Various Chitin Derivatives and Their Usefulness in Fiber Formation

Stephanie F. Baumgartner and J.D. Mendez

Indiana University – Purdue University Columbus, Division of Science, 4601 Central Ave., Columbus, IN 47203

Introduction to Chitin

- Chitin is an abundant biopolymer found in many living organisms, including the exoskeletons of arthropods and the cell walls of fungi and yeast. [1]
- Currently, the primary commercial sources of chitin are crab and shrimp shells.[1] Previous studies performed by our lab have utilized cicada exuviae as an alternative to these highly sought after commodities as previous work has shown no significant difference in these sources. [3]

Figure 1 – Cicada Exuviae

Figure 2 – Estonian Mushroom

- Our most recent work analyzes various mushroom sources to determine the size and location of chitin fibers in order to find a source with evenly distributed fibers, indicating a high surface area.

Applications for Chitin Fibers

- Chitin and its deacetylated form chitosan is able to bind to many heavy metals including mercury, copper, zinc, chromium, cadmium, nickel and lead. [1,2] Finding sources with higher surface areas will increase the likelihood of chitin binding to these surfaces.
- Our current work has focused on lead contamination of water since it has negative consequences for the central nervous system, especially for children, as has been highlighted by the recent lead catastrophe in Flint, Michigan.
- Additionally, chitin is utilized in wound dressing, drug delivery systems, food and chemical industries, agriculture, aquaculture, and dental and cosmetic treatment, therefore, any progress made in this area of study would have far reaching effects.[5]

Transmission Electron Microscopy (TEM)

- A transmission electron microscope was used to view the fibers at magnifications up to 340,000x.
- Transmission electron microscopy uses an electron beam to study the internal structures of a specimen. Our chitin samples were stained with heavy metals to increase electron density, so that electrons sent through the sample would display this pattern of electrons, generating an image.[6]
- These images can then be used to give us an idea of size of the fibers and the location of the fibers within composite materials.
- Using these images, the size of the fibers was measured by hand to determine the aspect ratio (Table 1).

TEM Images of Mushroom Source Material

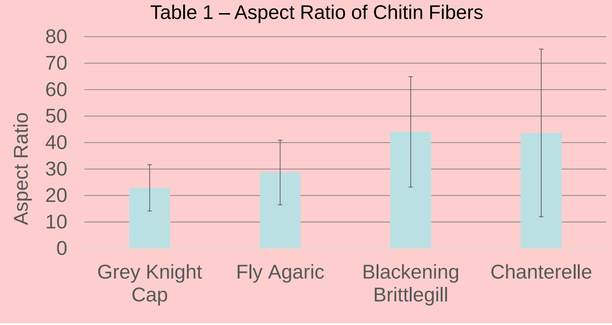
Figure 3 – Fly Agaric

Figure 4 – Blackening Brittlegill

Aspect Ratios of Various Chitin Source Materials

- The aspect ratio is the ratio of the height of something to the width.
- Something with a high aspect ratio would be long and skinny while a low aspect ratio would be short and wide.
- For example, a baseball has an aspect ratio of 1 while a baseball bat has an aspect ratio of about 15.

Table 1 – Aspect Ratio of Chitin Fibers



Conclusions

- The aspect ratio of all of the mushrooms was relatively high with possible variation among different species.
- This high aspect ratio is beneficial to the mechanical properties because it takes less fibers to form a continuous network.
- Think about dropping 20 marbles (low aspect ratio) on the ground; chances are low that all of them would end up touching each other.
- However, what if you dropped 20 pieces of dry spaghetti (high aspect ratio)? Chances are much greater that most of the pieces would be touching each other.
- Unlike pieces of spaghetti, chitin fibers not only have a high aspect ratio but also stick to each other through intermolecular bonds allowing each fiber to support the others around it.

Future Work

- We have a variety of other mushroom sources that need to be viewed under the electron microscope and analyzed.
- The error in our samples was high meaning the fibers have a large varittion or we need a better measurement system.
- For the sources we have obtained pictures of, we will measure even more fibers to increase our sample size.

Selected References

1. Younes, Islem and Marguerite Rinaudo. “Chitin and Chitosan Preparation from Marine Sources: Structure, Properties, and Applications.“ *Marine Drugs* 13.3 (2015): 1133-1174. Web. 19 December 2017.
2. Mohamed, Somar H., Ahmed A. El-Gendy, Amal H. Abdel-kader, and E.A. El-Ashkar. “Removal of Heavy Metals from Water by Adsorption on Chitin Derivatives.“ *Der Pharma Chemica.* 7.10 (2015): 275-283. Web. 28 February 2018.
3. Caldwell, J.; Mendez, J. D., Mechanical and Thermal Properties of Chitin from Diverse Sources. *Proceedings of the Indiana Academy of Science* 2016, 125 (2), 87-90.
4. Bellinger, David C. “Lead Contamination in Flint-An Abject Failure to Protect Public Health.” *The New England Journal of Medicine.* 374 (2016): 1101-1103. Web. 3 March 2018.
5. Park, Bae Keun and Kim Moon-Moo. “Applications of Chitin and its Derivatives in Biological Medicine.” *International Journal of Molecular Sciences* 11.12 (2010): 5152-5164. Web. 29 January 2018.
6. Reece, Jane B, Lisa A. Urry, Michael L. Cain, Steven A. Wasserman, Peter V. Minorsky and Robert B. Jackson. *Campbell Biology.* 9th Ed. San Francisco: Pearson Education, Inc. 2011. Print.

Acknowledgements

The authors would like to thank the Office of Student Research at IUPUC for financial support.