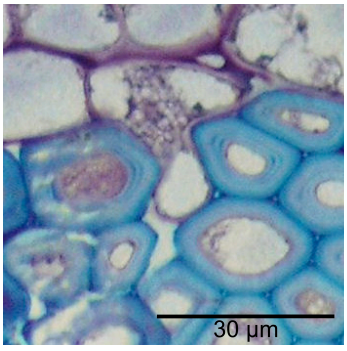
**Keywords:** Self-healing, Plants, Biomimetics, Analytical Model

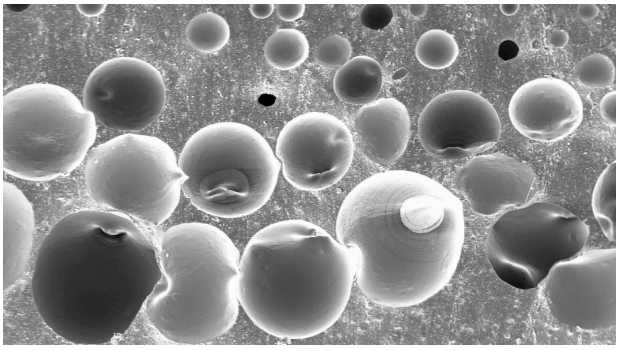
## ABSTRACT

In the course of 3.8 billion years plants have evolved the ability for rapid wound-sealing and wound-healing. As one can assume a high evolutionary pressure on the development of self-repairing abilities in nature, independent evolution of these properties including various mechanisms and structures in different plant groups and plant species is probable.

Previous studies revealed self-sealing of the sclerenchymatous outer ring of the twining vine *Aristolochia macrophylla* mediated by turgescent parenchymatous cortex cells. Due to their internal pressure these cells expand into the (micro-)fissures and seal them [1]. This functional principle has already been successfully transferred into the development of a biomimetic patent-registered PU-foam coating polymerized under pressure for pneumatic structures [2].




**a**



**b**

Figure 1: (a) *Aristolochia macrophylla*: a fissure in the sclerenchyma ring is sealed by a parenchymatous sealing cell, (b) self-sealing foam coating for pneumatic structures.

Within a current R&D-project model plants from different systematic groups were screened and selected according to different criteria, which make probable a high selective pressure on efficient self-repair. For example in succulent plants which evolved independently in various systematic groups strong effects were found. Growing in arid environments external wounds lead to an exceptional drought stress. Rapid self-repair protects the plant from dehydration and is therefore of eminent selective advantage. We selected *Delosperma cooperi*, a member of the Aizoaceae family with succulent leaves, as an especially promising role model.


Figure 2: *Delosperma cooperi*: (a) flowering plants in the Botanic Garden Freiburg, (b) healed leaf.

After an artificial injury, wound-sealing in leaves of *Delosperma cooperi* takes place by deformation and movement. Two principles are involved: (1) rolling in of the fringes of the lesion within a few minutes, and (2) curvature of the entire leaf within a time span of 20 to 30 minutes. In cross sections the almost cylindrical leaves of *Delosperma cooperi* reveal a centripetal arrangement of five tissue types consisting of an outer layer of window cells, a peripheral ring of chlorenchyma, a thin ring of isolated vascular bundles, an inner ring of parenchyma and a strand of vascular tissue in the leaf centre. The vascular tissue consists of wide-band tracheids, a specialized type of tracheids that prevent cell collapse under water stress. Mechanical properties of the entire leaf and of single tissue layers were studied in tensile tests. In addition tissue pressure and cell turgor were measured at the moment of injury and during the subsequent sealing and healing phase. An analytical model describing the self-sealing process is currently developed, based on mechanical properties of five hulls, representing the different tissue layers.

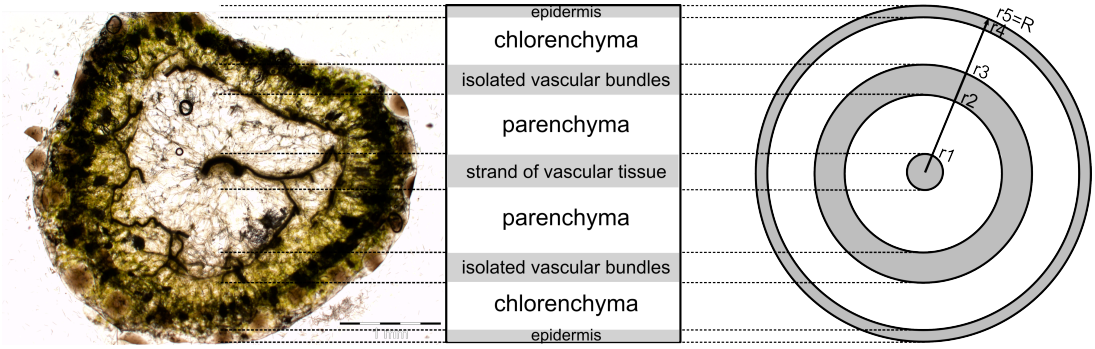



Figure 3: Leaf of the succulent plant *Delosperma cooperi*: cross-section (left), schematic drawing of the different tissue types included in the analytical model (right).

Quantitative morphological, histological and functional analyses and the development of models of the self-healing processes in the model plants are prerequisites for a successful transfer into innovative biomimetic self-repairing materials. In cases where mainly physical-chemical processes are involved in the first rapid phases of self-repair – as in *Aristolochia macrophylla* and in *Delosperma cooperi* – a transfer into bio-inspired technical materials is especially promising.

## REFERENCES

[1] S. Busch, R. Seidel, O. Speck and T. Speck, Morphological aspects of self-repair of lesions caused by internal growth stresses in stems of Aristolochia macrophylla and Aristolochia ringens, *Proc. R. Soc. B*, **277**, 2010, pp. 2113-2120.

[2] T. Speck, R. Luchsinger, S. Busch, M. Rüggeberg and O. Speck. *Self-healing processes in nature and engineering: self-repairing biomimetic membranes for pneumatic structures.* In: C.A. Brebbia (eds.), Design and Nature III, pp. WIT Press, Southampton, 2006, pp. 105-114.