Mycelium Afoot: Fashioning Sustainable Footwear

Wing Tang, Jillian Silverman, Kelly Cobb, Huantian Cao,
University of Delaware, USA.

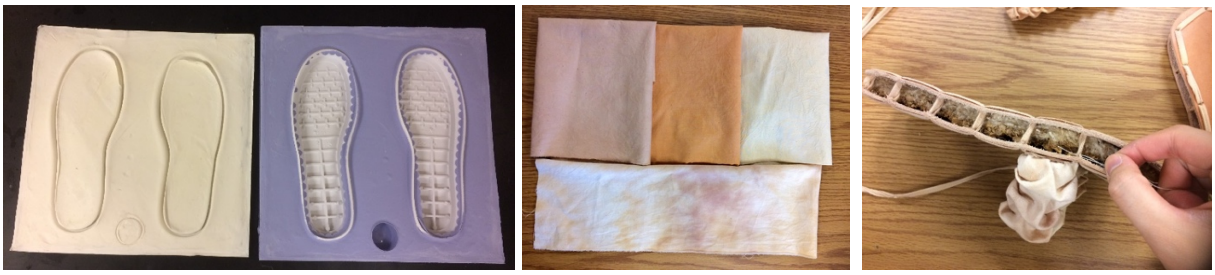
Keywords: Bio-material, sustainable footwear, eco-design, mycelium textile

Mentor statement: I acted as design advisor to this student through the process of designing the mycelium shoe. We met weekly as a team as part of a year-long grant funded project, of which the shoe design was one part. During the week this student was responsible for meeting goals and challenges, for which she excelled, and consistently amazed us. I offer my highest recommendation for the high quality, innovative creative work represented in this design.

Context: Apparel and footwear production and consumption contributes 21 billions of pounds of solid waste to landfills every year in the United States, comprising greater than 5.2% of the country's solid municipal waste (Council for Textile Recycling, n.d.). Furthermore, many of the shoes sent to landfills contain toxic materials such as PVC, lead, and chromium, which may contaminate soil, air, and water and pose significant risks to the environment and human health (McDonough & Braungart, 2002). To remedy these issues, bio-based materials have become increasingly popular in the fashion industry in the past few years, defined as "a material of which one or more of its components are sustainably grown and are fully renewable" and which help limit pollution and solid waste (Lelivelt, Lindner, Teuffel, & Lamers, 2015). Recent successful experimental designs include a green tea-based biodegradable cellulose fiber material (Nam & Lee, 2016) and soy-based resin for a shoe sole (Cao et al., 2014).

Concept: Mycelium, the root structure of mushrooms, has been used to make composite materials for applications including packaging, construction bricks, and shoe soles (Holt et al., 2012; Boyer, 2014; Jiang, Walczyk, McIntyre, & Chan, 2016). Grown on agricultural byproducts, mycelium acts as a natural binder, digesting and bonding to the surface of damp substrates as it grows (Jiang et al., 2016). Since all of the raw materials are natural, the mycelium composite is fully biodegradable (Holt et al., 2012). The purpose of this research was to develop and evaluate mushroom mycelium composites that have a potential application for shoe soles. To offer a solution to problems of waste, pollution, human health concerns, and resource depletion, this research incorporated exclusively natural and non-toxic materials, and many of the inputs were locally sourced. As previous studies focused on conservative footwear for men (Nam & Lee, 2016, Cao et al., 2014). **The design challenge** was to develop feminine footwear based on our target market of a college-aged woman between 18 and 25. We chose the format of a strappy fashion sandal with a cork-like shoe sole.

Material development: To develop mycelium shoe sole, the researchers mixed sawdust mushroom spawn with flour, psyllium husk, chicken feathers, and water for nutrition and structural support. The mixture was grown in a shoe-shaped mold for a week in a 25°C environmental chamber. The material was then heated at 90°C to deactivate the spores and prevent further growth.



(Process Images: Shoe mold, natural dye samples, shoe construction)

Process: Cotton muslin scraps from student design studio courses (draping and flat pattern) were collected from the design cutting floor. Natural dye materials were sourced from food and flora (green tea, yellow and red onion skins, rose bud tea leaves) and dye testing was conducted, results of which showed that onion skins offered the most saturated color. The final bath was composed of an onion skin liquor (boiled in water and soaked 24 hours) from which skins were then strained. Gathered fabric scraps were washed, wetted, and dyed in a concentrated bath, in which they were boiled and soaked overnight. The dimensional technique of smocking was applied to develop the strapping of this sandal, intended to mimic the overlapping nature of oyster mushrooms. A shoe sole was cut from vegetable tanned leather and hole punched with 16 holes. A mycelium inner sole was sandwiched between vegetable tanned leather outer and inner soles. A lacing method was developed to structurally sandwich shoe layers. The lacing is finished in half-inch fabric ball of dyed muslin was attached to each side of the shoe as an aesthetic design detail to make the shoes more appealing to our target consumer and to further utilize waste materials.

Design Contribution and Innovation: Findings from this design process contribute to the growing design research using bio-based materials. Furthermore, this research provided support for the utilization of mycelium composites for shoe sole applications, showing that compostable and nontoxic footwear products can still be stylish.
Acknowledgement: This work was funded by the U.S. EPA under grant No. SU839272. Date completed: April 6, 2017 Shoes Measurements (length × width × height): 9 3/4 ” x 3 1/2” x 7/8” (U.S. Women size 8)

References

Boyer, M. (2014, June 25). *Philip Ross molds Fast-Growing Fungi Into Mushroom Building Bricks That Are Stronger than Concrete.* Retrieved June 10, 2015, from http://inhabitat.com/phillip-ross-molds-fast-growing-fungi-into-mushroom-building-bricks-that-are-stronger-than-concrete/

Cao, H., Wool, R. P., Bonanno, P., Dan, Q., Kramer, J., & Lipschitz, S. (2014). Development and evaluation of apparel and footwear made from renewable bio-based materials. *International Journal of Fashion Design, Technology and Education*, *7*(1), 21-30.

Council for Textile Recycling (n.d.). *The facts about textile waste*. Retrieved from http://www.weardonaterecycle.org/about/issue.html

Holt, G. A., Mcintyre, G., Flagg, D., Bayer, E., Wanjura, J. D., & Pelletier, M. G. (2012). Fungal mycelium and cotton plant materials in the manufacture of biodegradable molded packaging material: Evaluation study of select blends of cotton byproducts. *Journal of Biobased Materials and Bioenergy*, *6*(4), 431-439.

Jiang, L., Walczyk, D., McIntyre, G., & Chan, W. K. (2016). Cost modeling and

optimization of a manufacturing system for mycelium-based biocomposite parts. *Journal of Manufacturing Systems*, *41*, 8-20.

Lelivelt, R. J. J., Lindner, G., Teuffel, P., & Lamers, H. (2015, June). The production process and compressive strength of mycelium-based materials. *Proceedings of First International Conference on Bio-based Building Materials*, Clermont-Ferrand, France (pp. 1-6).

McDonough, W., & Braungart, M. (2002). *Cradle to cradle: Remaking the way we make things.* New York: North Point Press.

Nam, C., & Lee, Y. -A. (2017). RETHINK III: Bio-shoes in urban campus life. International Textile and Apparel Association (ITAA) Annual Conference Proceedings. 67. https://lib.dr.iastate.edu/itaa_proceedings/2017/design/6

Image A- Front

Image B-Alternate view

Image C-side view

Image D-alternative view