A Multiphysics Model to Characterize the Mechanism of the Movement of Mimosa pudica

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Abstract

Both structural and functional properties of plants that are capable of generating rapid motions have great potentials in the field of biomimetic engineering. In particular, plant movements with multi-functionality and movement strategies serve as a good inspiration to create energy-conservative actuation mechanisms in sensor or actuator. Over the years, many researchers investigated the biological and physical properties that cause movements in varies plant species, but the mechanisms of plant movements are not fully understood until today. Movement of *Mimosa pudica* triggered by touch or shock is well-known for its fast moving and recovery speed. After mechanical stimulation of a petiole or a pulvinus, the petiole falls in a few seconds and relaxes to the initial state in a few minutes

Abundant reviewed literature reveals that the mechanism of *Mimosa pudica* movement has a great prospect in development of biomimetic smart sensor and actuator. However, most of studies on movement of plant were experiment-based work, and it is thus necessary to put great effort on development of a theoretical model. In present work, the performance of a rectangular-fan-shaped structure of plant pulvinus will be investigated. As a scientific contribution to the community, distributive ions and water are simulated by the theoretical model, resulting in mechanical bending-relaxation deformation of main pulvinus eventually. The model is validated through comparison with published experiment and good agreements are achieved on ionic distribution and moving speed of main pulvinus.

In addition, the model is also developed for electrical current formation and transduction in the macro- and micro-scale in *Mimosa pudica* movement. Elastic instability will be studied, especially the elastic energy storing and releasing to form a expandable/shrinkable state when the volumetric difference between adaxial and abaxial parts of is beyond a critical value in main pulvinus motor tissue. The recovery of the movement will also be investigated, focusing on the passive/active ions and water transport motivated by H^+-ATPase, ionic pumps and bio-chemical compounds. The present work may provide further insight into the bio-inspired mechanism of robotics actuation triggered by mechanical-electro-stimulations.

Keywords: *Mimosa Pudica*; Multiphysics model; Actuation