Antimicrobial Plastic for 3D Printing of Food-Safe Items

Kojo Adjei-Afriyie, Jonathan Dorogin, Ryan Kearns, Alex Vena

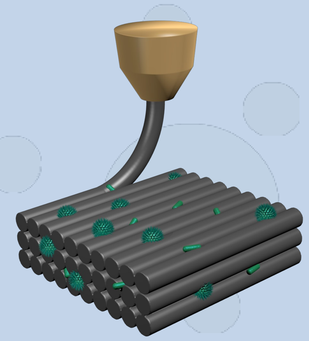
UNIVERSITY OF WATERLOO

Overview

3D printing has become popular in a variety of industries, as well as the consumer market. Although the technology has made significant improvements in both design and material, there are still major limitations, one of which is food safety. To address this problem, our team has developed an antimicrobial and food-safe polymer for 3D printing applications: Ag-HDPE. Our vision is to empower creators to invent food compatible products with peace of mind.

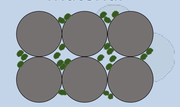
Motivation

Filament deposition 3D printing involves a layer-by-layer fabrication process that leads to deep striations on the material surface. These hard-to-clean striations form the perfect breeding ground for bacteria, creating a safety hazard for repeated use.



Potential Solutions

Untreated Material

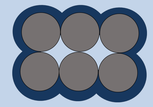


Bacterial safety issues prevent food-contact use.

Mechanical Processing

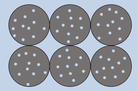
Mechanical techniques eliminate striations by smoothing the surface, but require extra user steps.

Chemical Treatment



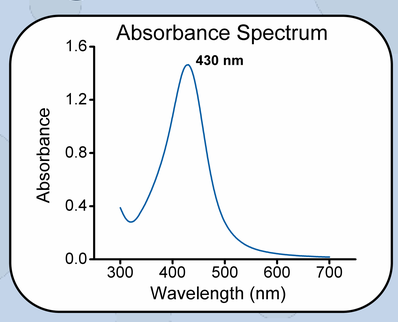
The application of an antimicrobial coating requires extra user steps and can be easily scratched off.

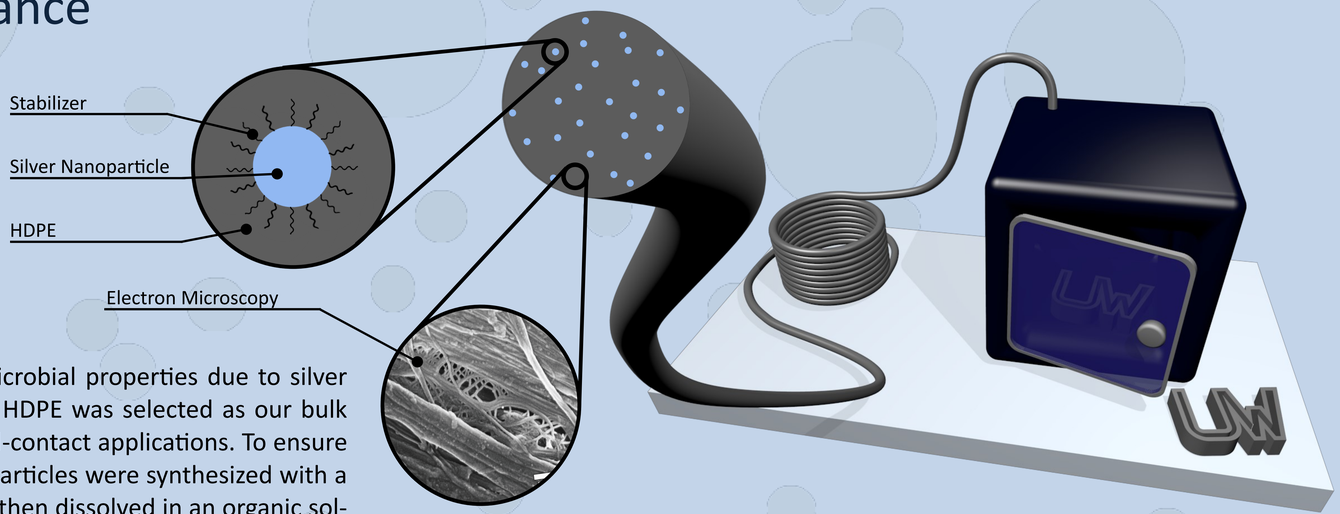
Our Solution



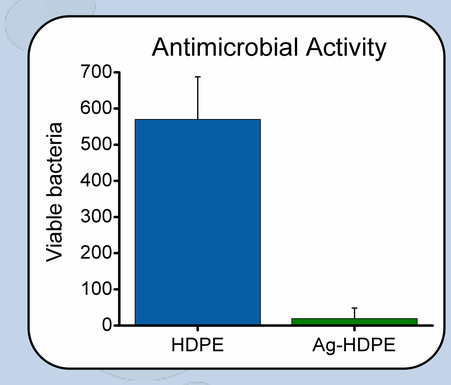
The material is antimicrobial with no extra user steps.

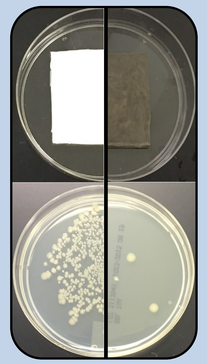
Integration & Performance





Silver nanoparticles have excellent antimicrobial properties due to silver ion release in the presence of water [1]. HDPE was selected as our bulk material due to its widespread use in food-contact applications. To ensure compatibility with HDPE, the 10nm nanoparticles were synthesized with a hydrophobic stabilizer. The particles were then dissolved in an organic solvent with HDPE at a high temperature. After evaporating the solvent, the raw material was melted and extruded into our antimicrobial filament.

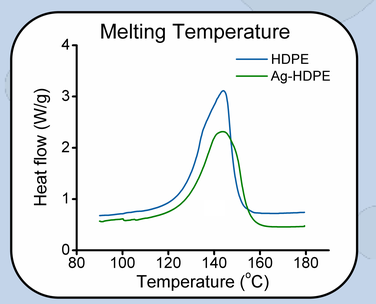


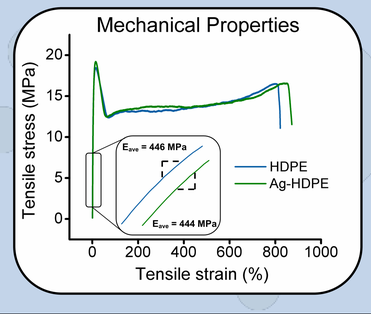


We selected *E. coli* as the model pathogen to verify the antimicrobial activity of our material. A bacterial solution was deposited on two surfaces: Ag-HDPE (active material) and plain HDPE (control). After incubation for 24 hours, there was a 97% average reduction in viable bacteria on our material as compared to the control samples.

Structural Properties

We evaluated the mechanical and thermal properties of Ag-HDPE against HDPE. Due to the low nanoparticle concentration in our material, the strength and melting temperature of Ag-HDPE were indistinguishable from unmodified HDPE.

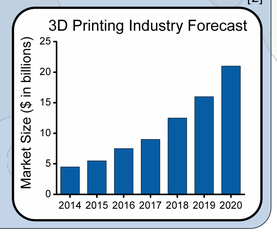




Economics

A large segment of the 3D printing market consists of hobbyists, who would be our target consumer. At its current scale, our filament is projected to be within the market price of commercial filaments, which range from $20 to $100 per kilogram.

[2]



Future Work

- Optimization of nanoparticle size and concentration in filament
- Incorporation of additives to modify filament colour
- Nanoparticle leaching tests for FDA approval
- Scaling up filament production

Acknowledgements

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- Dr. Laura Deakin
- Ricky Tjandra

References

[1] Y. Jeong, D. W. Lim, and J. Choi, "Assessment of Size-Dependent Antimicrobial and Cytotoxic Properties of Silver Nanoparticles," *Adv. Mater. Sci. Eng., vol. 2014, pp. 1–6, 2014.*

[2] L. Columbus, "2015 Roundup Of 3D Printing Market Forecasts And Estimates," 2015. [Online].Available: http://www.forbes.com/sites/louiscolumbus/2015/03/31/2015-roundup-of-3d-printing-market-forecasts-and-estimates. [Accessed: 1-Mar-2016].