Investigation into the Possibility of Making a Biodegradable Croc

Ryan P. D'Amore, Martin L. Tanaka
College of Engineering and Technology
Western Carolina University
Cullowhee, NC, USA

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Introduction:

The popular footwear known as Crocs produces significant waste each year because these shoes are not recyclable or biodegradable. The material used to construct crocs is "Croslite," which is made from a foam resin polymer known as ethylene-vinyl acetate (EVA). EVA is a copolymer between ethylene and vinyl acetate (VA), and the percent of VA present in the material provides flexibility in the design and manufacturing processes. Unfortunately, neither ethylene nor vinyl acetate are biodegradable, so Crocs are not environmentally friendly. While Crocs can certainly be donated and reused via secondhand organizations, (i.e., Soles4Souls), ultimately, their non-recyclability and non-biodegradability leads to the conclusion that at the end of their useful life they will end up in a landfill. Based on statistical estimates derived from comments by the CEO of Crocs, Andrew Rees, it is estimated that approximately 21,500 tons of waste could be produced from Crocs sold in 2020 and 2021 alone. This research uses 3D printing to evaluate the feasibility of making a Croc from biodegradable materials. In the 3D printing process, TPU is at the forefront of the research as the potential material, since it is similar to Croslite but with the benefit of being biodegradable within just a few years. Another benefit to the process is that 3D printing is becoming widely popular with both hobbyists and large-scale manufacturing companies such as Boeing, Ford, and Nike, to name a few. This research aims to determine if a shoe can be produced that has a lower environmental impact by evaluating alternative materials capable of replacing EVA.

Methods:

In searching for a potential solution, research was conducted into the matter. A baseline understanding was established through reading articles and watching videos online. Research began by developing an understanding of biomaterials as a whole, looking into a variety of biomaterials and learning about their specific properties. Originally, the majority of the research was focused into PLA and its counterparts (i.e., PLLA, PLRA, PLGA, etc.), all of which are biodegradable materials. To evaluate the feasibility, a 3D printed croc was produced. The first step was to obtain a 3D CAD model via making one or searching online. Taking the latter approach, a STL file for a Croc was found online through a website called thingiverse (https://www.thingiverse.com/thing:5158736/files), a popular website in the 3D printing community. The file was used to print a pair of test Crocs to evaluate if the process was possible. A Lulzbot taz printer was used to print the PLA sample Crocs because of its ability to printing a shoe large enough to wear.

Results:

Overall, the printing of one Croc took approximately two days to complete (Figure 1). The material used was a form of PLA, and did not perform as a real Croc since it is a hard, stiff material. To test the performance and usability, and to get an idea of what changes would be needed moving forward with the concept, the sample shoe was worn. The shoe itself was a great fit, similar to an actual Croc. In the printing process, the size was scaled up to 110% due to the concern that the Croc would be too small otherwise, but this proved unnecessary as it ended up

being a little too big. After further analyzing the process, a more efficient way of printing was discovered, which would take significantly less time, use less filament, and yield easier cleanup by avoiding excess support generation.

Figure 1: 3D PLA printed croc. a) front view of croc, b) rear view of croc, c) top view comparing printed and real croc, d) front view comparing printed and real croc

Discussion:

The current PLA print may not be the perfect replacement for the genuine Croc, but it answered questions on how the research would improve efficiency and biodegradability. For starters, it was determined that printing a much smaller Croc out of TPU would allow for the quick printing of another testable model. It would not be wearable, but would allow additional testing of the idea prior to moving onto a larger, final product. The research would also expand the printing to beyond just Crocs, now also including small solid and sponge like blocks. This will allow further testing of the materials, specifically to evaluate how they will handle harsh conditions realistic for an actual pair of Crocs worn regularly. These tests could consist of differing variables including heat, water, abrasion, and shock absorption to see how the materials hold up and what changes they undergo. Conceptually, TPU is a biodegradable material and would work well for the new models, but a TPU filament specifically marketed as biodegradable was unable to be located. As a substitute, a material called “YOGA Flex” from a company passionate about eco sustainability was selected. The manufacturer claims the material is a 100%

biodegradable, semi-flexible filament made from green materials, and that it has greater printability than TPU filaments.

Conclusion:

Overall, the research is progressing accordingly and the concept for a biodegradable 3D printed Croc is not out of the question. It was originally intended to use TPU for the final pair of printed Crocs, but complications have led to switching to "YOGA Flex" as the properties on paper meet the desired outcomes. The research will move forward in more physical testing in order to prepare for the final results.

References

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