Biodegradable and High-performance Bamboo Drinking Straws: Natural Substitutes for Plastic Straws

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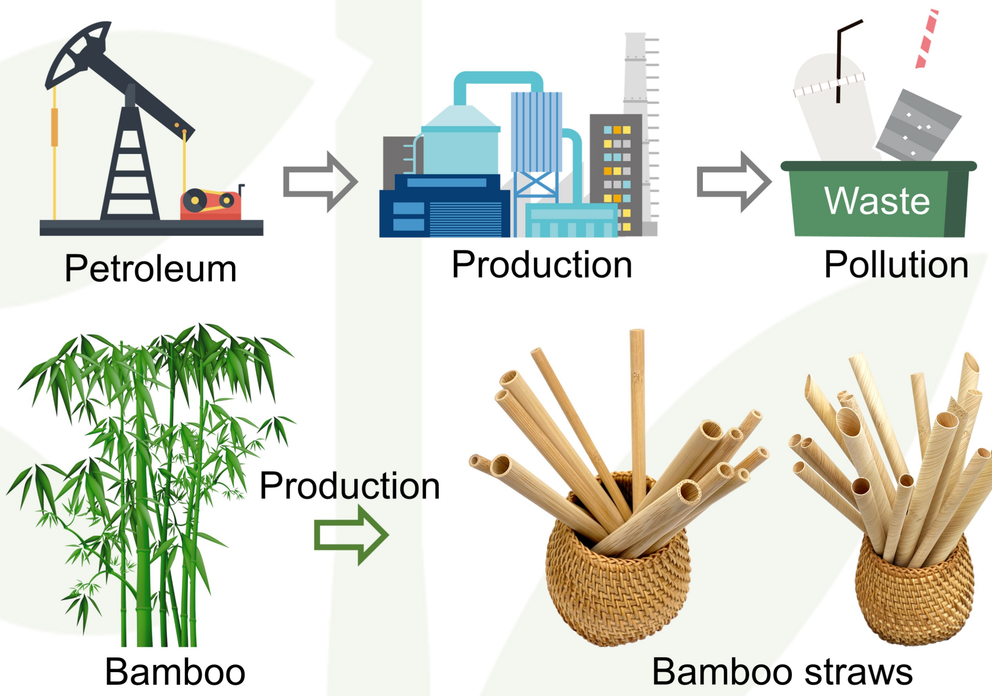
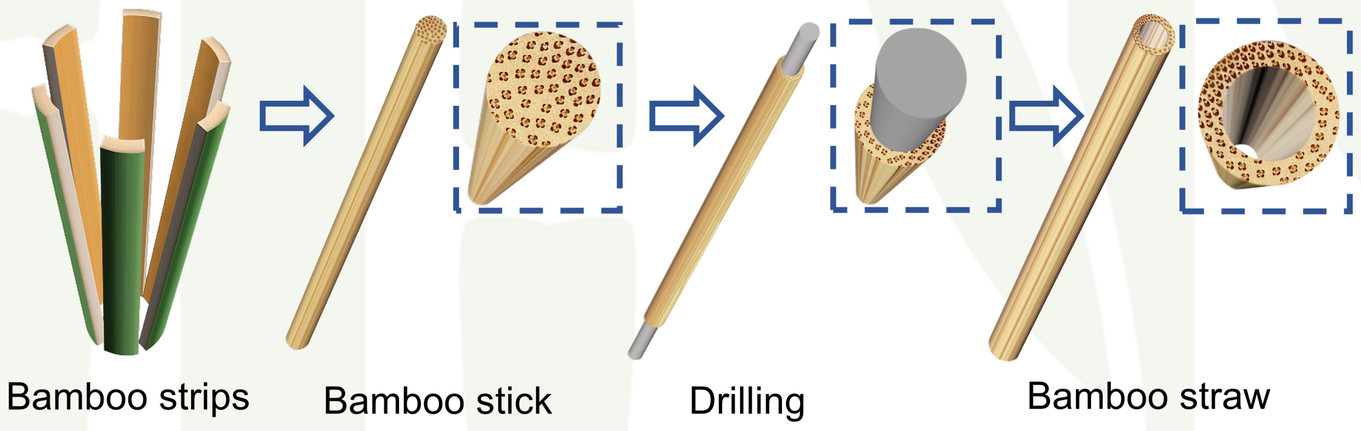
Abstract

The environmental problems caused by disposable plastic straws have been widely concerned around the world. Developing degradable straws made of eco-friendly materials is an effective solution. Nevertheless, the popular alternatives, for example, polylactic acid (PLA) straw and paper straw are far from satisfactory because of the restrictive degradation conditions, low mechanical performance, poor water stability, and the use of chemicals. As an abundant and sustainable natural resource, bamboo has been widely used in many fields. “Replacing plastic with bamboo” has become an affirmative trend aimed at reducing plastic usage, decreasing environmental pollution, and promoting sustainable development. Inspired by the natural structure, flexibility, and toughness of bamboo, this study proposed mechanized and automatic approaches for producing two types of bamboo straws: bamboo straws made by drilling hole on sticks and bamboo straws made by rolling bamboo veneer.



Bamboo straws made by drilling hole on sticks

➢ Production process

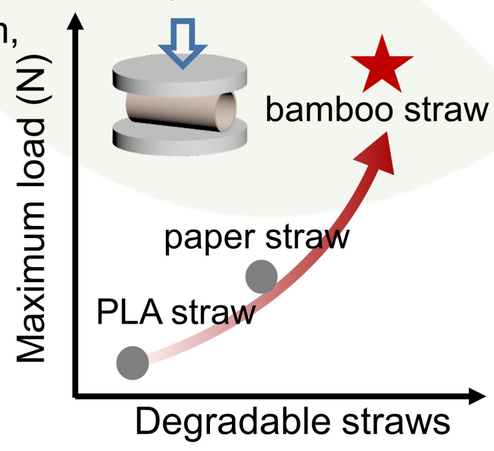


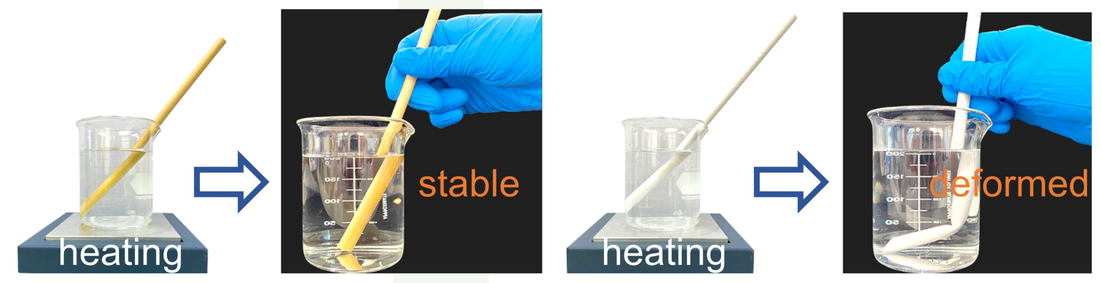
Firstly, bamboo strips were processed into bamboo sticks with external diameters from 6 mm to 12 mm by circular-arc cutters. Secondly, bamboo sticks were hydro-thermally treated at 105℃ with high-pressure steam for 70 min. Drilling machines were used to drill holes in sticks, the drilling process was fully automatic. As the different dimensions of the bamboo sticks, the bamboo straws with various external diameters (6 mm, 7 mm 8 mm, 9 mm, and 12 mm), a wall of 1.5 mm, and a length of 200 mm were produced. Finally, buffing and intelligent selection with cameras ensured great quality.

➢ Performance

The strength of bamboo straws was much higher than that of PLA straws and paper straws. After immersing in water for 15 min and touching the cup bottom, bamboo straw maintained its firm structure.

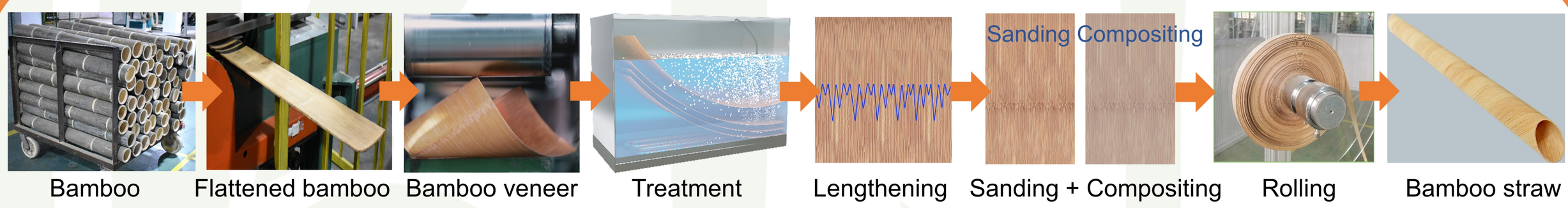
These results showed that bamboo straws possess great mechanical strength and wetting stability to meet practical applications.





Bamboo straws made by rolling bamboo veneer

➢ Production process



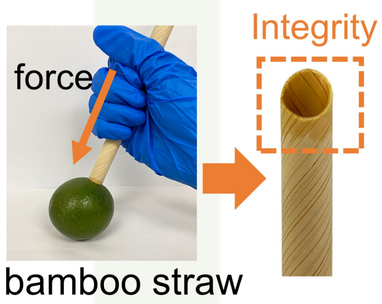
Firstly, bamboo strips with arc shape were processed in a non-notched flattening machine to obtain flattened bamboo splits. Secondly, flattened bamboo splits were sliced into fine veneers with a thickness of 0.4-0.6 mm. Thirdly, natural bamboo veneers were soaked at 80℃ for 6 hours and processed with an ultrasonic treatment. Treated bamboo veneer and tea bag paper made from plant pulp were composited into composite material. After fine sanding, ultra-thin veneers with a thickness of 0.3 mm were obtained. Then, bamboo veneers were cut into narrow strips with a preset width. Finally, two bamboo strips consisting of outer and inner strips overlapped by around half the width and were rolled synchronously by an automatic rolling machine with a rolling angle of approximately 50°. Bamboo drinking straws with various external diameters (8 mm, 10 mm 12 mm) adjusted by the diameter of the roller were produced to meet different needs.

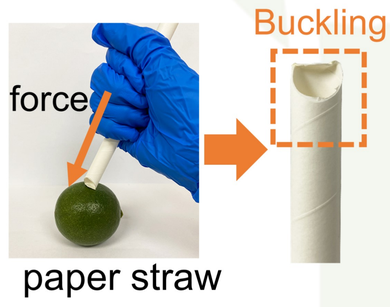
➢ Flexibility of bamboo veneer

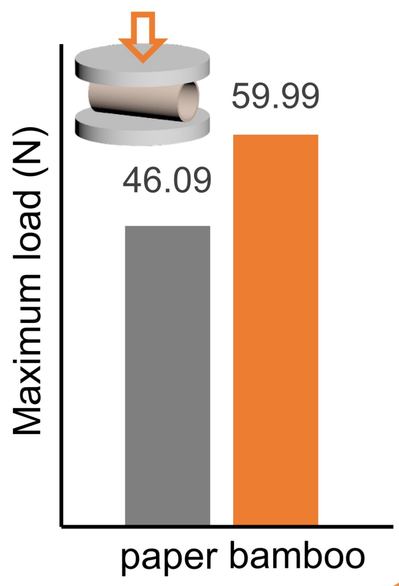
The ultra-thin bamboo veneers had exceptional flexibility, making it suitable for bending, twisting, and knotting without experiencing breakage or cracking.

➢ Performance of bamboo straw

Bamboo straw exhibited superior compressive strength and the strength of the tip compared to commercial paper straws, making it strong and durable enough to withstand typical usage and handling.







Conclusions

In this study, two effective and mechanized strategies were proposed to produce degradable bamboo drinking straws with different external diameters. As a sustainable alternative to plastic straws, bamboo straws boast both aesthetic appeal and cost-effective production processes. Furthermore, bamboo straws have superior mechanical properties compared to other materials such as PP, PLA, and paper straws. In addition to their durability, bamboo straws also exhibit exceptional wetting stability that preserves their appearance and strength. The research and development of bamboo straws enrich the types of degradable straw, which is of great significance to mitigate the “White Pollution” brought by plastic straws.