Determining the Chemical Composition of Toner Used by ASU Photocopiers

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ABSTRACT

This project seeks to analyze the physical properties and chemical composition of the toner used by ASU photocopying machines. Because current paper recycling processes require toner to be removed from paper, the manufacturing of recycled paper is expensive and can result in more greenhouse gas emissions than newly manufactured paper. There is growing interest in recycling processes that could allow toner to more easily separate from printed materials. Understanding toner compositions is critical in determining the recyclability of printed materials. By studying the toner formulation used by public ASU photocopiers, this project aims to directly influence university recycling practices.

BACKGROUND

- Though the exact formulations of photocopier toners are proprietary, toner powder is primarily composed of plastic.
  - Compiled data from analyses of 807 toner samples using reflection-absorption infrared spectroscopy show that most toner formulations are primarily composed of either polystyrene, polystyrene-co-acrylate, epoxy, epoxy plus acrylate, or polyethylene [1].
  - It can be expected that toner will be composed of plastic polymers in addition to other resins, pigments or dyes, iron oxide, amorphous silica, charge control agents, paraffin wax, surfactants, or inorganic additives [2].
- The majority of published analyses of toner composition stem from a surprising source—forensic science. This results in many studies using methodologies which involve sampling toner from printed material, introducing potential contamination errors.
- Prior studies have used differential scanning calorimetry (DSC) to study laser printer toners [3].

Figure 1: Black Photocopier Toner (n.d.). FarraTech. photograph. Retrieved from https://www.farratech.com/what-is-printer-toner/.

[1] Merrill, R.A., Bartick, E.G. & Taylor III, J.H. Forensic discrimination of photocopy and printer toners I. The development of an infrared spectral library. Anal Bioanal Chem 376, 1272–1278 (2003), https://doi.org/10.1007/s00216-003-2073-0.

[2] Neha Verma, Raj Kumar, Vishal Sharma, Analysis of laser printer and photocopier toners by spectral properties and chemometrics, Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, Volume 196, 2018, Pages 40-48, ISSN 1386-1425, https://doi.org/10.1016/j.saa.2018.02.001.

[3] Yordanova, D., Angelova, S., & Dombalov, I. (2014). Utilisation Options for Waste Toner Powder.

METHODS

<u>Sampling:</u>

Toner was sampled by opening a Canon GPR-30 Black Standard Yield Toner Cartridge and carefully pouring out toner powder onto a paper fiber optic cleaning wipe. From there, toner particles were transferred to pins using a laboratory scoop. The sample was weighed on a balance, and toner powder was added until the sample was approximately 50 mg.

<u>Differential Scanning Calorimetry (DSC):</u>

Five cycles were run on the DSC Q2000 V24.11 Build 124 machine: 1) ramp 20°C/min up to 200°C, 2) remain at 200° for 5 minutes, 3) ramp 20°C/min down to -80°C, 4) remain at -80°C for 5 minutes, and 5) ramp 10°C/min to 200°C.

RESULTS

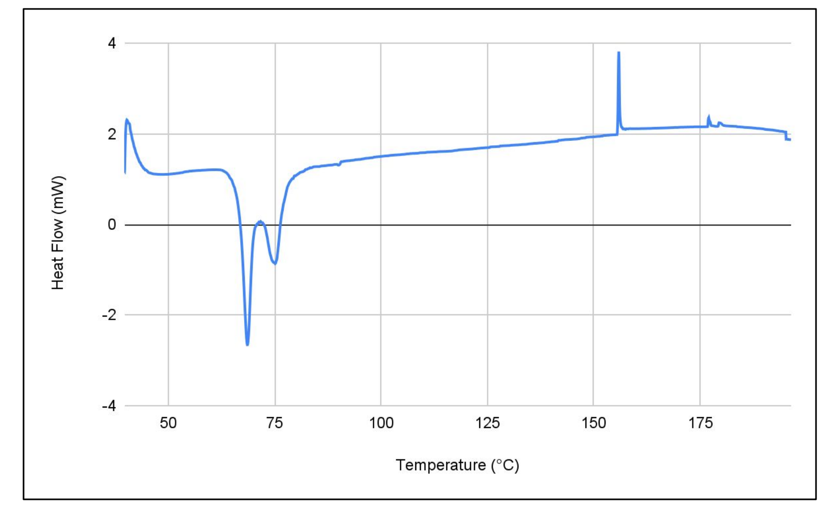

Figure 2: Heat Flow (mW) vs. Temperature (°C) for Cycle 1, Ramp 20°C/min until 200°C

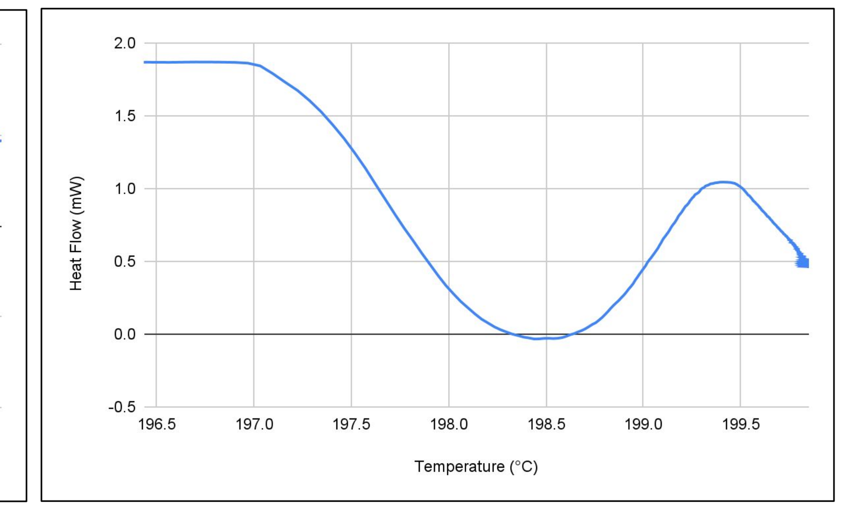

Figure 3: Heat Flow (mW) vs. Temperature (°C) for Cycle 2, Isothermal for 5 minutes at 200°C

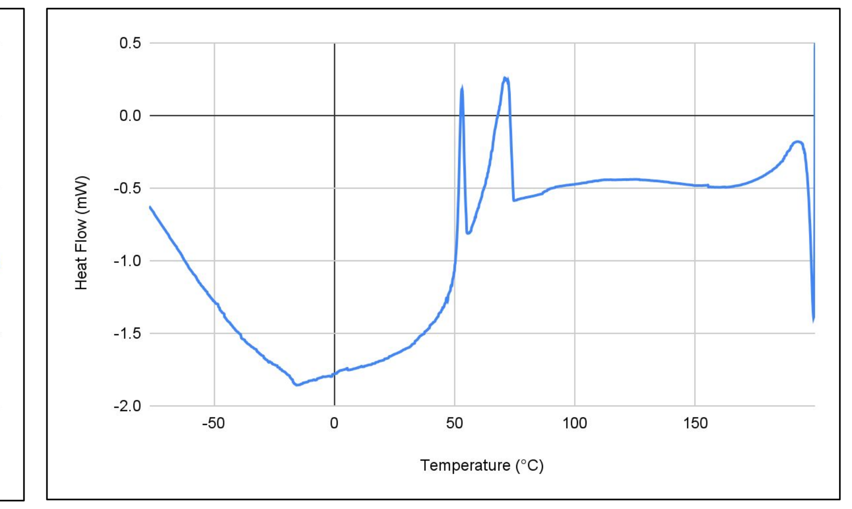

Figure 4: Heat Flow (mW) vs. Temperature (°C) for Cycle 3, Ramp 20°C/min until -80°C

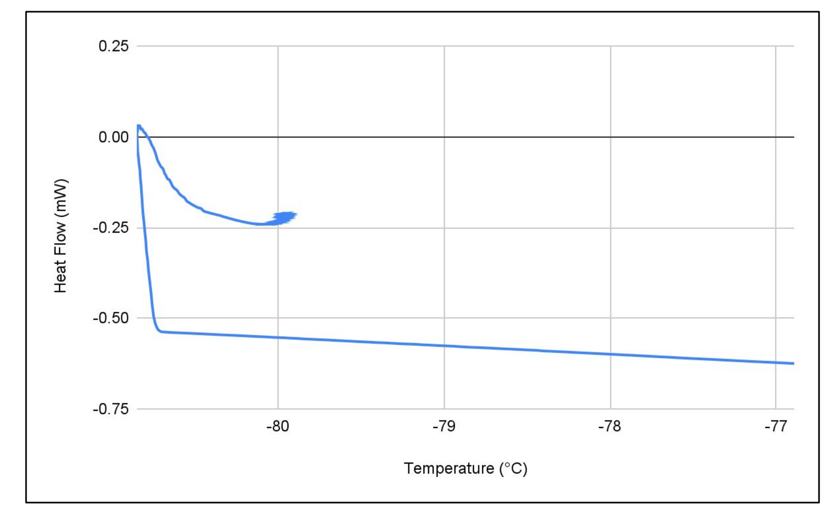

Figure 5: Heat Flow (mW) vs. Temperature (°C) for Cycle 4, Isothermal for 5 minutes at -80°C

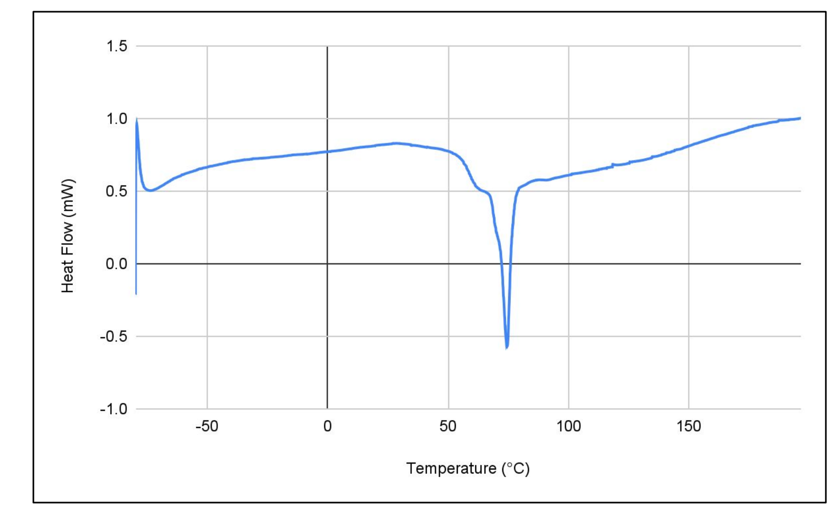

Figure 6: Heat Flow (mW) vs. Temperature (°C) for Cycle 5, Ramp 10°C/min until 200°C

CONCLUSION + NEXT STEPS

The multiple peaks in the heat flow vs. temperature plots made from differential scanning calorimetry data seem to indicate that the photocopier toner samples consist of multiple components which melt and crystallize at different temperatures. While these components cannot be determined from DSC data alone, this data adds to the current understanding of toner properties. Next steps to determine the components which make up toner could include: thermogravimetric analysis with fourier transform infrared spectroscopy (TGA-FTIR), contact angle testing to determine hydrophobicity, and optical microscopy to analyze the size and shape of individual toner particles.

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