Thermal Debinding Treatments of Polypropylene and PLA

Eric Tkach, Lehigh University
Mert Celikin, Department of Mechanical and Materials Engineering

Introduction

The concept of adding metal powder to a polymer to injection mold or 3d print a metal part has become common for metals such as copper or iron. To make a solid part the polymer is debinded thermally or chemically then there is a second heat treatment to sinter the metal powder into a solid part. In this research, magnesium powder additive manufacturing was investigated. Magnesium is more reactive than metals like copper resulting in high levels of oxidation in the metal. To prevent this, researchers have found that the debinding and sintering of the complex should be done in an Argon atmosphere with 5% Hydrogen gas. This also keeps the polymer from burning or reacting during the debinding process.

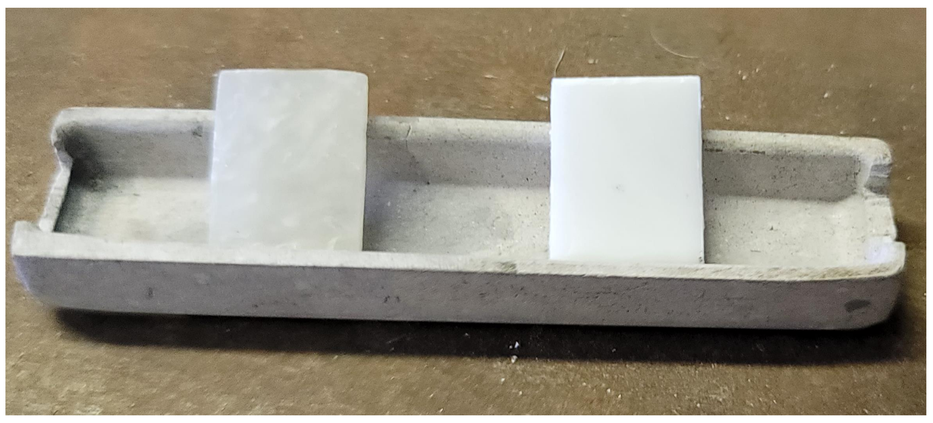
Objectives

- Understanding effect of gas atmosphere on thermal debinding kinetics of Magnesium/polypropylene composites
- Composites important for production of low-cost Mg components for biomedical implants.
- Processes needed for debinding metal powder from polymer in injection molded and 3d printed parts.
- Plot weight change vs time for different atmospheres and polymer ratios

Method

The experiment performed for this research module was placing a piece of PP and PLA in a furnace and raising the temperature up to 300 C over 30 min, holding at 300C for 30 min and then raising the temperature to 420C over 30 min. This heat treatment was done in a furnace with air to examine what remains of the polymers after the heat treatments. The samples were weighed before and after the heat treatment to find the percent change in weight.

Results

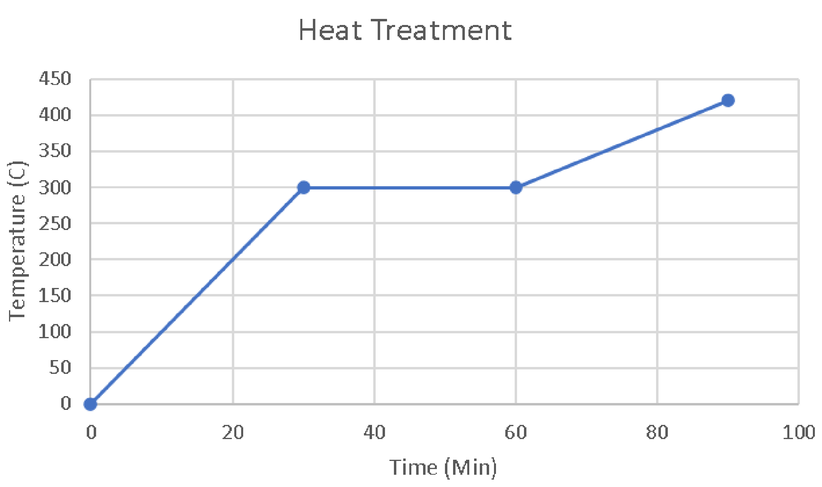


Polymer samples before heat treatment PP (right) PLA (left)

PP sample after heat treatment. A lot of residue was left being possibly indicating the polymer burned instead of vaporizing

PLA Sample after heat treatment left nearly no residue behind

Collected Data



Polymer	Starting Mass	Final Mass	% remaining
PP	0.5682g	0.0229g	4.03
PLA	0.7951g	0.0062g	0.779

References

Johannes G. Schaper, Martin Wolff, Björn Wiese, Thomas Ebel, Regine Willumeit-Römer, Powder metal injection moulding and heat treatment of AZ81 Mg alloy, Journal of Materials Processing Technology, Volume 267, 2019, Pages 241-246, ISSN 0924-0136,

Wolff, M.; Schaper, J.G.; Suckert, M.R.; Dahms, M.; Feyerabend, F.; Ebel, T.; Willumeit-Römer, R.; Klassen, T. Metal Injection Molding (MIM) of Magnesium and Its Alloys. Metals 2016, 6, 118.

Wolff, M., et al. Enhancement of Thermal Debinding and Sintering of Biodegradable MIM-Magnesium Parts for Biomedical Applications. The European Powder Metallurgy Association, Shrewsbury, 2016.

Schaper, Johannes Geronimo. Magnesium Polyolefin Interactions during Thermal Debinding in the MIM Process of Magnesium. Diss. Christian-Albrechts Universität Kiel, 2019.

Conclusions

The two polymer samples heated in air lost over 95 percent of their masses in the heat treatment. However, the polypropylene sample left black ash possibly indicating the sample combusted. PP has an autoignition temperature of 388C so it may have combusted in the 3rd step of the heat treatment.

The inclusion of Argon gas and removal air in the furnace would prevent the polymer from burning and favor vaporization. It would also prevent the magnesium powder that would be added to the polymer from oxidizing.

Acknowledgements

I would like to thank Dr. Mert Celikin for his willingness in taking me on for project for such a short amount of time and working to accomplish tasks in such a busy semester. I would additionally like to thank UCD and Dr. Kevin Nolan for this research opportunity in my time abroad.