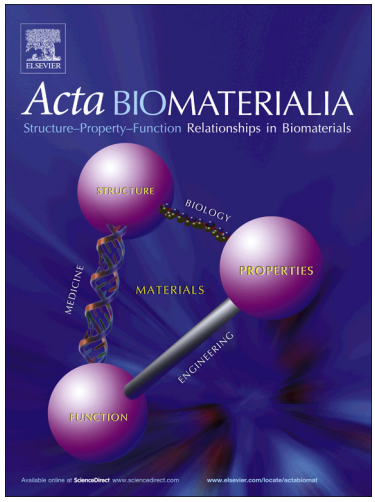

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PII: S1742-7061(15)30026-X
DOI: http://dx.doi.org/10.1016/j.actbio.2015.07.028
Reference: ACTBIO 3796

To appear in: *Acta Biomaterialia*

Received Date: 21 March 2015
Revised Date: 13 June 2015
Accepted Date: 17 July 2015

Please cite this article as: Moreno, M.D., Ma, K., Schoenung, J., Dávila, L.P., An integrated approach for probing the structure and mechanical properties of diatoms: Toward engineered nanotemplates, *Acta Biomaterialia* (2015), doi: http://dx.doi.org/10.1016/j.actbio.2015.07.028

An integrated approach for probing the structure and mechanical properties of diatoms: Toward engineered nanotemplates

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ABSTRACT

The wide variety of diatom frustule shapes and intricate architectures provide viable prototypes to guide the design and fabrication of nanodevices and nanostructured materials for applications ranging from sensors to nanotemplates. In this study, a combined experimental-simulation method was developed to probe the porous structure and mechanical behavior of two distinct marine diatom species, *Coscinodiscus sp.* (centric) and *Synedra sp.* (pennate), through ambient nanoindentation and finite element method analysis. These diatom frustule dimensions differed largely depending on diatom species with pore diameters *d* ranging from 0.3-3.0 μm. Young's modulus *E* and hardness *H* measurements of the diatom frustules were obtained via nanoindentation experiments. These values varied depending on diatom species (*E* from 1.1-10.6 GPa, *H* from 0.10-1.03 GPa for the *Coscinodiscus sp.*; and *E* from 13.7-18.6 GPa, *H* from 0.85-1.41 GPa for the *Synedra sp.*). Additionally, the mechanical response of diatom structures to uniform compression was examined. Predictive simulations were performed on the aforementioned diatom frustules, as well as another diatom structure (pennate *F. kerguelensis*), to correlate the mechanical response with specific morphology variables (e.g., pore or slit sizes). Results from calculated von Mises stress and displacement distributions unveil unique information on the effect that uniform loads have on these frustules, which can aid the design of tailored nanotemplates. A correlation between mechanical properties and porosity was established for selected frustules, and reported for the first time in this study.