# Structural Multi-Material Printing of Biocomposite Membranes

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## Abstract

We present a novel water-based fabrication and design approach for the 3D printing of functionally graded bio-composites. The project represents a further refinement and large-scale deployment of these technologies in the construction of architectural-scale membrane structures. Composed of the most abundant materials of our planet; cellulose, chitosan, and water, these composites comprise a novel system for the construction of dynamic membrane structures with graded mechanical and optical properties.

Our digital construction platform based on the Fabrication-Information Modeling (FIM) approach enables the simultaneous manufacturing and fusing of water-soluble materials through real-time feedback driven control logics. We explore programming material behaviors through the design of diffusion-based material gradients and the fused layering of hydrogels and explore the impact of local and global material cues on the full scale assembled structure. Novel generative design methods integrate material-specific fabrication parameters and enable differentiated, data-driven, hierarchical organization of the manufacturing workflow. The parametric control of the chemical composition in the 3D printing process allows for the tunability of structural, environmental and performative parameters of the structures on all scales.

Responding to humidity, light and heat with changes in color, texture and stiffness, we can point towards a future of highly engineered yet sustainable materials. Through the design of not only the final composition, but the full resource cycle we create biodegradable structures that are conscious of their use of matter and energy, creating artifacts that are in a direct relationship with their surroundings and can become part of their natural ecosystems.

## References

[1] J. Van Zak, J. Duro-Royo, Y. T. Tai, A. S. Ling, C. Bader, and N. Oxman, "Parametric Chemistry: Reverse Engineering Biomaterial Composites for Robotic Manufacturing of Bio-Cement Structures across Scales," in *Architectural Robotics*, 2017.

[2] J. Duro-Royo, J. Van Zak, ,A. Ling, Y.J. Tai, Hogan, B. Darweesh, and N. Oxman, July. Designing a Tree: Fabrication Informed Digital Design and Fabrication of Hierarchical Structures. In *Proceedings of IASS Annual Symposia* (Vol. 2018, No. 13, pp. 1-7). International Association for Shell and Spatial Structures (IASS), 2018.

[3] N. Oxman, C. Ortiz, F. Gramazio, and M. Kohler, "Material ecology," *Comput. Des. J.*, vol. 60, pp. 1–2, Mar. 2015.