Material Processing of a HIPS/AC FDM Filament for Water Filtration

A Major Qualifying Project
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ABS	Acrylonitrile Butadiene Styrene
AC	Activated Carbon
CAD	Computer Aided Design
DI	Deionized Water
FDM	Fused Deposition Modeling
HIPS	High Impact Polystyrene
MB	Methylene Blue
PID	Proportional Integral Derivative
PLA	Polylactic Acid
SEM	Scanning Electron Microscope
SSE	Single Screw Extruder
Tg	Glass Transition Temperature
TGA	Thermogravimetric Analysis
Tm	Melting Temperature
wt%	Weight Percentage

ABSTRACT

Additive manufacturing has seen extensive development within recent years, leading to innovations within a variety of industries. New printing technologies enable the incorporation of intricate geometry within a part unachievable using traditional manufacturing methods. These geometries, which can increase the surface area of a part, and the intrinsic high porosity of additive manufactured parts are advantageous to water filtration applications. One of the most common methods of water filtration involves the usage of activated carbon, a common material derived from plant matter. High surface area and unique pore structure make activated carbon a viable filter of organic compounds. In this project, a polymer-filler composite was developed for creating a filament with filtering properties, specifically targeting organic compounds. Fused deposition modeling filament was manufactured through a unique seven-step process. Utilizing the advantages of additive manufacturing and this new composite filament, a water filter was created that removed the organic compound methylene blue, illustrating the potential of this novel technology.

ACKNOWLEDGEMENTS

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- Anthony D’amico for providing us valuable insights into polymer processing and granting us access to important machines for characterizing our filament.
- Professor John Sullivan for allowing us to print with our experimental filament on the FDM printers in the Mechanical Engineering MQP lab.
- Todd Keiller for helping us pursue a preliminary patent through WPI.

1 INTRODUCTION

Inspiration for this project came from the usage of additive manufacturing (AM) technologies following natural disasters. Recent disaster relief efforts have seen non profit organizations install AM technologies, colloquially referred to as 3D printing, onsite to aid in recovery. This allows for portability (taking production to the point of need) and rapid re-design on site via computer aided design (CAD) software. Needed items such as replacement piping and valves, as well as medical supplies like syringes and clamps, can be quickly modeled and made on site for quicker turnaround compared to the days or weeks required for remote areas. This new application is made possible due to the rising popularity and innovation of AM.

Innovation in AM and material processing has led to a variety of new technologies across a multitude of industries, from aerospace and naval architecture to footwear. Materials research has given way to new and viable AM processes, further demonstrating AM utility within manufacturing. Two of the main appeals of AM are the customizability it offers and the opportunity for utilizing unique geometries, often not capable or practical when using traditional manufacturing methods.While traditional manufacturing methods involve carving or shaping parts into the desired form by removing material, AM allows for faster and efficient production, with less waste.

Utilizing this technology with a focus on these advantages, this project sought to create a water filter that could be manufactured on a consumer desktop fused deposition modeling (FDM) printer. A water filter was chosen to address the issue of water scarcity created by natural disasters, such as hurricanes and floods. Typically in these situations, large portions of the population must rely on emergency supplies of bottled or canned water With the benefits of portability and on-site design, water filtration systems can be quickly designed and produced to allow the availability of clean, potable drinking water in a fraction of the time in emergency situations.

The following sections outline the development process for producing an FDM water filter. Manufacturing of a composite filament, the design iterations of a FDM water filter, and determining appropriate printing parameters are detailed in discussing the development process.

2 BACKGROUND

This section begins with an overview of polymer processing and fused deposition modeling. Then, it focuses on the materials used in the project: high impact polystyrene, and activated carbon. Finally, it reviews how activated carbon is used in water filtration. These topics were extensively researched to provide the necessary knowledge and techniques used for the completion of this project.

2.1 Polymer Processing

There are several different methods to process polymers, including extrusion, injection molding, thermoforming, calendaring, blow molding, etc. However, various polymers may react differently to each of these processes, and therefore each method has its own distinct advantages and disadvantages, which depend on the application of the final product.

2.1.1 Polymer Composites

Polymer composites are multiphase systems consisting of an additive within a polymer matrix. Additives are primarily utilized to reduce material cost, improve processing, and modify material properties. Additives can be inorganic or organic, with various different geometries, such as flakes, fibers, and particles [1]. Some common additives are silica and carbon fiber, which are categorized as a filler and reinforcing fiber, respectively.

Additives modify material properties in a variety of ways. On a basic level, fibers can be used to improve a material’s strength predominantly in an anisotropic manner, while fillers improve a material’s conductivity, strength, and surface finish. Permeability is directly affected by an additive’s aspect ratio, the additive’s longest and shortest dimensions. Low aspect ratio additives, like fillers, significantly increase permeability of the material by increasing stress concentrations within the polymer matrix and thus increasing porosity. High aspect ratio additives, like fibers and flakes, will do the contrary [1].

Additionally, additives can impart desirable properties to a polymer. For example, electrical conductivity can be improved within polymers, as they are normally poor electrical conductors, with the addition of conductive fillers like aluminum [2]. Other examples include the addition of flame retardants, colorants, and plasticizers for their desired properties. Thus, additives allow for a polymer to inherit new properties and/or improve upon existing properties making them a valuable component of polymer processing.

2.1.2 Polymer Dissolution

Polymer dissolution involves the addition of a solvent to create a polymer-solvent system. The solvent transforms the layer properties of the polymer and the polymer undergoes normal dissolution. Normal dissolution composition is summarized in the Figure 1 below.

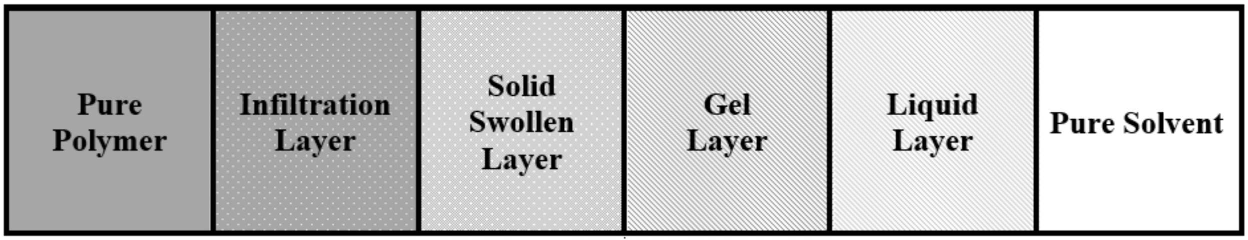


Figure 1. Schematic of polymer solvent surface layer composition [3].

Polymer dissolution has a wide variety of applications ranging from microlithography to controlled drug delivery [3]. A common application is the recycling of polymers. Several unsorted polymers can be separated using a single solvent. The polymers have varying solubilities at different temperatures, which allows for a temperature-step approach to removing polymers from the initial conglomerate. The polymer becomes liquid-like when dissolved in the solvent and is then drained from the rest of the system. From there the solvent is vaporized off, leaving pure polymer. This offers a unique processing technique that could be applied in other polymer applications.

Dissolution rate can be improved through varying environmental conditions. Agitation of the solution has been shown to increase dissolution rate [3]. A similar study referenced in the same article also found that, “external parameters such as agitation and temperature as well as radiation exposure can influence the dissolution process.” This phenomena can be attributed to the decreasing of the surface layer thickness as the solution is stirred. By utilizing simple conditions like heated mixing, the dissolution rate can be significantly improved, resulting in decreased material processing cycle time.

2.1.2.1 Solubility Parameters

"Substances with similar solubility parameters will be soluble because of the tendency for the solvent and solute molecules to minimize unfavorable interactions, or 'like dissolves like'"[4]. Polymers and solvents are assigned solubility parameters based on the following multidimensional solubility parameter developed by Hansen [5].

$\delta = \sqrt{\delta_D^2 + \delta_H^2 + \delta_P^2}$

δ_D^2= Accounts for energy from dispersion forces

δ_H^2= Accounts for energy of hydrogen bonds

δ_P^2= Accounts for the energy from dipolar intermolecular forces between molecules

δ = Hansen solubility parameter

For each substance, these three parameters are plotted on different axes, forming a 3D area known as the "Hansen space" (or sphere), as shown in Figure 2. The nearer two substances are in this space, the more likely they are to dissolve each other [4]. Table 1 shows the Hansen solubility parameters for common polymers and solvents.

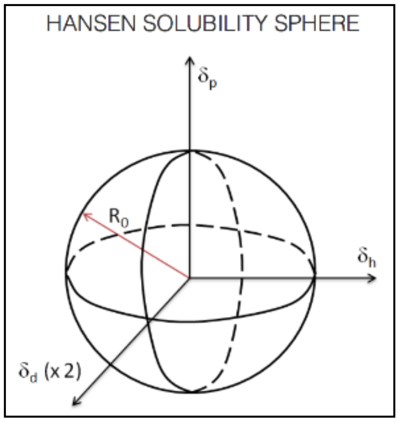
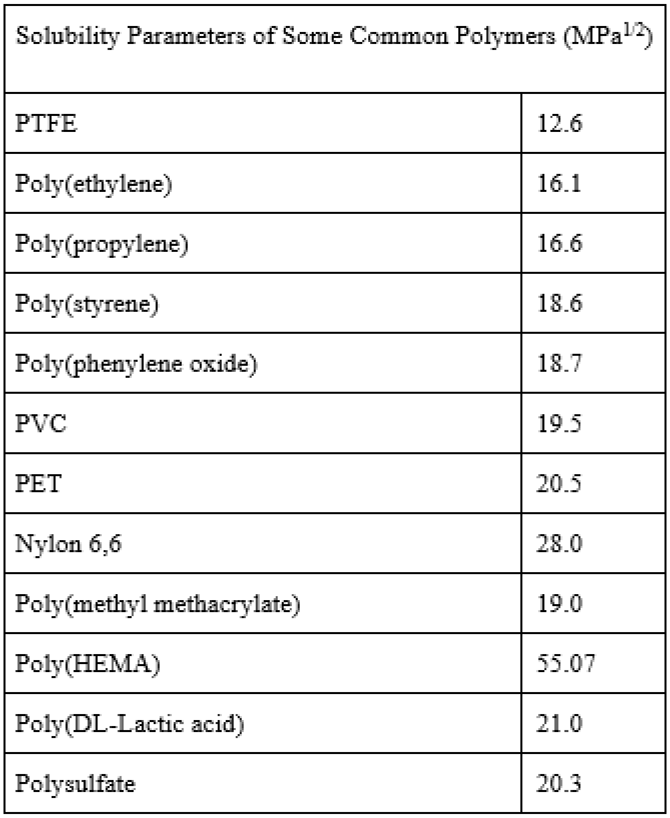
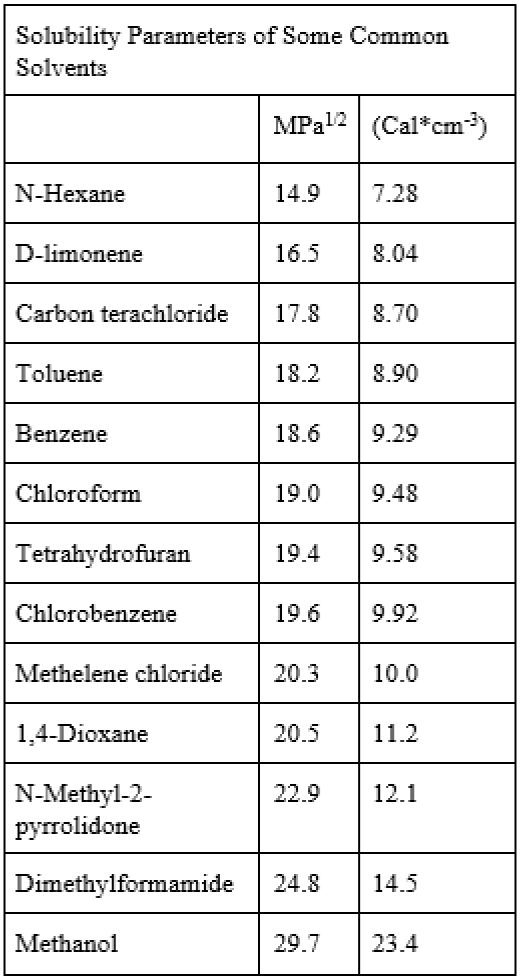


Figure 2. Illustration of the Hansen sphere [5].

Table 1. Solubility Parameters of common polymers and solvents.



Solubility Parameters of Some Common Polymers ($MPa^{1/2}$)	
PTFE	12.6
Poly(ethylene)	16.1
Poly(propylene)	16.6
Poly(styrene)	18.6
Poly(phenylene oxide)	18.7
PVC	19.5
PET	20.5
Nylon 6,6	28.0
Poly(methyl methacrylate)	19.0
Poly(HEMA)	55.07
Poly(DL-Lactic acid)	21.0
Polysulfate	20.3



Solubility Parameters of Some Common Solvents		
	$MPa^{1/2}$	($Cal*cm^{-3}$)
N-Hexane	14.9	7.28
D-limonene	16.5	8.04
Carbon terachloride	17.8	8.70
Toluene	18.2	8.90
Benzene	18.6	9.29
Chloroform	19.0	9.48
Tetrahydrofuran	19.4	9.58
Chlorobenzene	19.6	9.92
Methelene chloride	20.3	10.0
1,4-Dioxane	20.5	11.2
N-Methyl-2-pyrrolidone	22.9	12.1
Dimethylformamide	24.8	14.5
Methanol	29.7	23.4

When the difference between the solubility parameters of the solvent and the solute is less than 1 $[\frac{cal}{cm^3}]^{1/2}$, or 2.05 $MPa^{1/2}$, the solvent is a “good solvent” and the mixture will form a solution.

$$|\delta_{polymer}-\delta_{solvent}| < 1\ [\frac{cal}{cm^3}]^{1/2}\ (2.05\ MPa^{1/2}) \Rightarrow \text{SOLUTION}$$

Understanding and applying the solubility parameters for polymers and solvents are essential for applications such as paints and coatings, adhesion to polymers, diffusion of solvents into polymers, and dissolving support material on fused deposition modeling (FDM) parts.

2.1.3 Extrusion

For polymer processing, extrusion is the simplest technique, and more than 50% of plastics are produced in this manner [6]. This technique is mainly used for creating long plastic products with a fixed cross sectional shape. For the creation of filament used in FDM, extrusion is the optimal processing technique to make the spaghetti-like shape of the filament.

Extrusion involves the following steps:

1. Heating and melting the polymer
2. Pushing the polymer into a shaping unit
3. Forming the melt into the required shape
4. Cooling and solidification

Extrusion is completed above the melting temperature (T_m) of the polymer. At this temperature, the polymer demonstrates liquid-like behavior, making it easier to form into a desired geometry.

2.1.3.1 Screw Extrusion

Screw extrusion is used most often in the plastic industry, specifically the single screw extruder (SSE). “Single and twin screw extruders are used for the melting and pumping of polymers and for die extrusion for the production of film, sheet, pipe, tubing, profiles and fibres” [6]. The SSE shown in Figure 3 is comprised of a hopper, a barrel (usually insulated), a screw, and finally the die. Pelletized polymers are poured into the hopper and are conveyed through the barrel as the screw rotates. Additives and fillers can also be added to the hopper. In the first zone of the screw the pellets are trapped between the screw threads and the outer walls of the barrel and are packed closely together. To melt the polymer, a combination of mixing and heating is required. In the melting zone of an extruder, heaters within the barrel account for approximately 40% of the heat required to get above the glass transition temperature (T_g). As the pellets are tightly packed between the rotating screw threads and the barrel wall, the compression and movement results in shear thinning of the polymer, which decreases the viscosity. The shear forces create friction, which accounts for the remaining 60% of the energy required to melt the polymer completely. These shear forces provide a greater energy for mixing, which ensures greater homogeneity of the polymer and any fillers added to the mixture [7]. The liquefied polymer is then pushed towards the end of the barrel to the die. The die can be shaped into several different geometries, but for the purpose of fused deposition modeling (FDM), the die is a circle. Standard filament diameters for FDM filament are 1.75mm or 3mm. Once the polymer is out of the die, the cooling and solidifying step begins. For FDM filament, the solidifying step usually occurs seconds after the spaghetti-like polymer, or composite, flows out of the extruder into room temperature air. The filament can then be wound onto a spool and is now ready for the printing process.

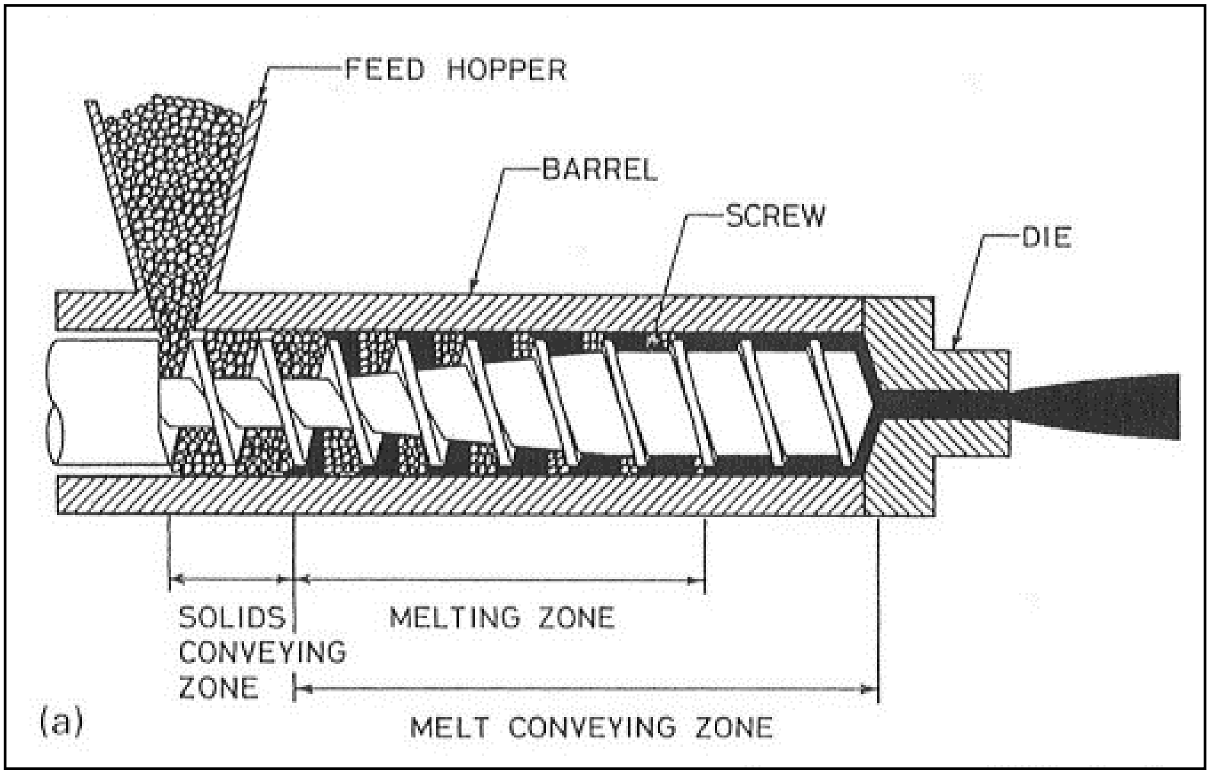


Figure 3. Diagram of a simple SSE [6].

2.2 FDM Parameter Characterization

Fused Deposition Modeling (FDM) is one of the most common forms of additive manufacturing. In FDM, filament is melted by the printer and extruded in a thin line onto the print bed. Line by line a layer is created, with each layer adding to the three dimensional object that was originally modeled as a CAD file [8].

2.2.1 Porosity

Porosity of a polymer after extrusion is a function of various processing parameters including extrusion velocity, extrusion temperature, viscosity of the material, and diameter of the exiting die. Furthermore, the porosity of the polymer can be impacted heavily by factors such as aspect ratio of the composite particulate and the bonding surface energy between the particles with the surrounding matrix. This makes determining a defining mechanism for porosity generation difficult, however it is generally accepted in the additive manufacturing community, specifically to FDM, that the deposition temperature and speed at which the material is deposited have some of the greatest influences on porosity generation [9]. Because of these properties, printing at a speed and temperature slightly above that of the optimized conditions for the printer will result in greater porosity. The increase in temperature can boil the polymer, inducing gaseous bubbles that generate pores. As the deposition speed increases the polymer is deposited less uniformly, increasing porosity.

2.2.2 Support Structure Geometry

When models have overhanging features, features that float in mid-air, the part requires support structure in order to print [10]. Otherwise, the feature risks structural integrity and can break-off mid print or the feature is unable to print entirely due to the lack of a print surface. Figure 4 illustrates an example of overhang and appropriate support placement.

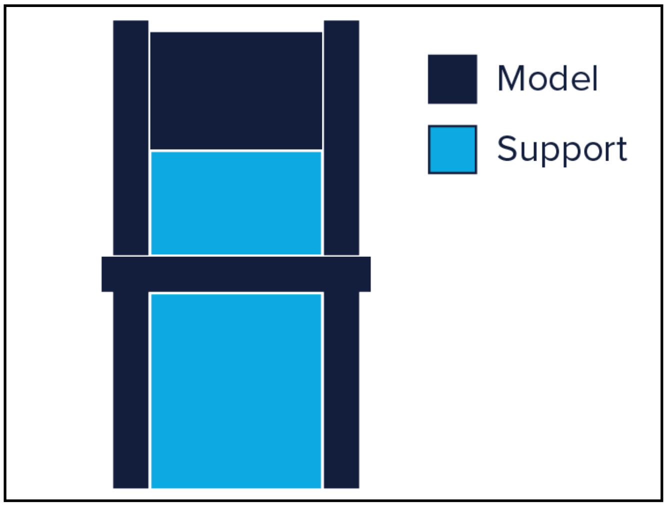


Figure 4. Models with support structure in overhang regions[10].

The slicer software Cura provides five types of support structure geometry. Patterns provide varying levels of part support at respective material costs. When selecting support geometry it is imperative that the complexity of the design geometry is taken into account. Figure 5 shows the support geometry options available with Cura.

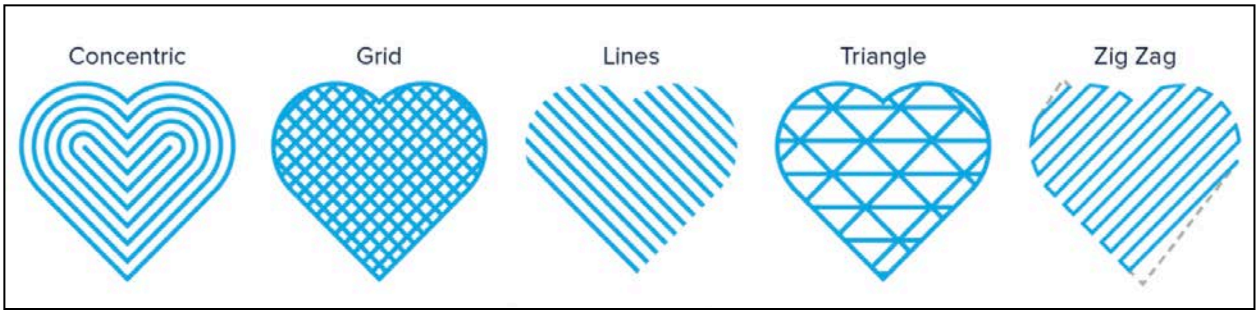


Figure 5. Support structure geometry available in Cura [10].

2.3 High Impact Polystyrene

High Impact Polystyrene (HIPS) is a versatile polymer used frequently in FDM applications. HIPS shares several characteristics with Acrylonitrile Butadiene Styrene (ABS) including a similar tensile strength (~7500 psi), relatively low cost, ease of processing, and both are widely used [11]. While ABS is used for FDM prototypes, HIPS is commonly used as support material for prints. Unlike ABS, HIPS is soluble in the chemical limonene, which is used to dissolve the support material off printed parts. HIPS is one of a few polymers that is FDA compliant, with a food grade variation used for applications such as plastic cutlery manufacturing [12]. These features: the low cost, level of safety, and FDM utilization make HIPS an appealing option for experimental manufacturing.

2.4 Activated Carbon and Water Filtration

Activated carbon (AC) can filter organic compounds and contaminants such as lead, chlorines, herbicides, and pesticides through a process called adsorption, which is one of two primary water filtration techniques. The second technique is called sediment, or mechanical filtration and it removes particles from water based on size; adsorption purification attracts solutes based on the particle composition [13]. Figure 6 illustrates the adsorption process.

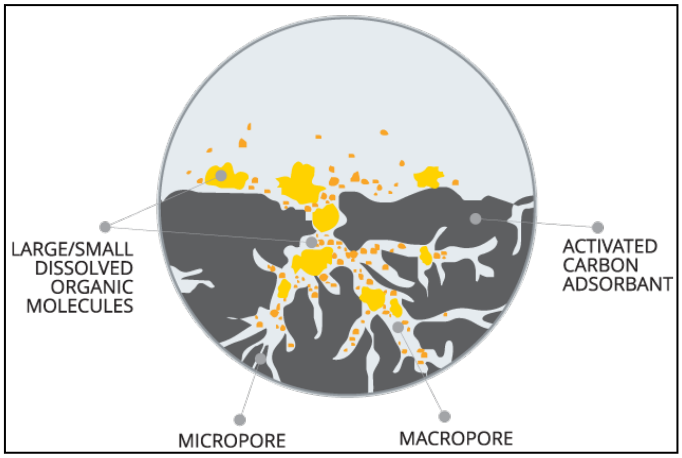


Figure 6. Activated carbon adsorption of organic molecules [14].

3 FILAMENT DEVELOPMENT

This section describes the overall process of how the HIPS/AC filament is produced as well as the results found through investigating different weight percentages (wt%) of AC.

3.1 HIPS/AC Filament Production Process

Starting with raw materials of HIPS polymer pellets and AC powder, a three step process (as shown in Figure 7) was completed for the creation of experimental HIPS/AC filament.

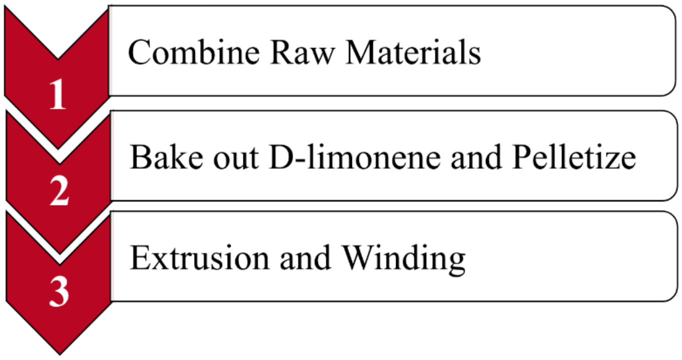


Figure 7. HIPS/AC filament production process.

3.1.1 Combine Raw Materials

D-limonene is used to combine the composite to produce a near homogeneous filament incorporating an additive (AC) to a polymer (HIPS), due to its similar solubility parameter to HIPS, as shown in Figure 9.

$$|\delta_{\text{polymer}}-\delta_{\text{solvent}}| = |\delta_{\text{polystyrene}}-\delta_{\text{D-limonene}}| = |18.5\text{MPa}^{1/2}-16.5\text{MPa}^{1/2}| < 2.05\ \text{MPa}^{1/2} \Rightarrow \text{SOLUTION}$$

Since the difference between the solubility parameters was less than 2.05 MPa$^{1/2}$, D-limonene dissolves HIPS to create a thick slurry substance, allowing easier integration of AC powder. A proportional-integral-derivative (PID) controlled heater, as shown in Figure 8, expedites the HIPS dissolving process by heating the polymer and D-limonene solution. A K-type thermocouple is used to monitor the temperature of the heater to keep the PID at a relatively constant temperature (between 70C and 90C).

The AC powder is sieved to separate the powder into three particle sizes: small particles (less than 45µm), medium particles (between 45 and 75 µm), and large particles (between 75 and 125 µm). The following process, shown in Figure 9 is completed for all weight percentages of HIPS/AC for the largest particle size (75-125µm). Refer to Appendix B for material safety information.

Figure 8. A proportional-integral-derivative (PID) controlled heater used for combining raw materials.

1. Set PID Heated Mixer to 60°C
2. Measure HIPS pellets in grams (i.)
3. Measure 45 mL D-limonene (iii.)
4. Pour HIPS pellets and D-limonene into PID heated mixer (iv.), and mix by hand with a metal stirring rod approximately every 10 min (v.)
5. Measure AC powder in grams (ii.)
6. Measure 30 mL D-limonene. The additional D-limonene improves mixing and creates the desired consistency for the slurry
7. Once mixture is a liquid-like slurry (approximately 75 minutes after initial combination), add measured AC powder and additional D-limonene (vi.)
8. Mix solution constantly with metal stirring rod for 15 minutes
9. After 90 total minutes in PID heated mixer, pour solution out onto wax paper, (approximately 5 mm thick) for autoclave preparation.

Figure 9. Combining raw materials in the PID heater. i: HIPS Pellets, ii: Carbon Particles, iii: D-limonene, iv. HIPS& D-limonene after 1 min, v: HIPS & D-limonene after 45 min, vi: HIPS & D-limonene & Carbon after 1 hour and 15 min.

3.1.2 Volatize D-Limonene and Pelletize

The volatizing process begins by heating the solution in an autoclave at 110°C to evaporate the D-limonene. After approximately 24 hours, the D-limonene is evaporated leaving a hardened HIPS/AC composite (shown in Figure 10), ready to be pelletized. Pelletize into approximately 5 mm x 5 mm pellets using a paper cutter.

Figure 10. HIPS/AC mixture post baking, ready to be pelletized.

3.1.3 Extrusion and Winding

The HIPS/AC pellets are manually fed into the "Filastruder" (shown in Figure 11), a filament extruder and winder apparatus, which consists of a motor, hopper, insulated barrel, cooler fan, and melt filler nozzle [19]. Prior to running the extruder, the barrel temperature must stabilize at the required temperature, which is 165°C for HIPS, for at least ten minutes. This ensures that the PID controller, that controls the barrel temperature, recognizes the proper input and output conditions. After the barrel temperature stabilizes, it is safe to turn the motor on, initiating the extruding process as the screw in the barrel begins turning. As pellets feed into the hopper, the extruder will start to produce filament. Molten filament exits the barrel at the die diameter of 1.75 mm. The filament is manually guided down to the sensor mounted two feet below it, as pictured in Figure 12, and then up to the winder, following a "U" shaped path.

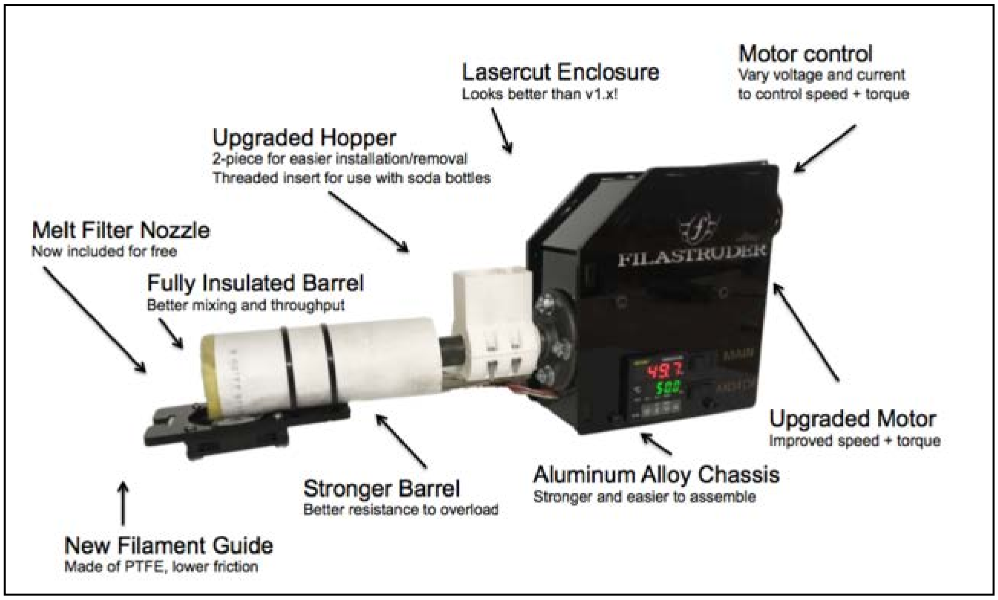


Figure 11. Filastruder FDM filament extruder diagram [20].

As the filament reaches the winder, it is attached to an empty spool, and the sensor governs the speed of the winder based on the speed of extrusion, as not to break the filament. The rate of extrusion is controlled internally by the extruder system and is varied between 10-36 inches of filament produced per minute [20]. The fan set below the extruder on the apparatus cools the filament, preventing the filament from thinning after exiting the barrel. Without cooling, the filament could remain in a semi-melted state and the weight of previously extruded filament would cause it to elongate and decrease the diameter.

Samples from each spool were then collected for testing to characterize the filament. These samples were taken from the beginning and end of the filament in order to preserve a consistent, continuous filament, ideal for printing.

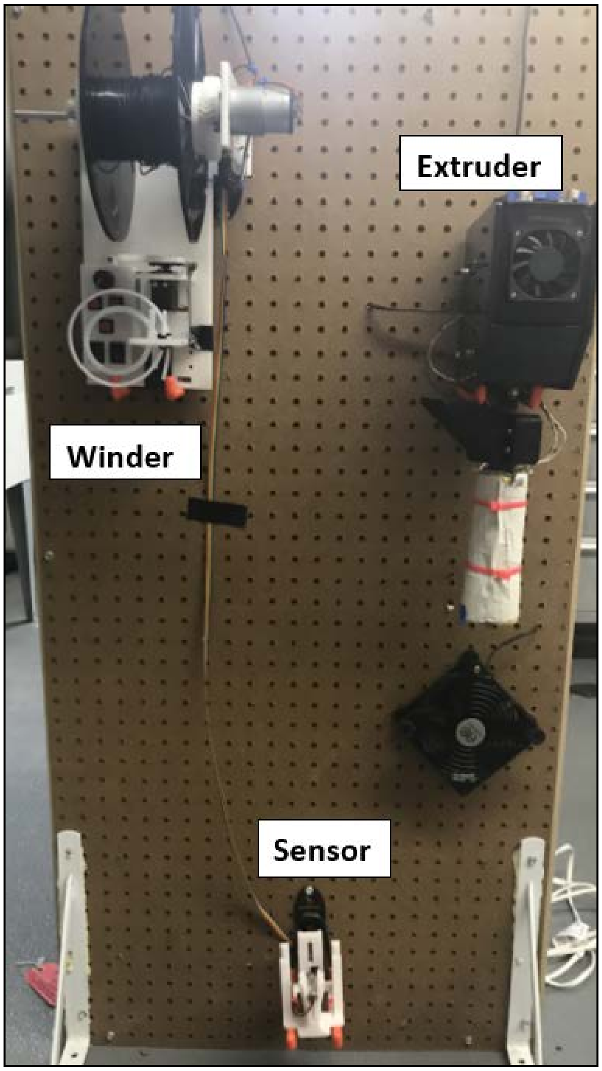


Figure 12. Extruder and winder apparatus.

3.2 Filament Development Results and Characterization

An investigation was conducted in order to determine optimal composition of the HIPS/AC material. HIPS/AC material was produced at the following weight percentages of AC: 10%, 20%, 30%, 40%, and 50%. Given that higher weight percentages were expected to yield higher filtering potential, 50 wt% was pursued first. The weight percent was then decreased in increments of 10% until a feasible filament could be produced.

When the 50 wt% AC mixture pellets were extruded, the filament could not wind onto the spool and would break when curved. This concluded that the AC content was too high , resulting in a brittle, unprintable filament. Due to the brittle properties of the produced filament at 50 wt%, the investigation did not go further with this mixture.

Both 40 wt% and 30 wt% were wound with multiple breaks in the filament along the spool. A print was attempted using the 40 wt% and 30 wt% filaments using a bowden style extruder, the Monoprice Select Mini v2 FDM printer shown in Figure 13.

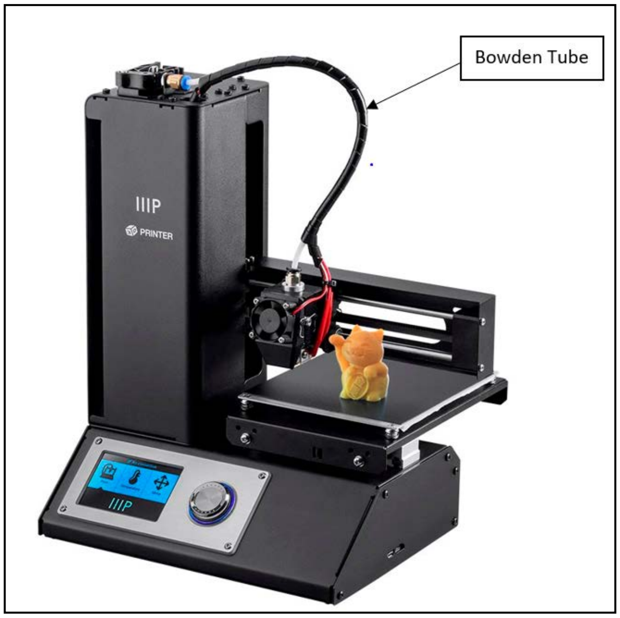


Figure 13. Monoprice Select Mini v2 printer with bowden tube [21].

The brittle filament tended to break throughout the tube, potentially due to the frictional forces within the tube, and/or the curvature of the tube. Additionally, with multiple breaks within the spooled filament itself, it was not possible to produce enough continuous length for printing an entire filter.

20 wt% and 10 wt% filament successfully extruded and wound with consistent diameter and length. Due to the unreliability of filaments produced with higher percentages of AC, the lower 20 wt% and 10 wt% AC composites were pursued for use in FDM and characterized through scanning electron microscopy (SEM) and thermogravimetric analysis (TGA).

After successful extrusion samples are imaged on the Thermofisher SEM using Bruker software to characterize the filament and carbon particles visually. Images were taken at this stage of the process to evaluate how the filament production process affected the raw materials and to characterize the final composite composition.

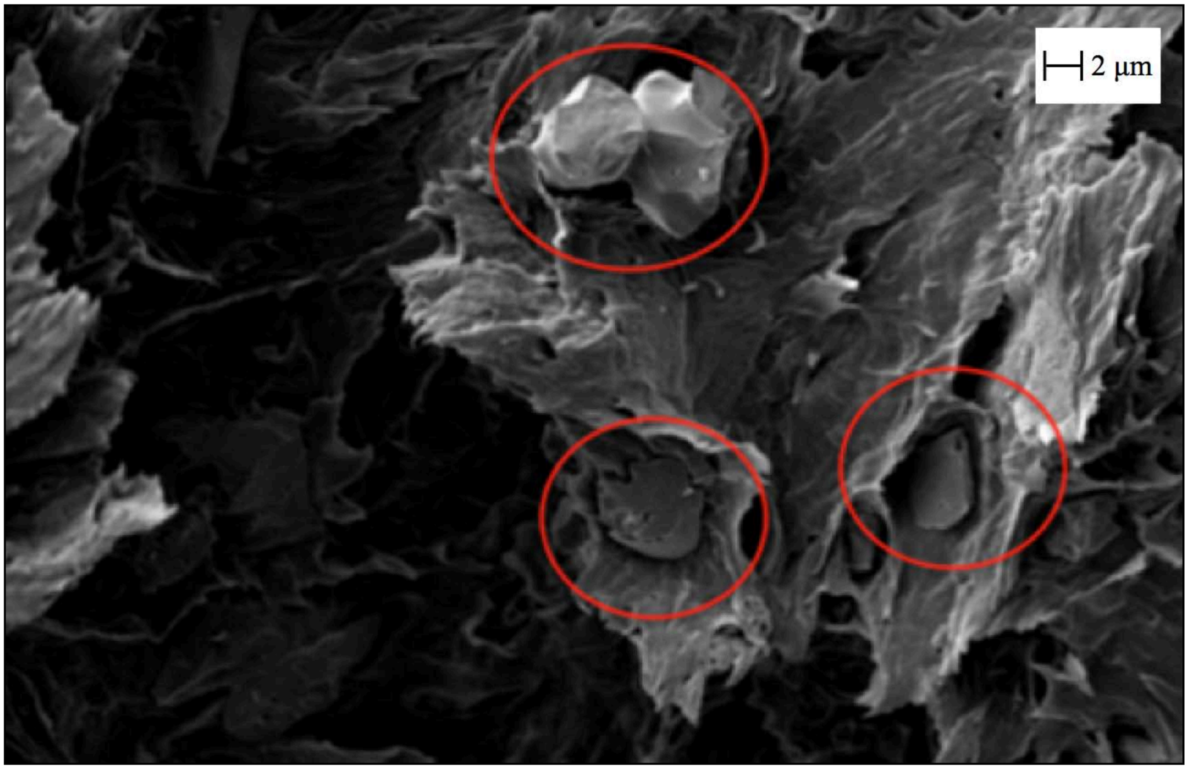


Figure 14. SEM image of HIPS/AC composite filament cross section with carbon particles shown embedded in HIPS, magnification 4.0K

Figure 14 demonstrates that AC particles were successfully integrated into the HIPS material. However, this image also suggests that at least one step in the filament production process breaks down the AC particles from their original size of 75-125 µm. Large AC particles (125 µm-75 µm) were combined and heated with D-limonene for 15 minutes to evaluate if and when the AC particles were broken down during the filament production process. The mixture was then placed in an autoclave until the D-limonene evaporated and only AC powder remained. SEM images were taken of both the stock AC, and treated AC.

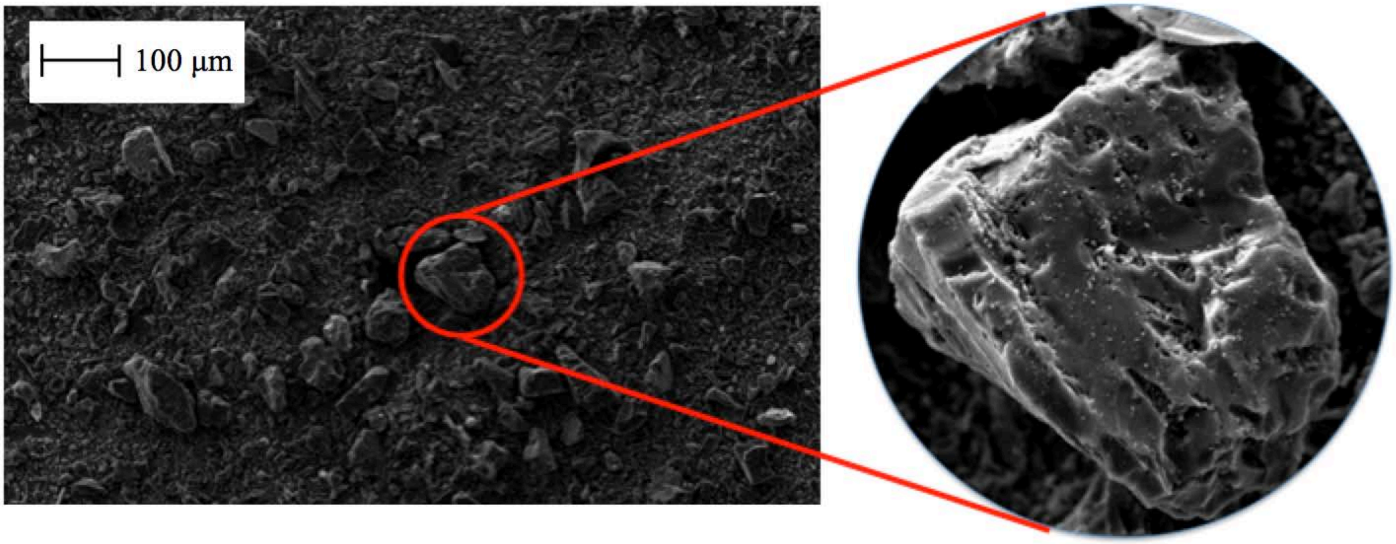


Figure 15. SEM image of stock carbon particles at 300 magnification.

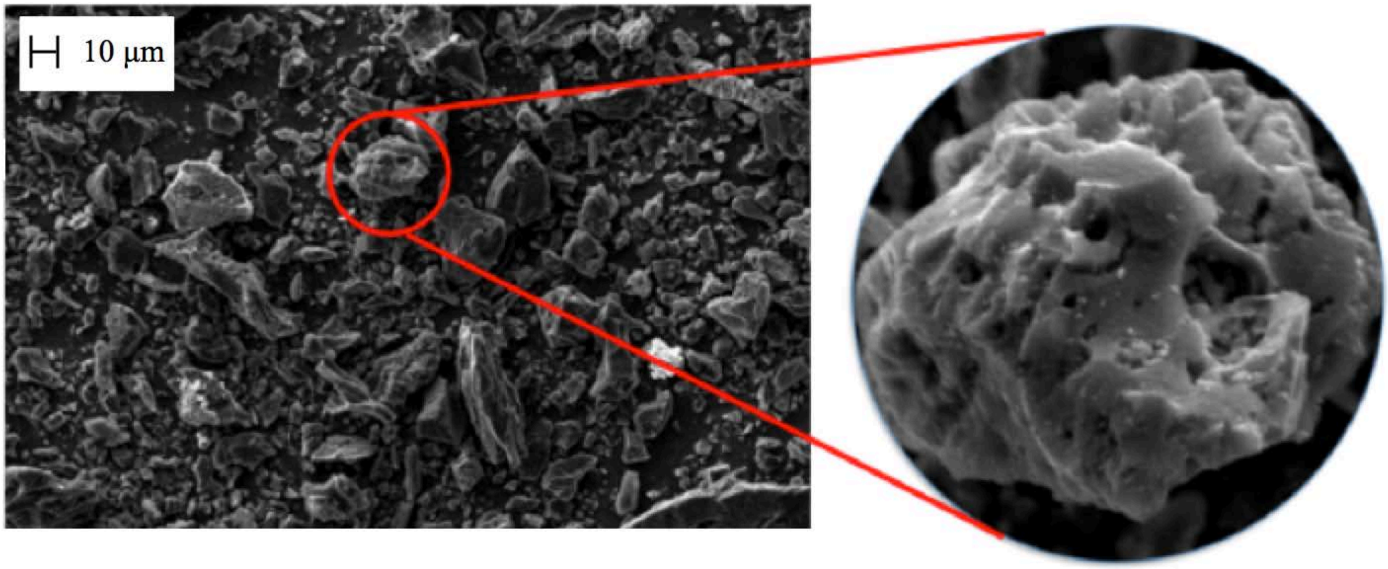


Figure 16. SEM image of carbon particles mixed with D-limonene at 900 magnification.

Figure 15 is a SEM image of AC particles after being sieved, prior to being mixed with D-limonene; the particle magnified on the right is approximately 100 μm, falling into the intended 75-125 μm range. This confirms that the mixing process begins with AC particles of the desired size, falling within the size range recommended for use in filtration applications. After being mixed with D-limonene and following the same processing as the HIPS/AC composite, the AC particles appear to be broken down, as seen in Figure 16. The particle magnified on the right is approximately 35 μm. This suggests that mixing AC particles with D-limonene under the same baking conditions as the composite material breaks down the AC particles to a size that is less than optimal for water testing applications. Additionally, various mechanical factors may have attributed to break down of AC particles. For example, the mixing shear forces involved in both the production of the composite as well as the plasticating extrusion process.

3.2.1 Thermogravimetric Analysis

Thermogravimetric analysis (TGA) tests were run to determine the carbon content in the HIPS/AC composite. Samples of pellets and filaments were weighed to 10.0 mg ± 0.5 mg and placed in an Al_2O_3 crucible in each trial. In each TGA test, the initial temperature was set to 30°C, and stepped by 20°C/min until reaching a final temperature of 1000°C. The test environment included purge and protective nitrogen gas flows. HIPS pellets were tested as a baseline to ensure proper machine function and confirmed 1000°C as an appropriate temperature, where HIPS completely volatilizes during the test, leaving no residual mass.

For each mixed percentage, the following samples were collected for TGA testing:

1. One sample of pellets, or bulk material
2. At least two samples of spooled filament
3. If printable, one sample of printed material from at least two successful prints

After the bulk material was pelletized for extrusion, the pellets were collected and a sample was selected at random for the TGA test. The filament samples were taken from beginning and end sections on the spool in order to determine composition consistency through the extruding process. Samples were not taken in the middle as to maintain the required continuous length for various prints. The 20 wt% filament made with large AC particles was also used to print small test samples in order to confirm that the AC content remained consistent. The 20 wt% material is the only printed material tested on TGA, as it was the only printable composition.

The TGA tests were compiled into one comprehensive graph for each separate mixture. The vertical decrease in mass percent, occurring between 400-500°C is the point at which HIPS volatizes and the only remaining content is AC. Below are the final tests conducted for the pellets and filament created using HIPS and 10 wt% AC particles sized 75-125µm.

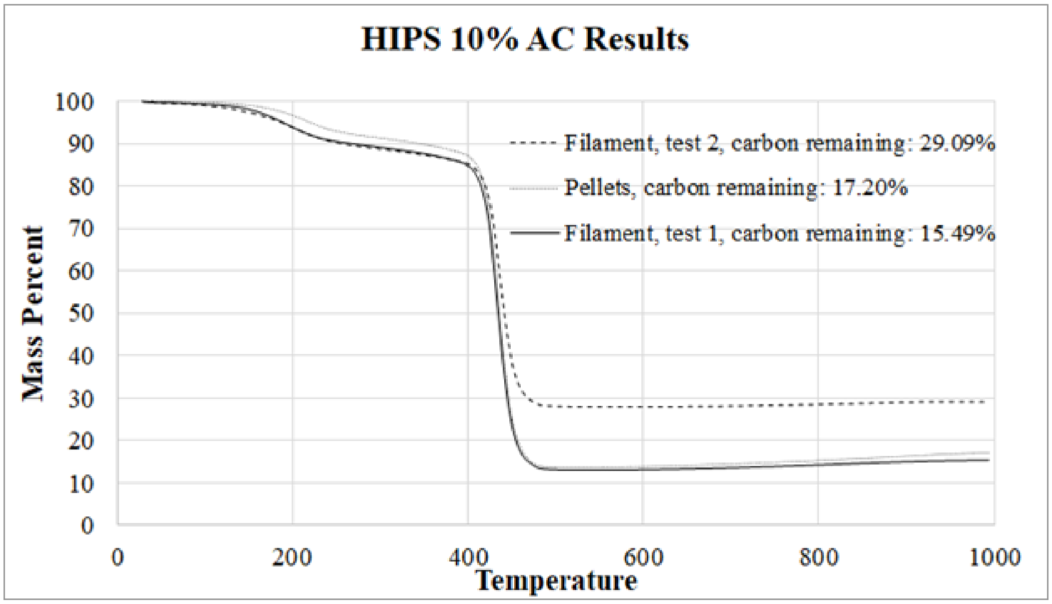


Figure 17. HIPS/10% AC TGA Results.

The results in Figure 17 illustrate inconsistencies in the 10 wt% mixture and filament. This data suggests both pre-extrusion and post-extrusion, the mixing of HIPS and 10 wt% AC yielded inconsistent product. A potential cause for these higher wt% values may be attributed to residual AC within the barrel from previous runs, as well as the lack of uniformity in the filament illustrated by the TGA results. Residual AC in the extruder was discovered after running various purges through the extruder with pure HIPS resin and still resulting in AC coated filament. The barrel was then inspected and further verified the case for residual AC. In addition, the non uniformity in the filament suggests AC may be collecting in some portions of the filament, while other sections may have significantly lower AC content.

Due to the inconsistency of 10 wt% filament, the 20 wt% filament was used to print samples or filters. Figure 18 below shows the final results from the pellets, filament, and printed material created using HIPS and 20 wt% AC particles sized 75-125 µm. The remaining mass percentages of residual AC average to about 17.8 wt% AC overall, as opposed to the target of 20 wt%.

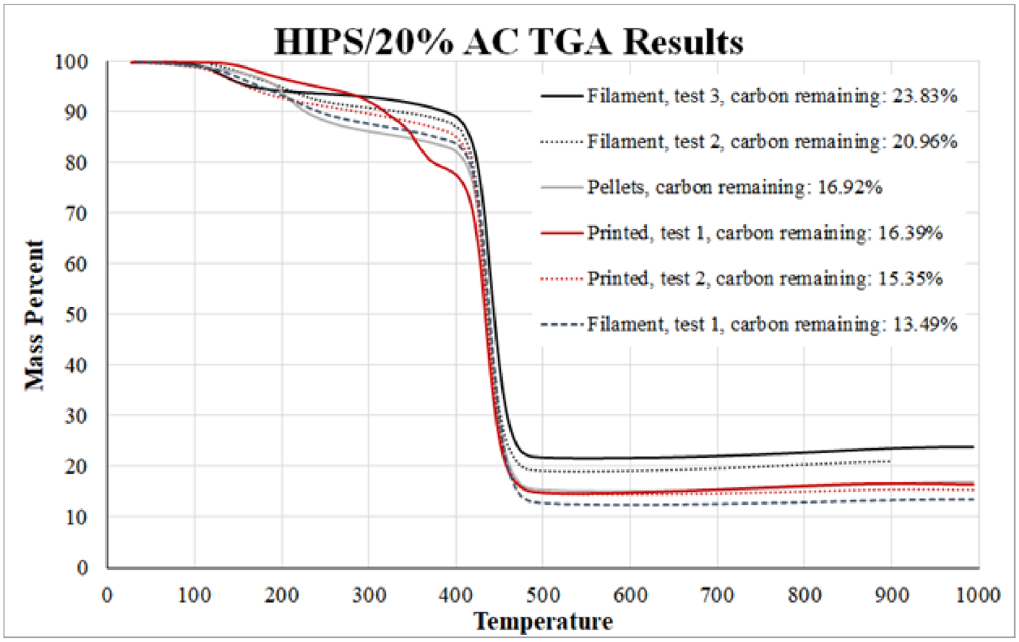


Figure 18. HIPS/20% AC TGA results.

As mentioned above, residual AC was found after purging the extruder barrel; this coupled with any possible filament inconsistencies could result in slightly variable AC percentages. In order to determine if any AC remained in the barrel of the extruder, the pure HIPS filament was tested using the TGA. This test proved that there was a quantifiable amount of AC in the barrel, with the final result showing a 6.6 wt% AC content in the filament. Other than demonstrating that material extruded from the barrel may contain AC, this may also explain the inconsistencies and loss of AC in the other filament samples. The full collection of TGA data and analysis for all filaments created can be found in Appendix A.

4 FILTER DESIGN

Design decisions were made for both the optimal material composition and optimal print design through a variety of iterative processes. There were two major design iterations. Initial designs focused on utilizing simple wafer prints that would benefit from the inherent porosity of FDM, however after various tests, wafer designs proved to be too solid for consistent flow. Following this, designs follow a more conical shape with perforated step layers to encourage increased contact time as well as to improve on the previous flow issue. These designs also sought to take advantage of the support geometry feature within the slicing software to add additional beneficial contact material to aid in filtration. The main variable changing between this second major design was the depth, and this was to improve contact time. Determinations are outlined in the following sections.

Considerations that guided the design process included: key components of AC water filters and advantageous FDM features. As these factors were identified, several prints were completed with Polylactic acid (PLA) to achieve a desired filter geometry for flow, without wasting the HIPS/20% AC filament.

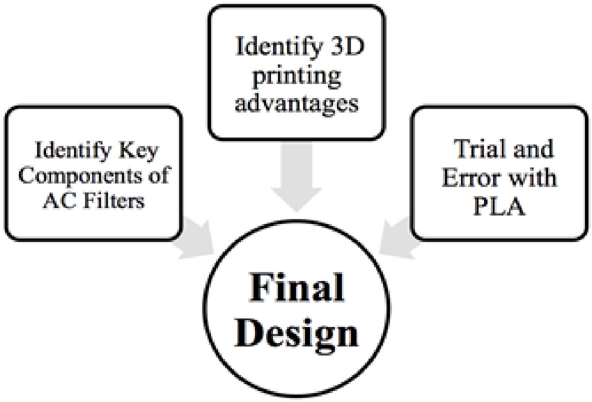


Figure 19. Filter design considerations and process.

Multiple design iterations were made, using simple geometries, such as a filter wafer shown in Figure 20. Initial filter wafer design.. The porosity of a FDM prints was expected to allow for effective water flow, but multiple attempts offered little or no flow through the part. Through many design changes it was determined that the most beneficial design would implement features for water to flow around the material as opposed to directly through a solid part, while taking advantage of the inherent porosity of the HIPS/AC filament and FDM manufacturing.

Figure 20. Initial filter wafer design.

The next major filter design involved a conical shape that promoted water flow, whilst saving material. Within this conical shape, perforated walls were added with 1mm diameter holes, that tapered to a final exit wall with 0.75mm diameter holes. Support structure was not only required to successfully print the filter, but it’s unique geometry also contributed to increasing the contact area between water and the HIPS/AC material . For this reason, the print was oriented with the wider side down to save material and to add this support structure in the desired regions. Two prints of each material were made, HIPS and HIPS/20%AC, in order to conduct thorough testing for water flow and filtration. A cross-sectional view Design A is shown in Figure 21.

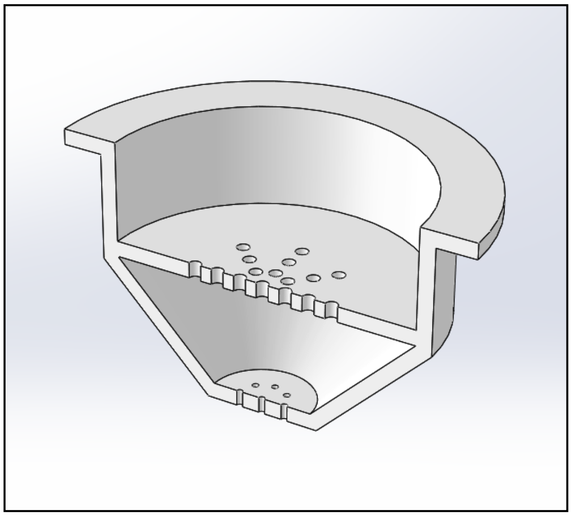


Figure 21. Solidworks render of Design A.

A second design was made in an effort to further improve AC contact time with the MB concentration. Filters often implement deep designs to achieve desirable contact time. The second major design utilized the same geometry as the previous, however the depth of the part was increased from 38 mm to 51 mm. All other quantities such as the taper angle of the cone and the diameter of the inlet and exit remained the same. Figure 22 shows the printed Design A on the left and Design B on the right.

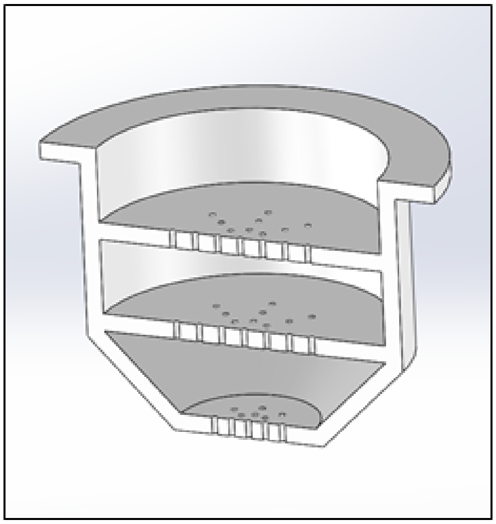


Figure 22. Solidworks render of Design B.

Figure 23. Printed HIPS/20% AC filters of Design A (left) and Design B (right).

4.1 Final Printing Parameters

Designs A and B were completed in both HIPS and HIPS/20% AC filament. HIPS filament was purchased from MG Chemicals in 1.75 mm diameter. Prints were produced on FDM printers with similar capabilities, the Monoprice Select Mini v2 and Prusa i3 mK2 style printers. The slicing software utilized was Cura 3.2.1. All prints were on a glass bed treated with a thin layer of E1588 Elmer's Disappearing Purple Glue Stick to improve bed adhesion. Refer to Appendix B for material safety information. SEM imaging was used to show the difference between the porosity and structure of the two printed materials as shown in Figure 24 and 25.

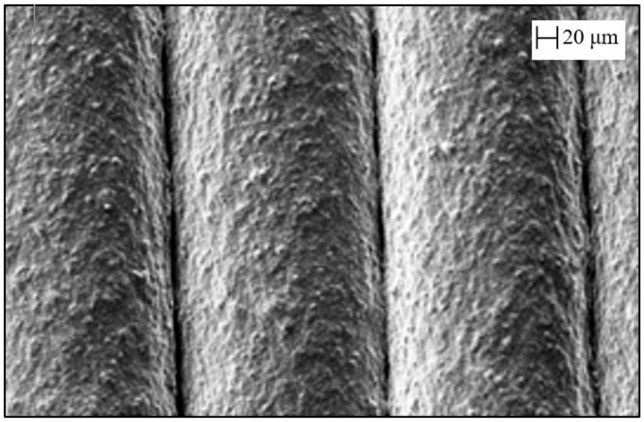


Figure 24. SEM image of printed support structure of pure HIPS at 500 magnification.

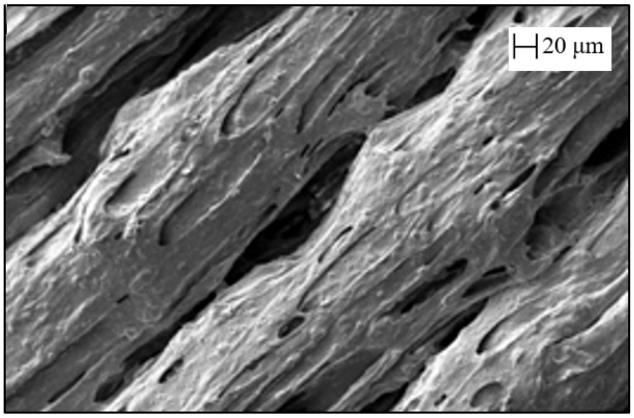


Figure 25. SEM image of printed support structure of HIPS/20% HIPS at 500 magnification.

These images demonstrate how the addition of AC to HIPS filament increases the porosity of printed material. These pores allow water or another solution to access the AC particles and encourage contact between the AC and contaminants.

The first full filter design, pictured in Figure 23 on the left, was printed on a Prusa i3 mk2 style printer (Printer 1) depicted in Figure 26. The Monoprice Select Mini v2 was unable to print the composite filament because the filament consistently broke in the bowden tube. The Prusa was used due to the direct feed extruder feature of the printer. The filament did not break in a direct injection printer, yielding a successful print. However, after one successful print, the same printer experienced numerous extruder clogs and failed mid print. Therefore, a different Prusa i3, Printer 2, was used for the second successful print, which included a new extruder tip.

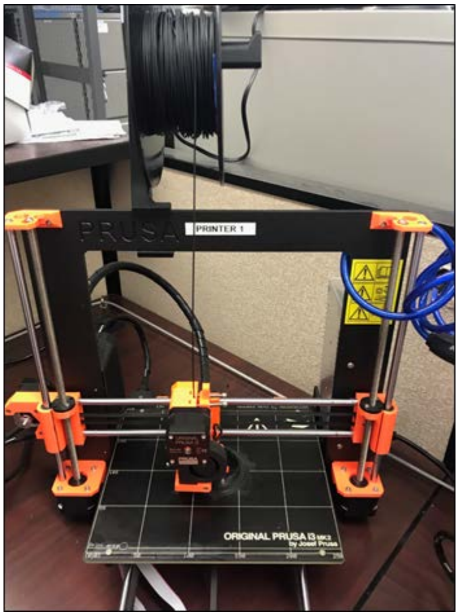


Figure 26. Prusa i3 mk2 printer.

Table 2 outlines the custom printing parameters utilized in the printing process for both materials, other quantities were left at their default values for the respective printers within the slicer.

Table 2. Printing parameters and values for all printed filters.

EXTRUDER TEMP. (°C)	215
BED TEMP. (°C)	65
PRINT SPEED (mm/s)	30
INFILL DENSITY (%)	20
LAYER THICKNESS	Draft Quality
SUPPORT GEOMETRY	Zig Zag
BED ADHESION	Brim

5 FILTER TESTING

Once the final HIPS/AC filters were successfully printed, water testing using the organic substance, methylene blue (MB), was conducted. The desired results were at least 50% removal of MB concentration, to prove the filters effectiveness. The following research questions were developed to guide the procedures completed for water testing of the filter Designs A and B for HIPS and HIPS/20%AC.

1. Does printing the filter with HIPS/ 20%AC filament decrease MB concentration compared to a filter printed with HIPS?
2. Does increasing the surface area of filter decrease MB concentration?
3. How does filtration effectiveness change after multiple uses?

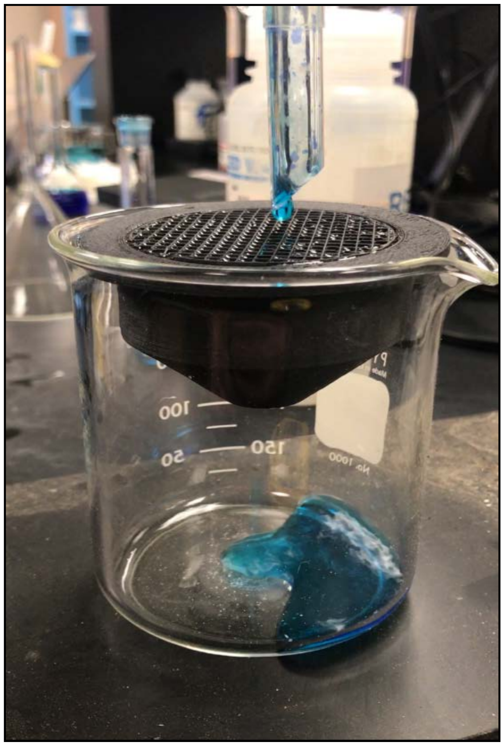


Figure 27. MB testing of Design A HIPS/20% AC printed filter.

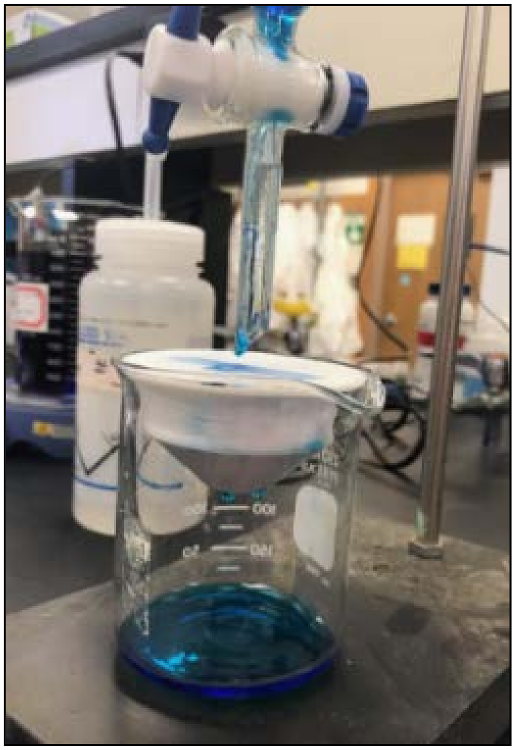


Figure 28. MB testing of Design A pure HIPS printed filter.

5.1 Filter Testing Procedure

The following procedure was conducted to evaluate the HIPS and HIPS/20%AC filters for Designs A and B.

1) Mix known concentration solution of MB and deionized water (DI)
    a) Weigh MB powder sample on scale
    b) Fill 1000 mL volumetric flask with DI water
    c) Pour half the volume of water into 1000 mL beaker
    d) Add metal stirring rod, MB powder sample, and remaining water to beaker
    e) Mix solution constantly on magnetic stirring plate
    f) Calculate and record the solution's concentration
2) Calibrate spectrometer
    a) Using a plastic pipette, dispense the original solution into a cuvette
    b) Using "scan" software determine the wavelength where peak absorbance is measured for MB (approximately 610 nm)
    c) Using a plastic pipette, dispense the original solution into three cuvettes
    d) For each cuvette, record the absorbance measured and average the samples
    e) Using a plastic pipette, place DI water into a cuvette and place into spectrometer
    f) Set spectrometer to read the absorbance at a wavelength of 610 nm, run scan, and record value obtained, if the absorbance is not 0 for DI water, the value it reads is the intercept of the calibration curve equation.
    g) Using the known concentration absorbance, and the DI water absorbance, plot the data points on a graph with concentration on the x-axis and absorbance on the y-axis.
    h) Using these two data points solve for the slope of the line
        i) Slope = Δ Absorbance/Δ Concentration
    i) Solve for concentration in the calibration curve equation
        i) Absorbance= Slope*Concentration+Intercept
        ii) Concentration = (Absorbance-Intercept)/Slope
3) Run MB solution through filter
    a) Weigh dry filter and record weight
    b) Place filter over an empty beaker (beaker size dependent on size of filter)

c) Place a burette above the filter and beaker, and pour 50 mL of the MB solution into the filter below
d) Once 10 mL of solution has flowed through the filter, begin a timer
e) After another 10 mL of solution has been filtered, stop timer and calculate flow rate
f) Once the solution stops dripping from the filter, use a plastic pipette to dispense the filtered solution into three cuvettes.
g) Measure and record the absorbance values for each cuvette sample in the spectrometer
h) Average the absorbance values, and calculate the concentration using the calibration curve equation
i) Weigh the filter and record weight
j) Repeat steps b through i using the same filtered MB solution from the previous trial, until the filter removes less than 2% concentration
k) After the filter reaches less than 2% removal, pour the original, MB solution with full concentration through the filter, record the concentration, and compare this value to the first run

5.2 Filter Testing Results

Two Design A filters were printed using HIPS filament and HIPS/20% AC Filament. The HIPS filters were used to address the research question: “Does printing the filter with HIPS/20%AC filament decrease MB concentration compared to a filter printed with HIPS?” Since the HIPS filters resulted in negligible removal percentages based on the results displayed in Figure 29, it was evident that the addition of AC to HIPS filament increases the filtering capabilities. Design B was printed with HIPS/20% AC filament to address the research question, “Does increasing the surface area of the filter decrease MB concentration?”. However, after testing Design B, which had more surface area, the percent MB concentration removed was still less than the original Design A print. Lastly, determining, “How does filtration effectiveness change with multiple uses?”, was done by performing test trials until the percent removal of MB was 2% or lower. 2% was chosen as the benchmark as at this point the percent removal tended to bottom out or approach zero. This confirmed the expectation that, similarly to other common AC filters, the filter effectiveness would decline at a sharp rate after reaching a saturation point.

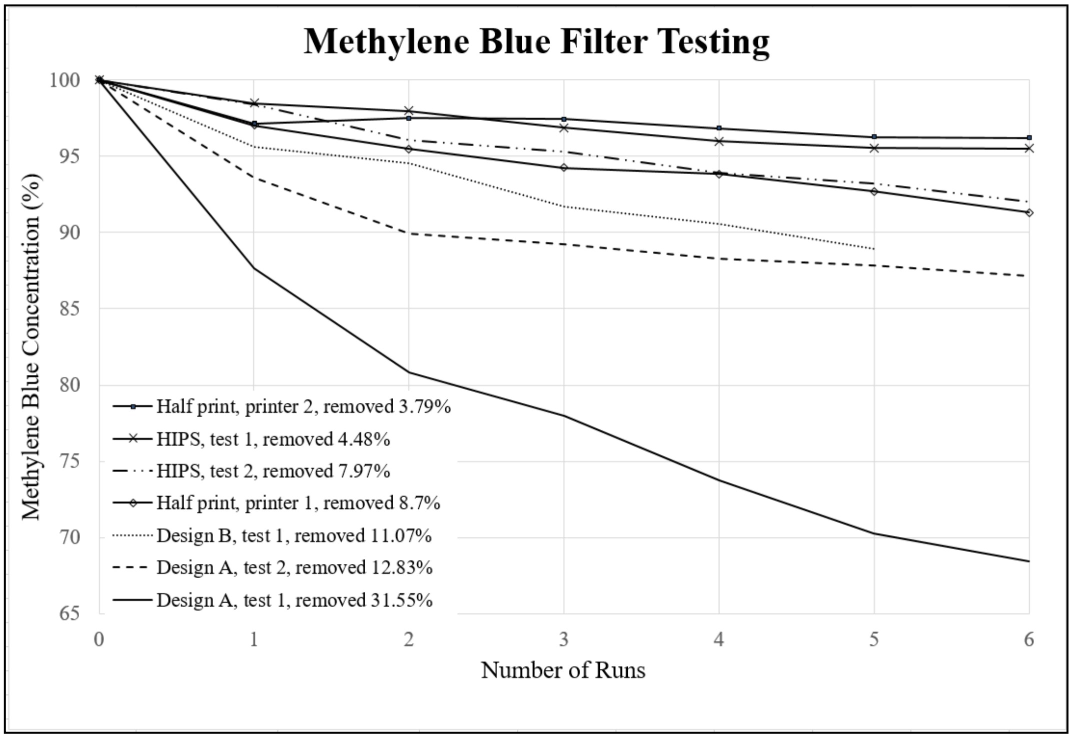


Figure 29. Methylene blue filter testing for all printed filters.

The first water test conducted was on the first Design A print, which filtered out 31.55% of the MB concentration. This filter was printed on Printer 1. Using the same model, software, and code on a second printer (Printer 2), a second Design A filter was printed to obtain more data points. This filter only removed a total of 12.83% MB. A comparison of these results are depicted in Figure 30 below. The filtration of the second Design A filter was much lower than the original; since the second Design A and Design B were printed on a different printer than the original Design A, further investigation into the printers and their resulting filters was conducted.

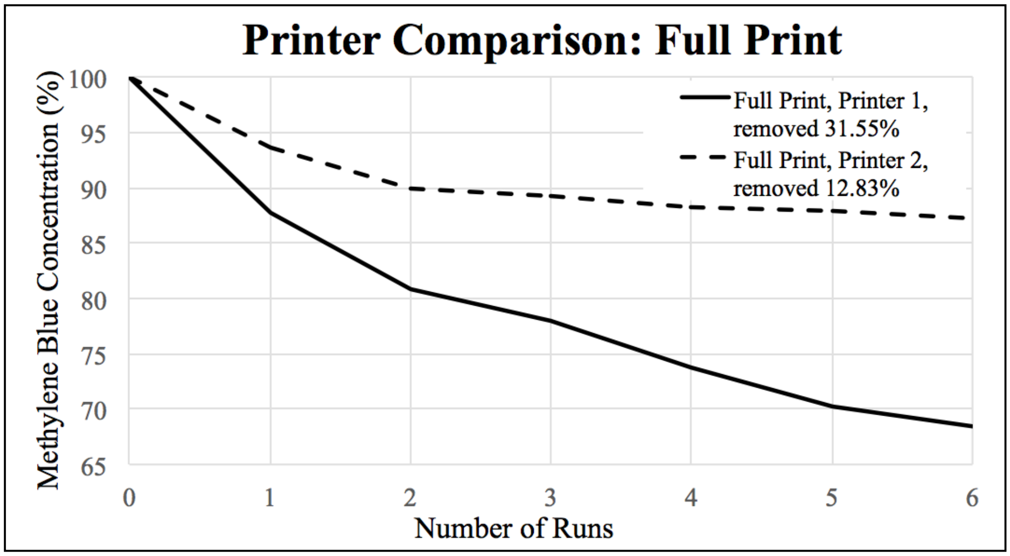


Figure 30. Methylene blue water testing results showing the comparison of the full prints from Printer 1 and Printer 2.

To visually investigate the difference between the two printers, the following SEM images were taken, comparing prints from Printer 1 and 2.

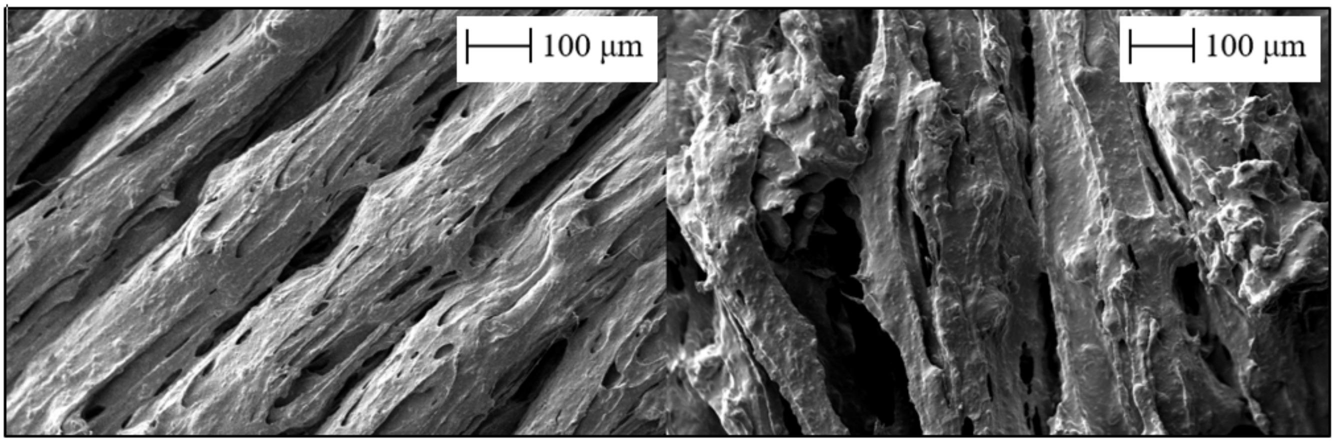


Figure 31. SEM images of support structure of HIPS/20% AC from Printer 1 (left) vs. support structure from Printer 2 (right), magnification 300.

Figure 31 shows the support structure produced by both Prusa i3 mK2 printers, on the left, Printer 1, and on the right, Printer 2. After MB testing with Design A from Printer 1 and Printer 2, it was evident that the filter produced by Printer 1 was more effective than the filter from Printer 2. These images show that the two distinct printers produce physically different outputs. The image on the left depicts a homogeneous and consistently porous support structure from Printer 1. The image on the right demonstrates not only less consistency but fewer visible pores in the support structure from Printer 2. The lack of pores in the printed material on the right may explain the notable difference in MB testing results. Since the AC particles exist right below the top surface of HIPS, the homogeneous porosity in the image on the left is how the MB solution accesses the AC, the filtering agent. Without these pores, the solution will not make nearly as much contact with the AC particles. In FDM, there are many factors that can cause severe degradation to the quality of the print including wear on the motors, belts, extruding tips, and heating elements. Additionally, environmental factors like room temperature, humidity, and air flow all significantly impact the quality of a print, even with the same printer being run. With using two different printers in different rooms with different ambient conditions, there can be many factors leading up to the significant differences between the prints.

To further explore the difference in printers, a half print, a filter design printed to 50% completion, from Printer 1 and a half print from Printer 2 were tested, and the results are compared in Figure 32.

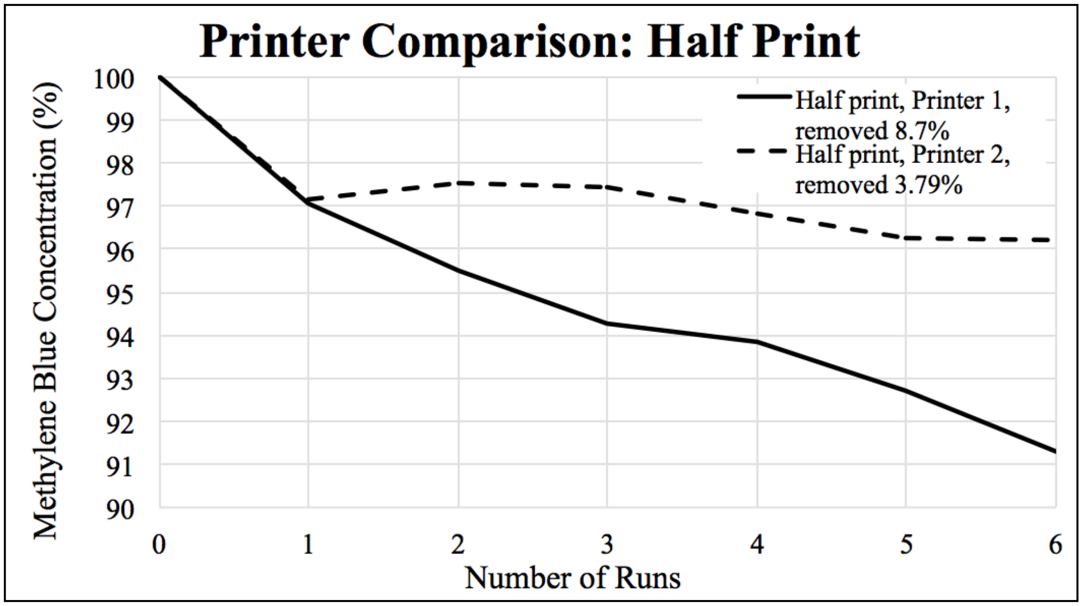


Figure 32. Methylene blue water testing results showing the comparison of the half prints from Printer 1 and Printer 2.

Half prints, was used for testing in order to preserve printable filament. These results corroborated the theory that a change in printer decreased how effectively the filter removed MB. The full print on the Printer 2 filtered approximately half as much MB concentration, as the full print from the Printer 1. The half print comparison shows a similar relationship between the printers.

After passing the same MB solution through the filter six times, the largest removal percentage amongst the filters was 31.55%, which was still significantly lower than the desired minimum of 50% MB concentration removal. One possible reason for this was the MB was not exposed to enough AC due to the particles being encapsulated under the HIPS. Another reason, could be that the filament production process broke down the size of the AC particles to smaller than the desirable size of approximately 140 μm. Printed support structure of HIPS/20%AC and pure HIPS were etched with D-limonene to investigate both of these possibilities.

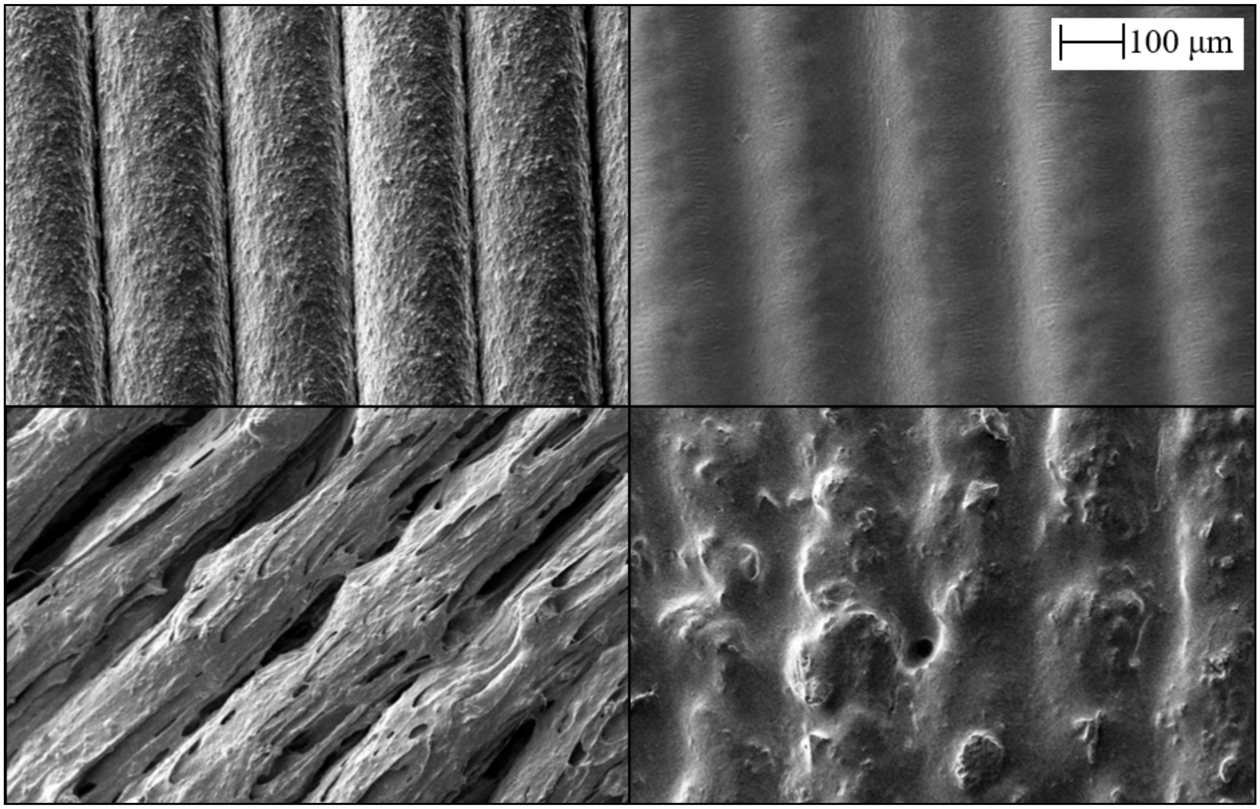


Figure 33. SEM images from top to bottom: HIPS support structure vs. etched HIPS support structure, HIPS/20%AC support structure vs. etched HIPS/20% AC support structure.

Figure 33 above shows a side-by-side comparison between the interaction of D-limonene used as an etchant on the support structure. In the top row, a pure HIPS support structure is exposed to pure D-limonene and as expected the support structure begins to dissolve into a smooth material. The same process was applied to the HIPS/20% AC support structure and AC is clearly exposed. This demonstrates that the filament production process does successfully integrate AC particles into filament and, moreover, indicates that the AC is encased by an outer layer of HIPS material.

A chemical etching process was investigated to further verify the encasement of AC particles within a outer HIPS layer, as well as to see if the material could be improved through etching. The printed material was etched using pure D-limonene in order to melt the HIPS material and assess where through the diameter of the filament the AC particles exist. The etched HIPS/20% AC demonstrated the material is relatively homogeneous in terms of the distribution of AC throughout the HIPS. Figure 34 as shown below, displays the size of a carbon particle exposed through etching. When the sample was being viewed, the particle below appeared to be a similar size to surrounding particles, approximately 100μm, with similar geometric features to the unprocessed AC samples.

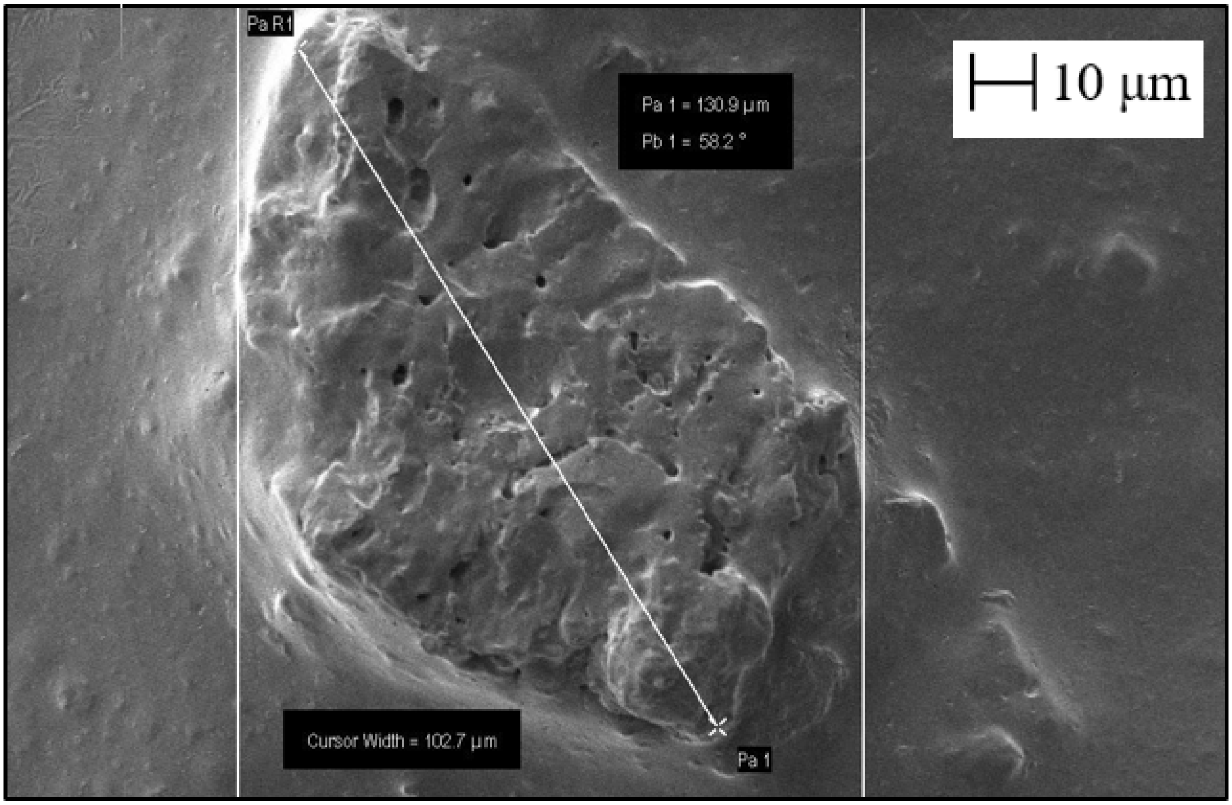


Figure 34. SEM image of etched support structure with labeled carbon particle size, at 1.5K magnification.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

This preliminary project demonstrated the potential for a novel technology in polymer composites and additive manufacturing. A HIPS/AC polymer-filler composite was processed with the intent of water filtration using the filtering properties of AC with organic molecules. Through various processing and design iterations, multiple filters were successfully printed using a newly processed composite material. The processing method was verified using both TGA and SEM analysis. TGA demonstrated the effectiveness of the processing method. SEM illustrated the successful impregnation of AC particles on the HIPS surface. Filters underwent water testing utilizing spectrometry and a MB solution for demonstrating organic contaminant removal. The most effective filter removed a total of 31.55% of the MB in solution. Thus, with further investigation a more effective filter could be created, illustrating the potential within water filtration, as well as other applications involving polymer composites and additive manufacturing.

6.2 Recommendations

Based on the above results the following recommendations are made for future work on HIPS/AC filament development with water filtration application. These are based primarily on results of water testing and further investigation using SEM based on those results.

6.2.1 Particle Size

The efficiency of the filter is predicated on the maximization of exposed AC particulate. One key element to take into consideration is how the AC is broken down mechanically through processing as AC is exceptionally brittle with relatively low hardness. The SEM images in section 3.2 indicate the AC particles are breaking down to as small as 35 µm after being mixed with D-Limonene. Studies have shown that removal of MB by AC is more effective with particles around 140µm [18]. The original AC particles in this development process were 75-125 μm, which resides at the lower limit of the optimal size range for AC particles in water filtration applications. In further development, larger particles should be used, with the expectation that through processing they will break down.

6.2.2 Heating Temperature and Duration

The removal of D-Limonene and re-solidification of the HIPS/AC is critical to proper deposition during printing. When the D-Limonene is not fully evaporated, it is vaporized during extrusion, producing breaks in the winding process and discontinuities while printing. Further investigation should be done to optimize the temperature and duration in which the HIPS/AC and D-limonene is baked is baked in an autoclave in order to minimize residual D-Limonene.

6.2.3 Etching

Because of the nature of FDM, as the filament is deposited during printing, the carbon becomes encased within the extrudate. In future work, a light etching process should be experimented with and used to expose the carbon to increase the efficacy of the printed filter. A 25% D-Limonene solution was attempted as an etchant, however it dissolved the entire filter, rendering it unusable. Acetone may be an effective option for this post processing etchant as the solubility parameters allow for the removal of HIPS from the surface, and it is polar allowing it to be easily diluted with reagent grade water.

6.2.4 Rate of Mixing and Temperature

Combining the raw materials should be done so in a heated mixer with an automated mixer. The importance of this stems from the breaking down of carbon as over processing the material will produce significantly broken down AC resulting in a loss of efficiency. Heating expedites the process of melting the HIPS material. Without heat the process could take up to 24 hours to dissolve the pellets before the AC can be added. Additionally, without heat the mixture was more viscous and mixing the AC homogeneously was impossible, which was evident after the pelletizing process when there were large HIPS pellets embedded in the larger composite sheet. The automated mixer would create more consistency between each mixture of composite, mixing by hand is not as reliable. The speed of mixing with automation can also be optimized in order to limit AC breakdown.

6.1.5 Print Parameters

Another optimization process includes investigating the print parameters and their effect on filter quality. It was evident that printer settings are pertinent to how effective the filter is after testing two different printers. However, further considerations into printer extrusion temperature, infill, speed, and other parameters and how they affect the print quality and filtering ability are recommended. Additionally, determining ideal conditions for the printer environment could eliminate further variability.

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APPENDICES

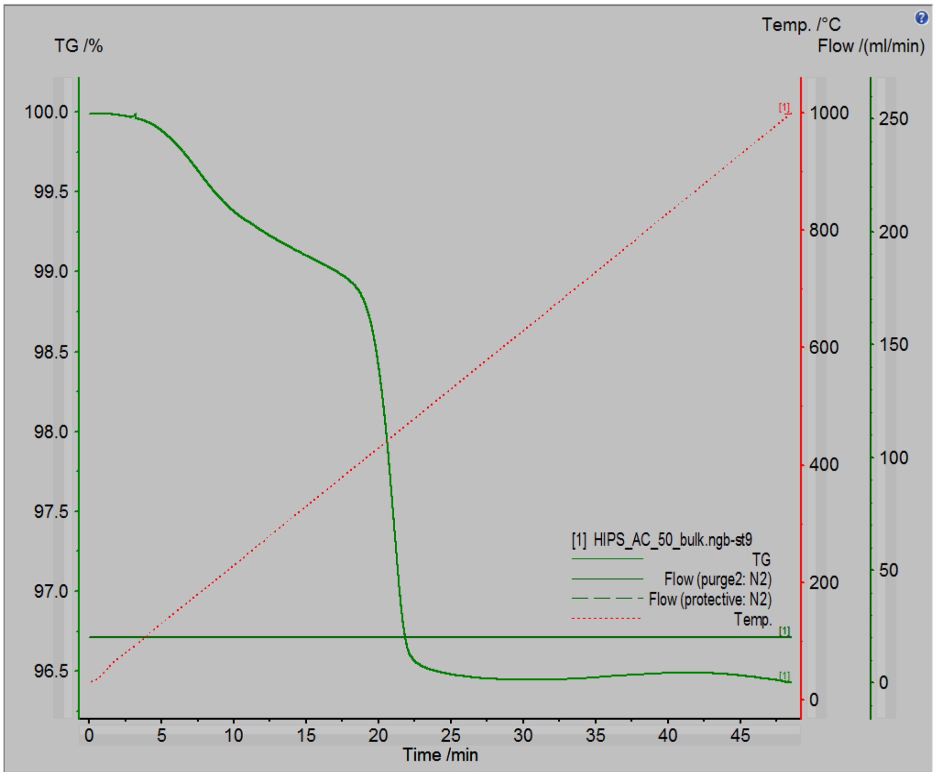
The following sections provide additional data collected as well as safety data sheets for all materials used throughout the filter design process.

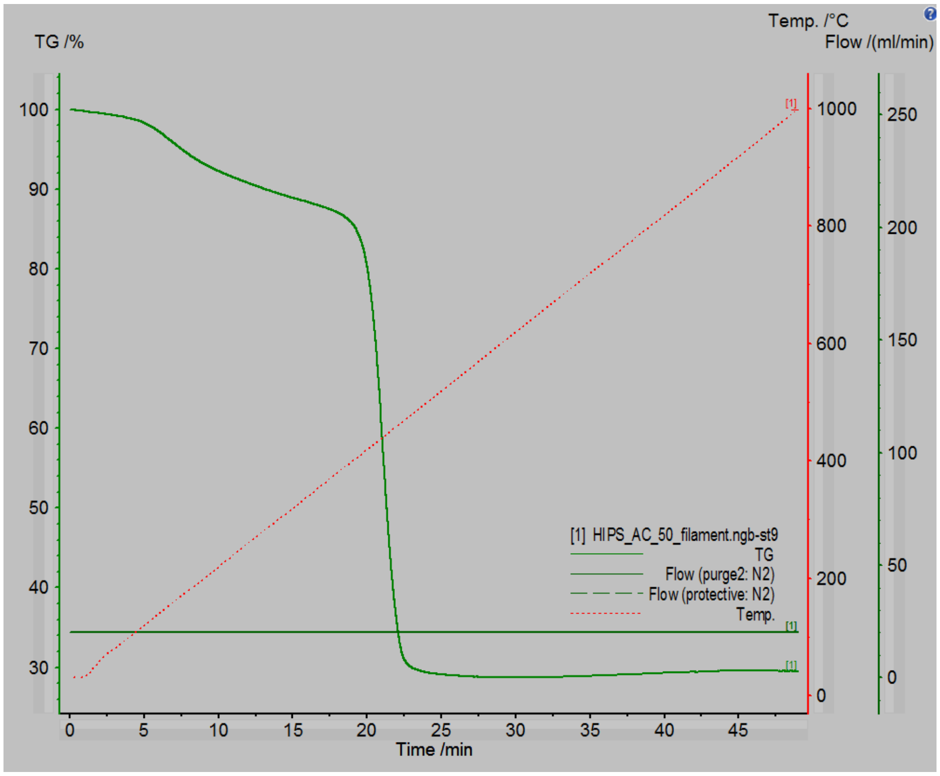
Appendix A

Thermogravimetric Analysis Results

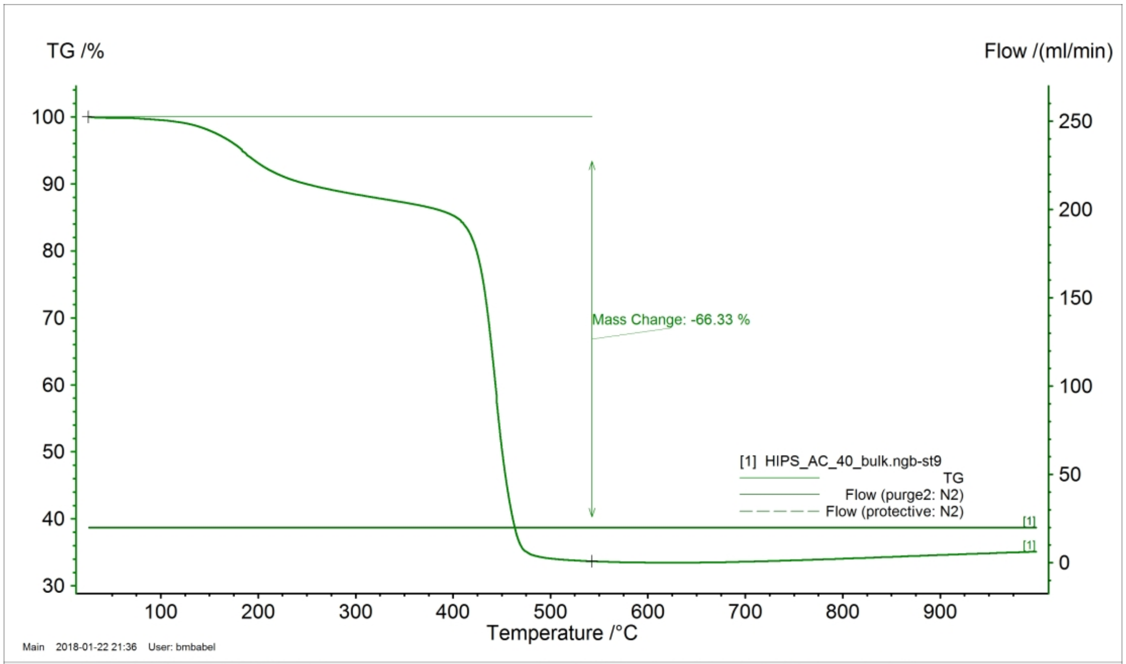
Thermogravimetric analysis was conducted using the Netzsch TG209 F1 Libra and Proteus 9.1 software to confirm the weight percent of activated carbon in the filament. Below are graphs generated by the Proteus software that confirm our processing methods yield low activated carbon loss in 10 weight percent increments from 50 to 0 percent.

50 Weight Percent Carbon Trials





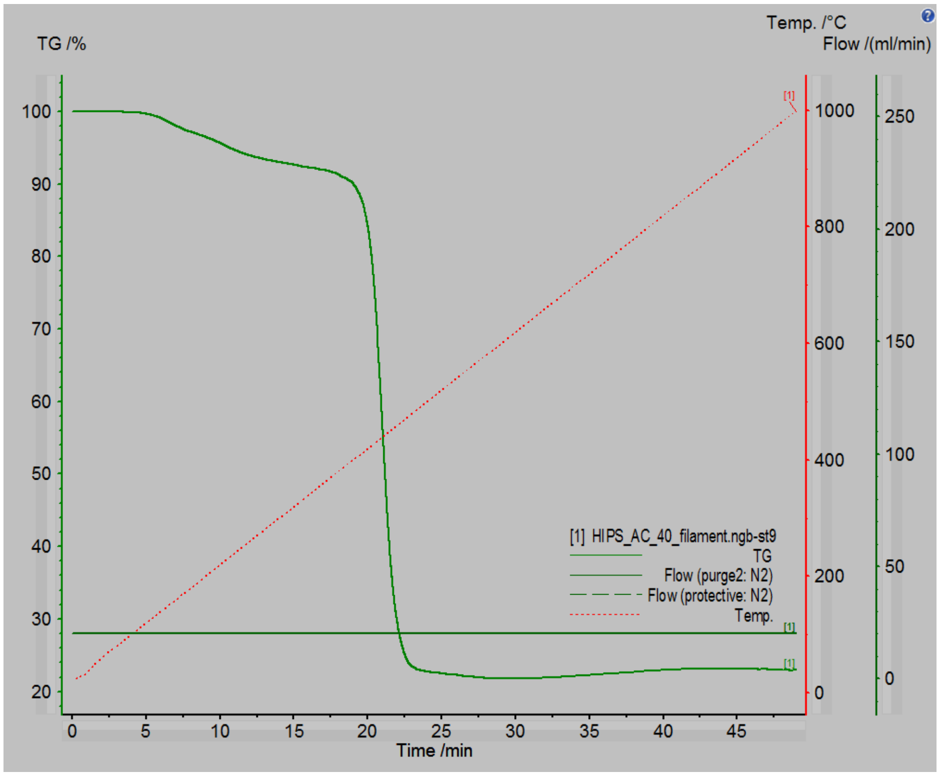
40 Weight Percent Carbon Trials

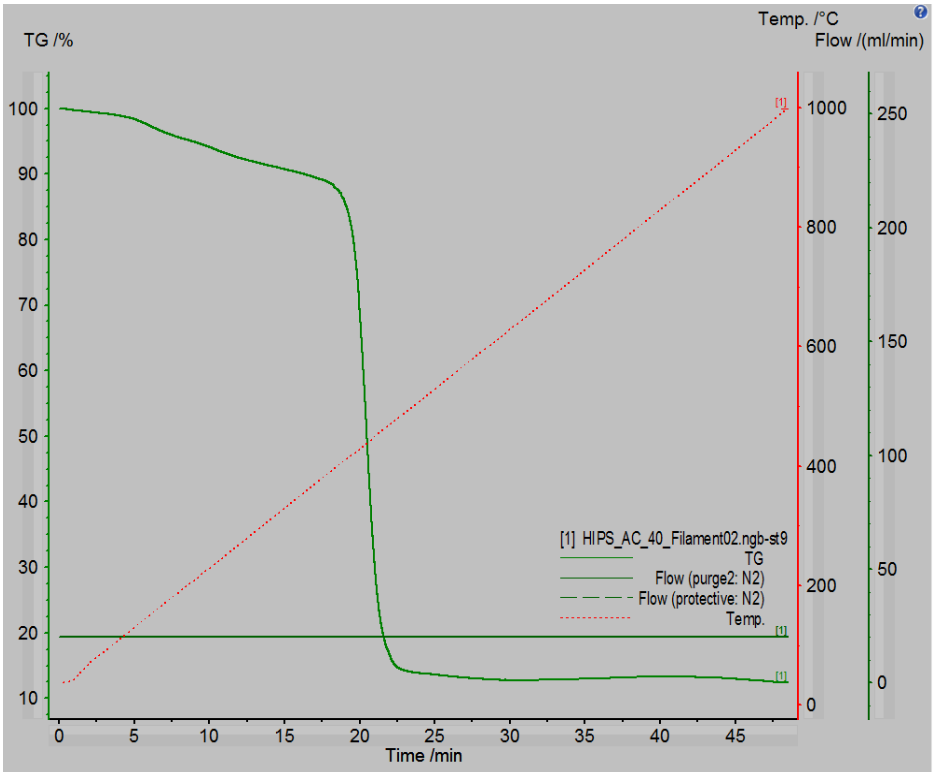


Instrument : NETZSCH TG 209F1 Libra TGA209F1D-0030-L **File :** C:\NETZSCH\Proteus70\data\MQP RP\HIPS_AC_40_bulk.ngb-st9

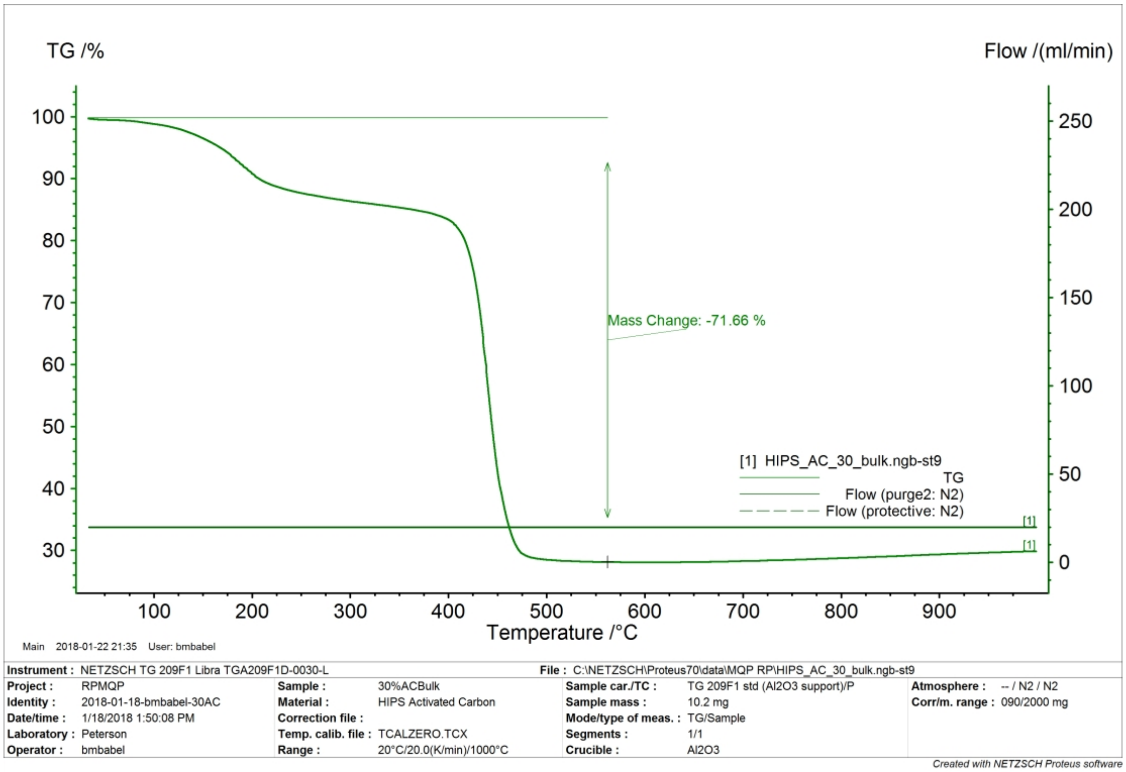
Project :	RP MQP	**Sample :**	Bulk 40% AC	**Sample car./TC :**	TG 209F1 std (Al2O3 support)/P	**Atmosphere :**	-- / N2 / N2
Identity :	01-19-2018-bmbabel-40%	**Material :**	HIPS Activated Carbon	**Sample mass :**	10.4 mg	**Corr/m. range :**	090/2000 mg
Date/time :	1/19/2018 11:54:23 AM	**Correction file :**		**Mode/type of meas. :**	TG/Sample		
Laboratory :	Peterson	**Temp. calib. file :**	TCALZERO.TCX	**Segments :**	1/1		
Operator :	bmbabel	**Range :**	20°C/20.0(K/min)/1000°C	**Crucible :**	Al2O3		

Created with NETZSCH Proteus software




TG /%
Temp. /°C
Flow /(ml/min)
100
90
80
70
60
50
40
30
20
10
1000
800
600
400
200
0
250
200
150
100
50
0
0
5
10
15
20
25
30
35
40
45
Time /min
[1] HIPS_AC_40_Filament02.ngb-st9
TG
Flow (purge2: N2)
Flow (protective: N2)
Temp.
[1]
[1]
[1]

30 Weight Percent Carbon Trials

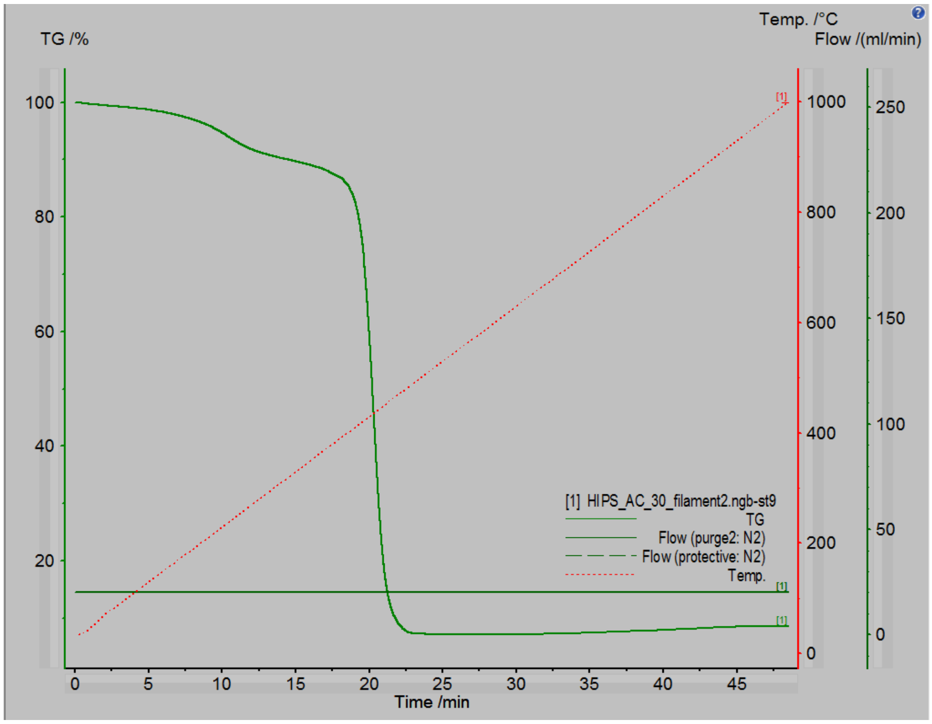


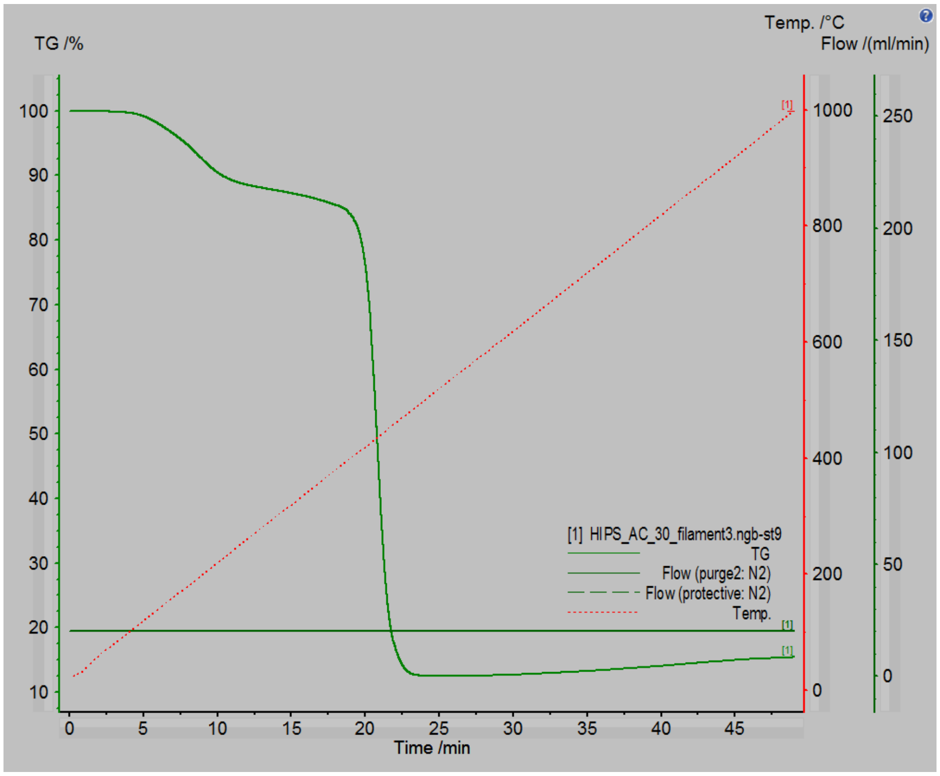
Main 2018-01-22 21:35 User: bmbabel

Instrument : NETZSCH TG 209F1 Libra TGA209F1D-0030-L
File : C:\NETZSCH\Proteus70\data\MQP RP\HIPS_AC_30_bulk.ngb-st9

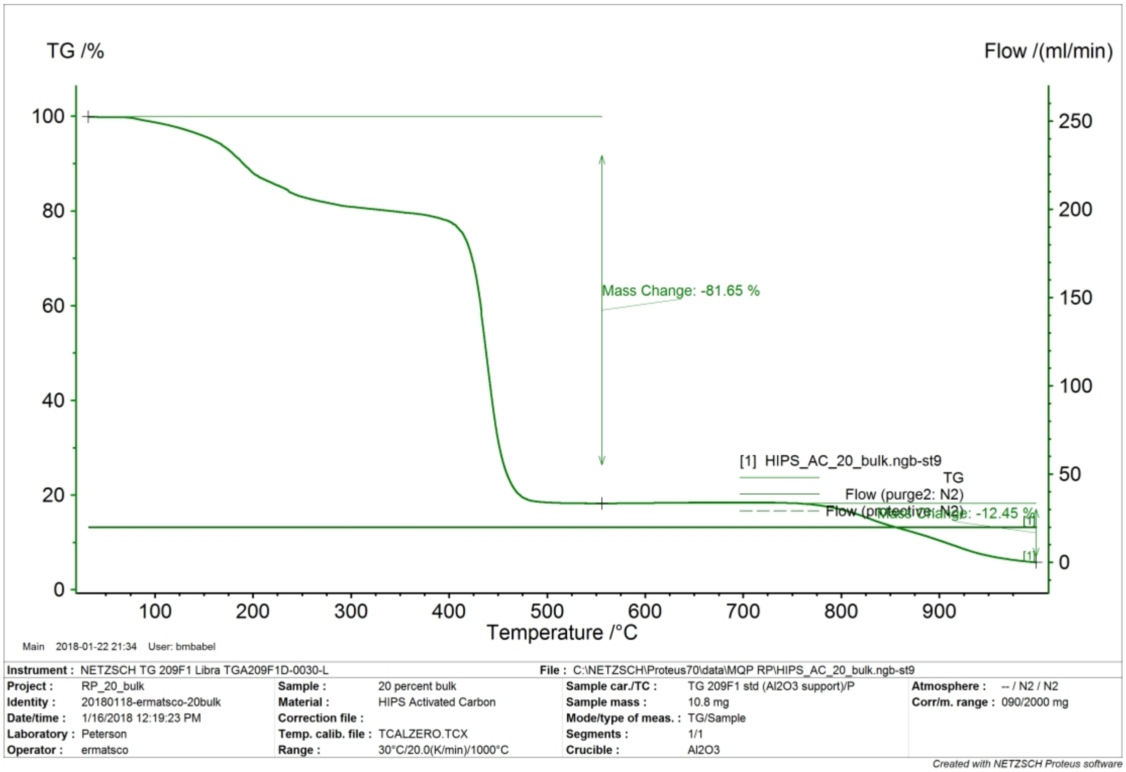
Project :	RPMQP	**Sample :**	30%ACBulk	**Sample car./TC :**	TG 209F1 std (Al2O3 support)/P	**Atmosphere :**	-- / N2 / N2
Identity :	2018-01-18-bmbabel-30AC	**Material :**	HIPS Activated Carbon	**Sample mass :**	10.2 mg	**Corr/m. range :**	090/2000 mg
Date/time :	1/18/2018 1:50:08 PM	**Correction file :**		**Mode/type of meas. :**	TG/Sample		
Laboratory :	Peterson	**Temp. calib. file :**	TCALZERO.TCX	**Segments :**	1/1		
Operator :	bmbabel	**Range :**	20°C/20.0(K/min)/1000°C	**Crucible :**	Al2O3		

Created with NETZSCH Proteus software




TG /%
Temp. /°C
Flow /(ml/min)
100
90
80
70
60
50
40
30
20
10
1000
800
600
400
200
0
250
200
150
100
50
0
[1]
[1] HIPS_AC_30_filament3.ngb-st9
TG
Flow (purge2: N2)
Flow (protective: N2)
Temp.
[1]
[1]
0
5
10
15
20
25
30
35
40
45
Time /min

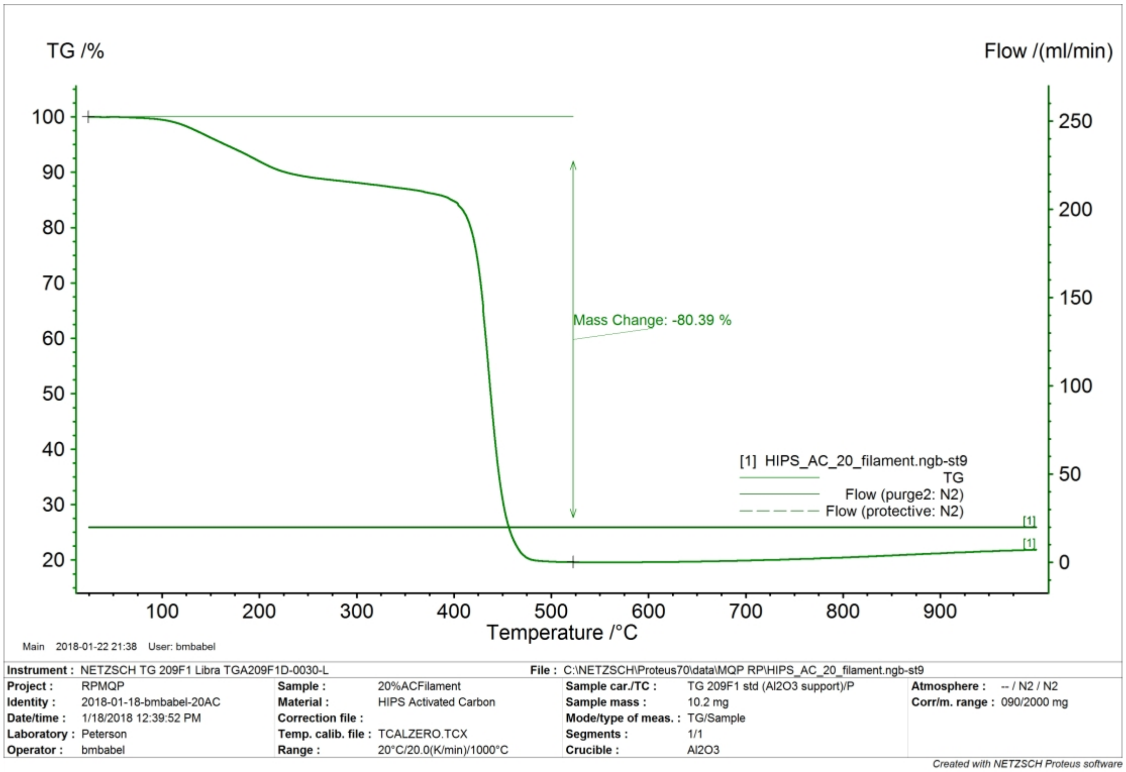
20 Weight Percent Carbon Trials



Instrument : NETZSCH TG 209F1 Libra TGA209F1D-0030-L **File :** C:\NETZSCH\Proteus70\data\MQP RP\HIPS_AC_20_bulk.ngb-st9

Project :	RP_20_bulk	**Sample :**	20 percent bulk	**Sample car./TC :**	TG 209F1 std (Al2O3 support)/P	**Atmosphere :**	-- / N2 / N2
Identity :	20180118-ermatsco-20bulk	**Material :**	HIPS Activated Carbon	**Sample mass :**	10.8 mg	**Corr/m. range :**	090/2000 mg
Date/time :	1/16/2018 12:19:23 PM	**Correction file :**		**Mode/type of meas. :**	TG/Sample		
Laboratory :	Peterson	**Temp. calib. file :**	TCALZERO.TCX	**Segments :**	1/1		
Operator :	ermatsco	**Range :**	30°C/20.0(K/min)/1000°C	**Crucible :**	Al2O3		

Created with NETZSCH Proteus software

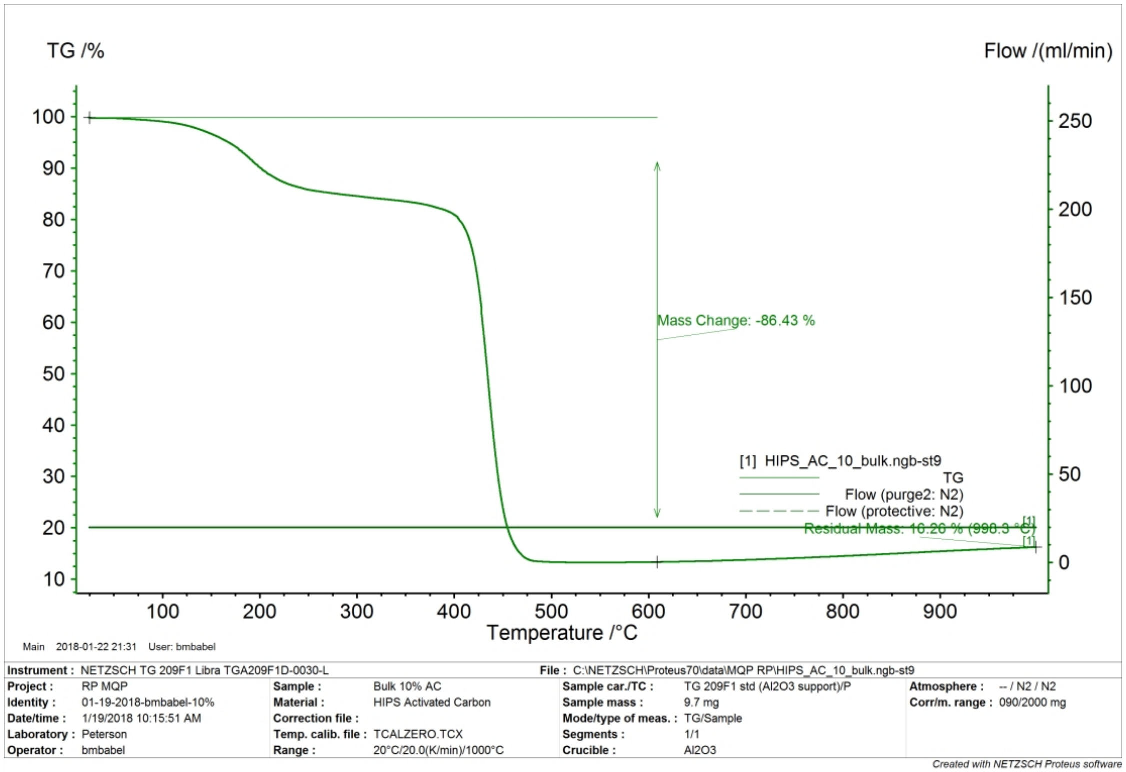


Instrument : NETZSCH TG 209F1 Libra TGA209F1D-0030-L **File :** C:\NETZSCH\Proteus70\data\MQP RP\HIPS_AC_20_filament.ngb-st9

Project :	RPMQP	**Sample :**	20%ACFilament	**Sample car./TC :**	TG 209F1 std (Al2O3 support)/P	**Atmosphere :**	-- / N2 / N2
Identity :	2018-01-18-bmbabel-20AC	**Material :**	HIPS Activated Carbon	**Sample mass :**	10.2 mg	**Corr/m. range :**	090/2000 mg
Date/time :	1/18/2018 12:39:52 PM	**Correction file :**		**Mode/type of meas. :**	TG/Sample		
Laboratory :	Peterson	**Temp. calib. file :**	TCALZERO.TCX	**Segments :**	1/1		
Operator :	bmbabel	**Range :**	20°C/20.0(K/min)/1000°C	**Crucible :**	Al2O3		

Created with NETZSCH Proteus software

10 Weight Percent Carbon Trials



Instrument : NETZSCH TG 209F1 Libra TGA209F1D-0030-L
File : C:\NETZSCH\Proteus70\data\MQP RP\HIPS_AC_10_bulk.ngb-st9

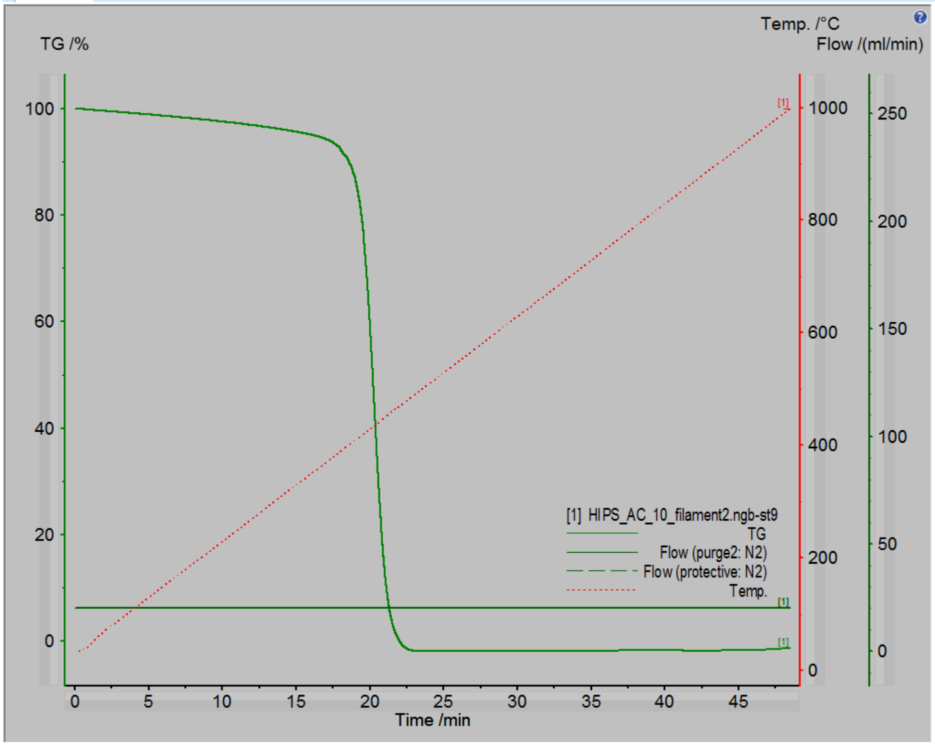
Project : RP MQP
Identity : 01-19-2018-bmbabel-10%
Date/time : 1/19/2018 10:15:51 AM
Laboratory : Peterson
Operator : bmbabel

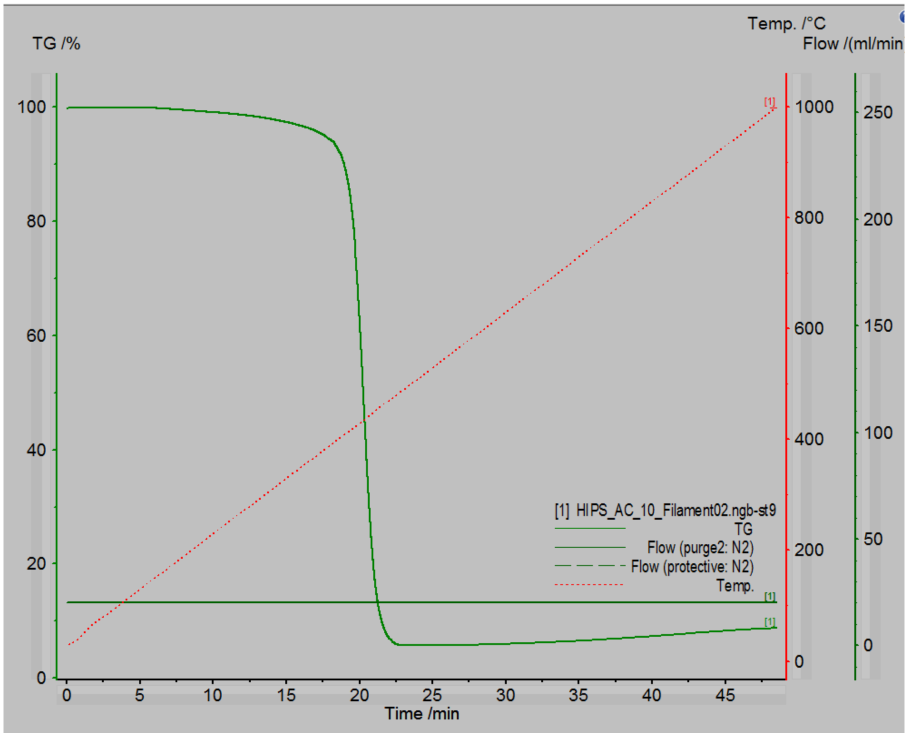
Sample : Bulk 10% AC
Material : HIPS Activated Carbon
Correction file :
Temp. calib. file : TCALZERO.TCX
Range : 20°C/20.0(K/min)/1000°C

Sample car./TC : TG 209F1 std (Al2O3 support)/P
Sample mass : 9.7 mg
Mode/type of meas. : TG/Sample
Segments : 1/1
Crucible : Al2O3

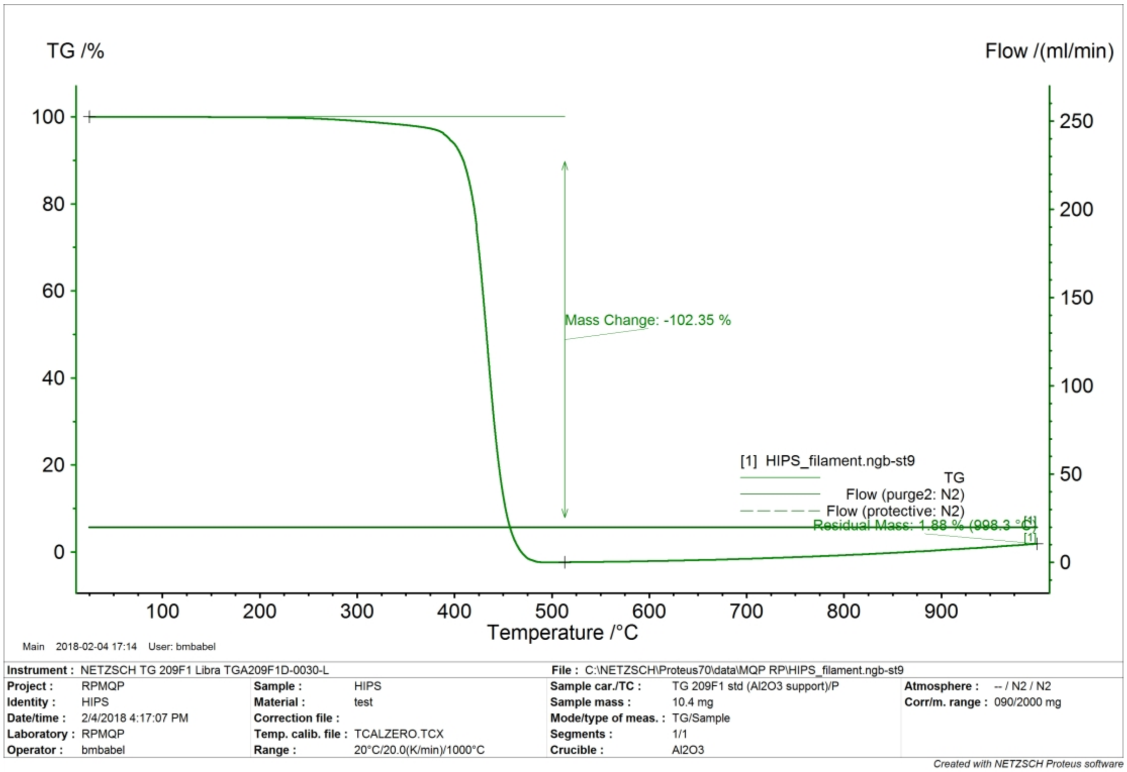
Atmosphere : -- / N2 / N2
Corr/m. range : 090/2000 mg

Created with NETZSCH Proteus software




TG /%
Temp. /°C
Flow /(ml/min
100
80
60
40
20
0
1000
800
600
400
200
0
250
200
150
100
50
0
0
5
10
15
20
25
30
35
40
45
Time /min
[1] HIPS_AC_10_Filament02.ngb-st9
TG
Flow (purge2: N2)
Flow (protective: N2)
Temp.
[1]
[1]
[1]

Pure HIPS – 0 Weight Percent Carbon Trials



Instrument :	NETZSCH TG 209F1 Libra TGA209F1D-0030-L			**File :**	C:\NETZSCH\Proteus70\data\MQP RP\HIPS_filament.ngb-st9		
Project :	RPMQP	**Sample :**	HIPS	**Sample car./TC :**	TG 209F1 std (Al2O3 support)/P	**Atmosphere :**	-- / N2 / N2
Identity :	HIPS	**Material :**	test	**Sample mass :**	10.4 mg	**Corr/m. range :**	090/2000 mg
Date/time :	2/4/2018 4:17:07 PM	**Correction file :**		**Mode/type of meas. :**	TG/Sample		
Laboratory :	RPMQP	**Temp. calib. file :**	TCALZERO.TCX	**Segments :**	1/1		
Operator :	bmbabel	**Range :**	20°C/20.0(K/min)/1000°C	**Crucible :**	Al2O3		

Created with NETZSCH Proteus software

Appendix B

Material Safety Data Sheets/ Safety Data Sheets

The following material safety data sheets (MSDS) and safety data sheets (SDS) are from the manufacturers of the materials used in this major qualifying project. Because our processing involved the mixing of various chemicals it was important understand the materials being used and how they would interact with each other.

The following documents appear in the order that they were used:

- LOCTITE 242
- LOCTITE 271
- LOCTITE Epoxy Putty Hard
- High Impact Polystyrene Resin
- HIGH PURITY Food Grade d-LIMONENE
- Raw Organic Coconut Charcoal Bulk Food Grade
- Elmer’s Disappearing Purple Glue Stick
- Methylene Blue Trihydrate

Safety Data Sheet

Revision Number: 008.0 **Issue date:** 08/21/2014

1. PRODUCT AND COMPANY IDENTIFICATION

Product name:	**LOCTITE® 242™ THREADLOCKER MEDIUM STRENGTH**	**IDH number:**	135354
Product type:	Anaerobic Sealant	**Item number:**	24221
Restriction of Use:	None identified	**Region:**	United States

Company address:
Henkel Corporation
One Henkel Way
Rocky Hill, Connecticut 06067

Contact information:
Telephone: (860) 571-5100
MEDICAL EMERGENCY Phone: Poison Control Center
1-877-671-4608 (toll free) or 1-303-592-1711
TRANSPORT EMERGENCY Phone: CHEMTREC
1-800-424-9300 (toll free) or 1-703-527-3887
Internet: www.henkelna.com

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW	
WARNING:	CAUSES SKIN AND EYE IRRITATION. MAY CAUSE AN ALLERGIC SKIN REACTION.

HAZARD CLASS	HAZARD CATEGORY
SKIN IRRITATION	2
EYE IRRITATION	2B
SKIN SENSITIZATION	1

PICTOGRAM(S)

Precautionary Statements

Prevention:	Avoid breathing vapors, mist, or spray. Wash thoroughly after handling. Contaminated work clothing should not be allowed out of the workplace. Wear protective gloves.
Response:	IF ON SKIN: Wash with plenty of soap and water. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to remove. Continue rinsing. If skin irritation or rash occurs: Get medical attention. If eye irritation persists: Get medical attention. Take off contaminated clothing.
Storage:	Not prescribed
Disposal:	Dispose of contents and/or container according to Federal, State/Provincial and local governmental regulations.

Classification complies with OSHA Hazard Communication Standard (29 CFR 1910.1200) and is consistent with the provisions of the United Nations Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

See Section 11 for additional toxicological information.

3. COMPOSITION / INFORMATION ON INGREDIENTS

Hazardous Component(s)	CAS Number	Percentage*
Polyglycol dimethacrylate	Proprietary	60 - 100

Polyglycol oleate	Proprietary	10 - 30
Saccharin	81-07-2	1 - 5
Silica, amorphous, fumed, crystal-free	112945-52-5	1 - 5
Cumene hydroperoxide	80-15-9	1 - 5
Propane-1,2-diol	57-55-6	1 - 5
Cumene	98-82-8	0.1 - 1

* Exact percentage is a trade secret. Concentration range is provided to assist users in providing appropriate protections.

4. FIRST AID MEASURES

Inhalation: Move to fresh air. If breathing is difficult, give oxygen. If not breathing, give artificial respiration. Get medical attention.

Skin contact: Immediately flush skin with plenty of water (using soap, if available). Remove contaminated clothing and footwear. Wash clothing before reuse. Get medical attention.

Eye contact: Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Get medical attention.

Ingestion: DO NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention.

Symptoms: See Section 11.

5. FIRE FIGHTING MEASURES

Extinguishing media: Water spray (fog), foam, dry chemical or carbon dioxide.

Special firefighting procedures: Wear self-contained breathing apparatus and full protective clothing, such as turn-out gear. In case of fire, keep containers cool with water spray.

Unusual fire or explosion hazards: Uncontrolled polymerization may occur at high temperatures resulting in explosions or rupture of storage containers.

Hazardous combustion products: Oxides of carbon. Oxides of sulfur. Oxides of nitrogen. Irritating organic vapours.

6. ACCIDENTAL RELEASE MEASURES

Use personal protection recommended in Section 8, isolate the hazard area and deny entry to unnecessary and unprotected personnel.

Environmental precautions: Do not allow product to enter sewer or waterways.

Clean-up methods: Remove all sources of ignition. Evacuate and ventilate spill area; dike spill to prevent entry into water system; wear full protective equipment during clean-up. Soak up with inert absorbent material (e.g. sand, silica gel, acid binder, universal binder, sawdust). Scrape up as much material as possible. Store in a partly filled, closed container until disposal. Refer to Section 8 "Exposure Controls / Personal Protection" prior to clean up.

7. HANDLING AND STORAGE

Handling:	Use only with adequate ventilation. Prevent contact with eyes, skin and clothing. Do not breathe vapor and mist. Wash thoroughly after handling. Keep container closed. Refer to Section 8.
Storage:	For safe storage, store between 0 °C (32°F) and 32 °C (89.6 °F) Keep in a cool, well ventilated area away from heat, sparks and open flame. Keep container tightly closed until ready for use.

For information on product shelf life contact Henkel Customer Service at (800) 243-4874.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Employers should complete an assessment of all workplaces to determine the need for, and selection of, proper exposure controls and protective equipment for each task performed.

Hazardous Component(s)	ACGIH TLV	OSHA PEL	AIHA WEEL	OTHER
Polyglycol dimethacrylate	None	None	None	None
Polyglycol oleate	None	None	None	None
Saccharin	None	None	None	None
Silica, amorphous, fumed, crystal-free	10 mg/m3 TWA Inhalable dust. 3 mg/m3 TWA Respirable fraction.	20 MPPCF TWA 0.8 mg/m3 TWA	None	None
Cumene hydroperoxide	None	None	1 ppm (6 mg/m3) TWA (SKIN)	None
Propane-1,2-diol	None	None	10 mg/m3 TWA Aerosol.	None
Cumene	50 ppm TWA	50 ppm (245 mg/m3) PEL (SKIN)	None	None

Engineering controls:	Provide adequate local exhaust ventilation to maintain worker exposure below exposure limits.
Respiratory protection:	Use NIOSH approved respirator if there is potential to exceed exposure limit(s).
Eye/face protection:	Safety goggles or safety glasses with side shields. Full face protection should be used if the potential for splashing or spraying of product exists. Safety showers and eye wash stations should be available.
Skin protection:	Use chemical resistant, impermeable clothing including gloves and either an apron or body suit to prevent skin contact. Neoprene gloves. Butyl rubber gloves. Natural rubber gloves.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Liquid
Color:	Blue
Odor:	Mild
Odor threshold:	Not available.
pH:	Not applicable
Vapor pressure:	< 5 mm hg (27 °C (80.6 °F))
Boiling point/range:	> 149 °C (> 300.2 °F)
Melting point/ range:	Not available.
Specific gravity:	1.1 at 23.9 °C (75.02 °F)
Vapor density:	Not available.
Flash point:	> 93.3 °C (> 199.94 °F) Tagliabue closed cup
Flame projection:	Not applicable
Flammable/Explosive limits - lower:	2.6 % (propylene glycol)
Flammable/Explosive limits - upper:	12.5 % (propylene glycol)

Autoignition temperature:	Not determined
Evaporation rate:	Not available.
Solubility in water:	Slight
Partition coefficient (n-octanol/water):	Not available.
VOC content:	0.56 %; 6.17 g/l
Viscosity:	Not available.
Decomposition temperature:	Not available.

10. STABILITY AND REACTIVITY

Stability: Stable under normal conditions of storage and use.

Hazardous reactions: None under normal processing. Polymerization may occur at elevated temperature or in the presence of incompatible materials.

Hazardous decomposition products: Oxides of carbon. Oxides of sulfur. Oxides of nitrogen. Irritating organic vapours.

Incompatible materials: Strong oxidizing agents. Free radical initiators. Strong reducing agents. Alkalis. Oxygen scavengers. Other polymerization initiators. Copper. Iron. Zinc. Aluminum. Rust.

Reactivity: Not available.

Conditions to avoid: Elevated temperatures. Heat, flames, sparks and other sources of ignition. Store away from incompatible materials.

11. TOXICOLOGICAL INFORMATION

Relevant routes of exposure: Skin, Inhalation, Eyes, Ingestion

Potential Health Effects/Symptoms

Inhalation:	Inhalation of vapors or mists of the product may be irritating to the respiratory system.
Skin contact:	Causes skin irritation. May cause allergic skin reaction.
Eye contact:	Causes eye irritation.
Ingestion:	May cause gastrointestinal tract irritation if swallowed.

Hazardous Component(s)	LD50s and LC50s	Immediate and Delayed Health Effects
Polyglycol dimethacrylate	None	Allergen, Irritant
Polyglycol oleate	None	Irritant
Saccharin	None	No Target Organs
Silica, amorphous, fumed, crystal-free	None	Nuisance dust
Cumene hydroperoxide	None	Allergen, Central nervous system, Corrosive, Irritant, Mutagen
Propane-1,2-diol	Oral LD50 (RABBIT) = 18 g/kg Oral LD50 (RAT) = 30 g/kg	Irritant
Cumene	Oral LD50 (RAT) = 2.91 g/kg Oral LD50 (RAT) = 1,400 mg/kg Inhalation LC50 (RAT, 4 h) = 8000 ppm	Central nervous system, Irritant, Lung

Hazardous Component(s)	NTP Carcinogen	IARC Carcinogen	OSHA Carcinogen (Specifically Regulated)
Polyglycol dimethacrylate	No	No	No
Polyglycol oleate	No	No	No
Saccharin	No	No	No
Silica, amorphous, fumed, crystal-free	No	No	No
Cumene hydroperoxide	No	No	No
Propane-1,2-diol	No	No	No
Cumene	No	Group 2B	No

12. ECOLOGICAL INFORMATION

Ecological information: Not available.

13. DISPOSAL CONSIDERATIONS

Information provided is for unused product only.

Recommended method of disposal: Follow all local, state, federal and provincial regulations for disposal.

Hazardous waste number: Not a RCRA hazardous waste.

14. TRANSPORT INFORMATION

The transport information provided in this section only applies to the material/formulation itself, and is not specific to any package/configuration.

U.S. Department of Transportation Ground (49 CFR)
Proper shipping name: Not regulated
Hazard class or division: None
Identification number: None
Packing group: None

International Air Transportation (ICAO/IATA)
Proper shipping name: Not regulated
Hazard class or division: None
Identification number: None
Packing group: None

Water Transportation (IMO/IMDG)
Proper shipping name: Not regulated
Hazard class or division: None
Identification number: None
Packing group: None

15. REGULATORY INFORMATION

United States Regulatory Information

TSCA 8 (b) Inventory Status: All components are listed or are exempt from listing on the Toxic Substances Control Act Inventory.
TSCA 12 (b) Export Notification: None above reporting de minimis

CERCLA/SARA Section 302 EHS: None above reporting de minimis
CERCLA/SARA Section 311/312: Immediate Health, Delayed Health
CERCLA/SARA Section 313: This product contains the following toxic chemicals subject to the reporting requirements of section 313 of the Emergency Planning and Community Right-To-Know Act of 1986 (40 CFR 372). Saccharin (CAS# 81-07-2). Cumene hydroperoxide (CAS# 80-15-9).
CERCLA Reportable quantity: Cumene hydroperoxide (CAS# 80-15-9) 10 lbs. (4.54 kg)

California Proposition 65: This product contains a chemical known in the State of California to cause cancer. This product contains a chemical known to the State of California to cause birth defects or other reproductive harm.

Canada Regulatory Information

CEPA DSL/NDSL Status: All components are listed on or are exempt from listing on the Canadian Domestic Substances List.

16. OTHER INFORMATION

This safety data sheet contains changes from the previous version in sections: New Safety Data Sheet format.

Prepared by: Sheila Gines, Regulatory Affairs Specialist

Issue date: 08/21/2014

DISCLAIMER: The data contained herein are furnished for information only and are believed to be reliable. However, Henkel Corporation and its affiliates ("Henkel") does not assume responsibility for any results obtained by persons over whose methods Henkel has no control. It is the user's responsibility to determine the suitability of Henkel's products or any production methods mentioned herein for a particular purpose, and to adopt such precautions as may be advisable for the protection of property and persons against any hazards that may be involved in the handling and use of any Henkel's products. In light of the foregoing, Henkel specifically disclaims all warranties, express or implied, including warranties of merchantability and fitness for a particular purpose, arising from sale or use of Henkel's products. Henkel further disclaims any liability for consequential or incidental damages of any kind, including lost profits.

Safety Data Sheet

Revision Number: 009.3 **Issue date:** 04/26/2017

1. PRODUCT AND COMPANY IDENTIFICATION

Product name:	**LOCTITE 271 HS TL known as LOC 6ML 271RED TLOCKER H 12PG**	**IDH number:**	209741
Product type:	Anaerobic Sealant	**Item number:**	27100
Restriction of Use:	None identified	**Region:**	United States

Company address:
Henkel Corporation
One Henkel Way
Rocky Hill, Connecticut 06067

Contact information:
Telephone: (860) 571-5100
MEDICAL EMERGENCY Phone: Poison Control Center
1-877-671-4608 (toll free) or 1-303-592-1711
TRANSPORT EMERGENCY Phone: CHEMTREC
1-800-424-9300 (toll free) or 1-703-527-3887
Internet: www.henkelna.com

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW	
WARNING:	CAUSES SKIN IRRITATION. MAY CAUSE AN ALLERGIC SKIN REACTION. CAUSES SERIOUS EYE IRRITATION.

HAZARD CLASS	HAZARD CATEGORY
SKIN IRRITATION	2
EYE IRRITATION	2A
SKIN SENSITIZATION	1

PICTOGRAM(S)


Precautionary Statements

Prevention:	Avoid breathing vapors, mist, or spray. Wash affected area thoroughly after handling. Contaminated work clothing should not be allowed out of the workplace. Wear protective gloves, eye protection, and face protection.
Response:	IF ON SKIN: Wash with plenty of water. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If skin irritation or rash occurs: Get medical attention. If eye irritation persists: Get medical attention. Take off contaminated clothing.
Storage:	Not prescribed
Disposal:	Dispose of contents and/or container according to Federal, State/Provincial and local governmental regulations.

Classification complies with OSHA Hazard Communication Standard (29 CFR 1910.1200) and is consistent with the provisions of the United Nations Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

See Section 11 for additional toxicological information.

3. COMPOSITION / INFORMATION ON INGREDIENTS

Hazardous Component(s)	CAS Number	Percentage*
Polyglycol dimethacrylate	25852-47-5	60 - 70
Saccharin	81-07-2	1 - 5
Cumene hydroperoxide	80-15-9	1 - 5
Cumene	98-82-8	0.1 - 1

* Exact percentages may vary or are trade secret. Concentration range is provided to assist users in providing appropriate protections.

4. FIRST AID MEASURES

Inhalation:	Move to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.
Skin contact:	Immediately flush skin with plenty of water (using soap, if available). Remove contaminated clothing and footwear. Wash clothing before reuse. Get medical attention.
Eye contact:	Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Get medical attention.
Ingestion:	DO NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Get medical attention.
Symptoms:	See Section 11.

5. FIRE FIGHTING MEASURES

Extinguishing media:	Water spray (fog), foam, dry chemical or carbon dioxide.
Special firefighting procedures:	Wear self-contained breathing apparatus and full protective clothing, such as turn-out gear. In case of fire, keep containers cool with water spray.
Unusual fire or explosion hazards:	Uncontrolled polymerization may occur at high temperatures resulting in explosions or rupture of storage containers.
Hazardous combustion products:	Oxides of carbon. Oxides of sulfur. Oxides of nitrogen. Irritating organic vapours.

6. ACCIDENTAL RELEASE MEASURES

Use personal protection recommended in Section 8, isolate the hazard area and deny entry to unnecessary and unprotected personnel.

Environmental precautions:	Do not allow product to enter sewer or waterways.
Clean-up methods:	Remove all sources of ignition. Evacuate and ventilate spill area; dike spill to prevent entry into water system; wear full protective equipment during clean-up. Soak up with inert absorbent material (e.g. sand, silica gel, acid binder, universal binder, sawdust). Scrape up as much material as possible. Store in a partly filled, closed container until disposal. Refer to Section 8 "Exposure Controls / Personal Protection" prior to clean up.

7. HANDLING AND STORAGE

Handling:	Use only with adequate ventilation. Prevent contact with eyes, skin and clothing. Do not breathe vapor and mist. Wash thoroughly after handling. Keep container closed. Refer to Section 8.
Storage:	For safe storage, store at or below 38 °C (100.4 °F) Keep in a cool, well ventilated area away from heat, sparks and open flame. Keep container tightly closed until ready for use.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Employers should complete an assessment of all workplaces to determine the need for, and selection of, proper exposure controls and protective equipment for each task performed.

Hazardous Component(s)	ACGIH TLV	OSHA PEL	AIHA WEEL	OTHER
Polyglycol dimethacrylate	None	None	None	None
Saccharin	None	None	None	None
Cumene hydroperoxide	None	None	1 ppm (6 mg/m3) TWA (SKIN)	None
Cumene	50 ppm TWA	50 ppm (245 mg/m3) PEL (SKIN)	None	None

Engineering controls:	Provide adequate local exhaust ventilation to maintain worker exposure below exposure limits.
Respiratory protection:	Use NIOSH approved respirator if there is potential to exceed exposure limit(s).
Eye/face protection:	Safety goggles or safety glasses with side shields. Full face protection should be used if the potential for splashing or spraying of product exists. Safety showers and eye wash stations should be available.
Skin protection:	Use chemical resistant, impermeable clothing including gloves and either an apron or body suit to prevent skin contact. Butyl rubber gloves. Natural rubber gloves. Neoprene gloves.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Liquid
Color:	Red
Odor:	Mild
Odor threshold:	Not available.
pH:	Not applicable
Vapor pressure:	< 5 mm hg (26.7 °C (80.1 °F))
Boiling point/range:	> 148.9 °C (> 300°F)
Melting point/ range:	Not available.
Specific gravity:	1.1
Vapor density:	Not available.
Flash point:	> 93.3 °C (> 199.94 °F) Tagliabue closed cup
Flammable/Explosive limits - lower:	Not available.
Flammable/Explosive limits - upper:	Not available.
Autoignition temperature:	Not available.
Flammability:	Not applicable
Evaporation rate:	Not available.
Solubility in water:	Slight
Partition coefficient (n-octanol/water):	Not available.
VOC content:	0.82 %; 7.81 g/l
Viscosity:	Not available.
Decomposition temperature:	Not available.

10. STABILITY AND REACTIVITY

Stability:	Stable under normal conditions of storage and use.
Hazardous reactions:	None under normal processing. Polymerization may occur at elevated temperature or in the presence of incompatible materials.
Hazardous decomposition products:	Phenolics. Oxides of sulfur. Oxides of carbon. Oxides of nitrogen. Irritating organic vapours.
Incompatible materials:	Strong oxidizing agents. Strong acids. Copper. Iron. Strong reducing agents. Rust.
Reactivity:	Not available.
Conditions to avoid:	Elevated temperatures. Heat, flames, sparks and other sources of ignition. Store away from incompatible materials.

11. TOXICOLOGICAL INFORMATION

Relevant routes of exposure: Skin, Inhalation, Eyes, Ingestion

Potential Health Effects/Symptoms

Inhalation:	Inhalation of vapors or mists of the product may be irritating to the respiratory system.
Skin contact:	Causes skin irritation. May cause allergic skin reaction.
Eye contact:	Causes serious eye irritation.
Ingestion:	May cause gastrointestinal tract irritation if swallowed.

Hazardous Component(s)	**LD50s and LC50s**	**Immediate and Delayed Health Effects**
Polyglycol dimethacrylate	None	Allergen, Irritant
Saccharin	Oral LD50 (Mouse) = 17 g/kg	No Target Organs
Cumene hydroperoxide	Inhalation LC50 (Mouse, 4 h) = 200 mg/l	Allergen, Central nervous system, Corrosive, Irritant, Mutagen
Cumene	Oral LD50 (Rat) = 2.91 g/kg Oral LD50 (Rat) = 1,400 mg/kg Inhalation LC50 (Rat, 4 h) = 8000 ppm	Central nervous system, Irritant, Lung

Hazardous Component(s)	**NTP Carcinogen**	**IARC Carcinogen**	**OSHA Carcinogen (Specifically Regulated)**
Polyglycol dimethacrylate	No	No	No
Saccharin	No	No	No
Cumene hydroperoxide	No	No	No
Cumene	Reasonably Anticipated to be a Human Carcinogen.	Group 2B	No

12. ECOLOGICAL INFORMATION

Ecological information: Not available.

13. DISPOSAL CONSIDERATIONS

Information provided is for unused product only.

Recommended method of disposal:	Follow all local, state, federal and provincial regulations for disposal.
Hazardous waste number:	Not a RCRA hazardous waste.

14. TRANSPORT INFORMATION

The transport information provided in this section only applies to the material/formulation itself, and is not specific to any package/configuration.

U.S. Department of Transportation Ground (49 CFR)

Proper shipping name:	RQ, Environmentally hazardous substance, liquid, n.o.s.
Hazard class or division:	9
Identification number:	UN 3082
Packing group:	III
DOT Hazardous Substance(s):	alpha,alpha-Dimethylbenzylhydroperoxide

International Air Transportation (ICAO/IATA)

Proper shipping name:	RQ, Environmentally hazardous substance, liquid, n.o.s.
Hazard class or division:	9
Identification number:	UN 3082
Packing group:	III

Water Transportation (IMO/IMDG)

Proper shipping name:	RQ, ENVIRONMENTALLY HAZARDOUS SUBSTANCE, LIQUID, N.O.S.
Hazard class or division:	9
Identification number:	UN 3082
Packing group:	III

15. REGULATORY INFORMATION

United States Regulatory Information

TSCA 8 (b) Inventory Status:	All components are listed or are exempt from listing on the Toxic Substances Control Act Inventory.
TSCA 12 (b) Export Notification:	None above reporting de minimis
CERCLA/SARA Section 302 EHS:	None above reporting de minimis. None above reporting de minimis.
CERCLA/SARA Section 311/312:	Immediate Health, Delayed Health
CERCLA/SARA Section 313:	This product contains the following toxic chemicals subject to the reporting requirements of section 313 of the Emergency Planning and Community Right-To-Know Act of 1986 (40 CFR 372). Saccharin (CAS# 81-07-2). Cumene hydroperoxide (CAS# 80-15-9).
CERCLA Reportable quantity:	Cumene hydroperoxide (CAS# 80-15-9) 10 lbs. (4.54 kg)
California Proposition 65:	This product contains a chemical known in the State of California to cause cancer.

Canada Regulatory Information

CEPA DSL/NDSL Status:	Contains one or more components listed on the Non-Domestic Substances List. All other components are listed on or are exempt from listing on the Domestic Substances List. Components listed on the NDSL must be tracked by all Canadian Importers of Record as required by Environment Canada. They may be imported into Canada in limited quantities. Please contact Regulatory Affairs for additional details.

16. OTHER INFORMATION

This safety data sheet contains changes from the previous version in sections: Reviewed SDS. Reissued with new date. 3

Prepared by: Sheila Gines, Regulatory Affairs Specialist

Issue date: 04/26/2017

Safety Data Sheet

Revision Number: 001.3 **Issue date:** 03/24/2017

1. PRODUCT AND COMPANY IDENTIFICATION

Product name: **DELETE Loctite Epoxy Putty Hard**
Product type: Epoxy stick
Restriction of Use: None identified
Company address:
Henkel Corporation
One Henkel Way
Rocky Hill, Connecticut 06067

IDH number: 1071293

Region: United States
Contact information:
Telephone: (860) 571-5100
MEDICAL EMERGENCY Phone: Poison Control Center
1-877-671-4608 (toll free) or 1-303-592-1711
TRANSPORT EMERGENCY Phone: CHEMTREC
1-800-424-9300 (toll free) or 1-703-527-3887
Internet: www.henkelna.com

2. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW	
WARNING:	CAUSES SKIN IRRITATION. MAY CAUSE AN ALLERGIC SKIN REACTION. CAUSES SERIOUS EYE IRRITATION. MAY CAUSE RESPIRATORY IRRITATION.

HAZARD CLASS	HAZARD CATEGORY
SKIN IRRITATION	2
EYE IRRITATION	2A
SKIN SENSITIZATION	1
SPECIFIC TARGET ORGAN TOXICITY - SINGLE EXPOSURE	3

PICTOGRAM(S)

Precautionary Statements

Prevention:	Avoid breathing dust or fumes. Wash affected area thoroughly after handling. Use only outdoors or in a well-ventilated area. Contaminated work clothing should not be allowed out of the workplace. Wear protective gloves, eye protection, and face protection.
Response:	IF ON SKIN: Wash with plenty of water. IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing. Call a POISON CENTER or physician if you feel unwell. IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing. If skin irritation or rash occurs: Get medical attention. If eye irritation persists: Get medical attention. Take off contaminated clothing.
Storage:	Store in a well-ventilated place. Keep container tightly closed. Store locked up.
Disposal:	Dispose of contents and/or container according to Federal, State/Provincial and local governmental regulations.

Classification complies with OSHA Hazard Communication Standard (29 CFR 1910.1200) and is consistent with the provisions of the United Nations Globally Harmonized System of Classification and Labeling of Chemicals (GHS).

See Section 11 for additional toxicological information.

3. COMPOSITION / INFORMATION ON INGREDIENTS

Hazardous Component(s)	CAS Number	Percentage*
Talc	14807-96-6	60 - 70
Glass, oxide, chemicals	65997-17-3	30 - 40
Epichlorohydrin-4,4'-isopropylidene diphenol resin	25068-38-6	5 - 10
Triethylenetetramine	112-24-3	1 - 5
Quartz (SiO2)	14808-60-7	1 - 5

* Exact percentages may vary or are trade secret. Concentration range is provided to assist users in providing appropriate protections.

4. FIRST AID MEASURES

Inhalation:	Move to fresh air. If symptoms develop and persist, get medical attention.
Skin contact:	Immediately flush skin with plenty of water (using soap, if available). Remove contaminated clothing and footwear. Wash clothing before reuse. Get medical attention.
Eye contact:	Immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.
Ingestion:	Do not induce vomiting. Keep individual calm. Never give anything by mouth to an unconscious person. Get medical attention.
Symptoms:	See Section 11.

5. FIRE FIGHTING MEASURES

Extinguishing media:	Water spray (fog), foam, dry chemical or carbon dioxide.
Special firefighting procedures:	Wear self-contained breathing apparatus and full protective clothing, such as turn-out gear.
Unusual fire or explosion hazards:	None
Hazardous combustion products:	Aldehydes. Acids. Oxides of carbon. Oxides of nitrogen. Oxides of sulfur.

6. ACCIDENTAL RELEASE MEASURES

Use personal protection recommended in Section 8, isolate the hazard area and deny entry to unnecessary and unprotected personnel.

Environmental precautions:	Do not allow product to enter sewer or waterways.
Clean-up methods:	Store in a partly filled, closed container until disposal. Scrape up as much material as possible.

SAFETY DATA SHEET
High Impact Polystyrene Resin

Printed: 09/17/2015
Revision: 09/17/2015
Supersedes Revision: 06/30/2015

1. Product and Company Identification

Product Name:	High Impact Polystyrene Resin
Trade Name:	Certene
Company Name:	Muehlstein Ravago Americas 10 Westport Rd Wilton, CT 06897
Web site address:	www.muehlstein.com
Emergency Contact:	ChemTrec: (800) 424-9300
Information:	1-800-25-RESIN

2. Hazards Identification

Combustible Dust

GHS Signal Word:	**Warning**
GHS Hazard Phrases:	May form combustible dust concentrations in air. While this product may not be a combustible dust as sold, further processing or handling may form combustible dust concentrations in air.
GHS Precaution Phrases:	No phrases apply.
GHS Response Phrases:	No phrases apply.
GHS Storage and Disposal Phrases:	No phrases apply.
OSHA Regulatory Status:	This product has been classified in accordance with the hazard communication standard 29 CFR 1910.1200, the SDS and labels contain all the information as required by the standard.
Potential Health Effects (Acute and Chronic):	The components of this product are embedded in an impervious polymer matrix and therefore present a negligible exposure risk under normal conditions of processing and handling.
Inhalation:	Fumes produced during melt process may cause eye, skin and respiratory irritation. Secondary operations such as material transfer, grinding, sanding or sawing can produce combustible dust.
Skin Contact:	Heated material can cause thermal burns resulting in pain, redness and blistering.
Eye Contact:	May cause eye irritation.
Ingestion:	May be harmful if swallowed.
Medical Conditions Generally Aggravated By Exposure:	None known.

3. Composition/Information on Ingredients

CAS #	Hazardous Components (Chemical Name)	Concentration
NA	NONE	~100 %

4. First Aid Measures

Emergency and First Aid Procedures:	For processing fume inhalation, leave the contaminated area and breathe fresh air.
In Case of Inhalation:	Remove from exposure and move to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid.
In Case of Skin Contact:	Get medical aid if irritation develops or persists. Flush skin with plenty of soap and water.
In Case of Eye Contact:	In case of contact, immediately flush eyes with copious amounts of water for at least {15} minutes.
In Case of Ingestion:	If swallowed, wash out mouth with water provided person is conscious. Call a physician.
Signs and Symptoms Of Exposure:	The components of this product are embedded in an impervious polymer matrix and therefore present a negligible exposure risk under normal processing conditions.
Note to Physician:	None

5. Fire Fighting Measures

Flash Pt:	NA Method Used: Not Applicable
Explosive Limits:	LEL: NA UEL: NA
Autoignition Pt:	NA
Suitable Extinguishing Media:	Water spray and foam. Water is the best extinguishing medium.
Fire Fighting Instructions:	Emits toxic fumes under fire conditions. Approved positive pressure demand breathing apparatus (SCBA) and protective clothing should be used for all fires.
Flammable Properties and Hazards:	Carbon dioxide and carbon monoxide generated when the material burns. Combustible Dust may form during material transfer. Estimated Dust Explosion Class = ST2; Kst estimated (bar.m/s): >200 - </=300
Hazardous Combustion Products:	No data available.

6. Accidental Release Measures

Steps To Be Taken In Case Material Is Released Or Spilled:	Vacuum or sweep up material and place into a suitable disposal container.

7. Handling and Storage

Precautions To Be Taken in Handling:	Use with adequate ventilation. Minimize dust generation and accumulation as combustible dust mixtures may be formed.
Precautions To Be Taken in Storing:	Store in a cool, dry place.

8. Exposure Controls/Personal Protection

CAS #	Partial Chemical Name	OSHA TWA	ACGIH TWA	Other Limits
NA	NONE	No data.	No data.	No data.

Respiratory Equipment (Specify Type):	Follow the OSHA respirator regulations found in {149} CFR {1910.134} or European Standard EN {149}. Use a NIOSH/MSHA or European Standard EN {149} approved respirator if exposure limits are exceeded or if irritation or other symptoms are experienced.
Eye Protection:	Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in {1910.133} CFR {1910.133} or European Standard EN166.
Protective Gloves:	Wear appropriate protective gloves to minimize skin exposure.
Other Protective Clothing:	Wear appropriate protective clothing to minimize contact with skin.
Engineering Controls (Ventilation etc.):	Use adequate ventilation to keep airborne concentrations low. Use process enclosure, local exhaust ventilation, or other engineering controls to control airborne levels.

Work/Hygienic/Maintenance Practices:	Wash thoroughly after handling.

9. Physical and Chemical Properties

Physical States:	[ ] Gas [ ] Liquid [X] Solid
Appearance and Odor:	Pellets with slight or no odor.
pH:	No data.
Melting Point:	> 90.00 C (194.0 F) - 0.00 C (32.0 F)
Boiling Point:	NA
Flash Pt:	NA Method Used: Not Applicable
Evaporation Rate:	NA
Flammability (solid, gas):	No data available.
Explosive Limits:	LEL: NA UEL: NA
Vapor Pressure (vs. Air or mm Hg):	NA
Vapor Density (vs. Air = 1):	NA
Specific Gravity (Water = 1):	> 1
Solubility in Water:	NA
Solubility Notes:	Insoluble in cold water.
Octanol/Water Partition Coefficient:	No data.
Percent Volatile:	< 1.0 %
Autoignition Pt:	NA
Decomposition Temperature:	> 300.00 C (572.0 F)
Viscosity:	No data.

10. Stability and Reactivity

Stability:	Unstable [ ] Stable [X]
Conditions To Avoid - Instability:	Stable under recommended conditions of storage and handling.
Incompatibility - Materials To Avoid:	No special recommendations.
Hazardous Decomposition or Byproducts:	Processing fumes evolved at recommended processing conditions may include trace levels of low molecular weight hydrocarbon fragments, carbon dioxide, carbon monoxide, styrene monomer and Irritating fumes and gases.
Possibility of Hazardous Reactions:	Will occur [ ] Will not occur [X]
Conditions To Avoid - Hazardous Reactions:	Under normal conditions of use, hazardous decomposition will not occur.

11. Toxicological Information

Toxicological Information:	No data available.
Carcinogenicity/Other Information:	

CAS #	Hazardous Components (Chemical Name)	NTP	IARC	ACGIH	OSHA
NA	NONE	n.a.	n.a.	n.a.	n.a.

12. Ecological Information

General Ecological Information:	This product is not classified as environmentally hazardous. However, this does not exclude the possibility that large or frequent spills can have a harmful or damaging effect on the environment.
Persistence and Degradability:	No data available.
Bioaccumulative Potential:	This product will not readily bioaccumulate due to its insolubility in water.
Mobility in Soil:	Soil mobility is expected to be negligible, because the product is insoluble in water.

13. Disposal Considerations

Waste Disposal Method:	Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. US EPA guidelines for the classification determination are listed in {261} CFR Parts {261.3}. Additionally, waste generators must consult state and local hazardous waste regulations to ensure complete and accurate classification. RCRA P-Series: None listed. RCRA U-Series: None listed.

14. Transport Information

LAND TRANSPORT (US DOT):

DOT Proper Shipping Name:	Not regulated as a hazardous material.
DOT Hazard Class:	
UN/NA Number:	

AIR TRANSPORT (ICAO/IATA):

ICAO/IATA Shipping Name:	Non-Hazardous for Air Transport.

15. Regulatory Information

EPA SARA (Superfund Amendments and Reauthorization Act of 1986) Lists

CAS #	Hazardous Components (Chemical Name)	S. 302 (EHS)	S. 304 RQ	S. 313 (TRI)
NA	NONE	No	No	No

This material meets the EPA 'Hazard Categories' defined for SARA Title III Sections 311/312 as indicated:

[ ] Yes [X] No Acute (immediate) Health Hazard
[ ] Yes [X] No Chronic (delayed) Health Hazard
[X] Yes [ ] No Fire Hazard
[ ] Yes [X] No Sudden Release of Pressure Hazard
[ ] Yes [X] No Reactive Hazard

CAS #	Hazardous Components (Chemical Name)	Other US EPA or State Lists
NA	NONE	CAA HAP,ODC: No; CWA NPDES: No; TSCA: No

CAS #	Hazardous Components (Chemical Name)	International Regulatory Lists
NA	NONE	Canadian DSL: No; Canadian NDSL: No; Mexico INSQ: No; REACH: No

16. Other Information

Revision Date:	09/17/2015
Preparer Name:	Safety & Environmental Department

Additional Information About This Product:

Information given herein is offered in good faith as accurate, but without guarantee. The conditions of use and suitability of the product for an application is beyond our control. All risks of use of the product are therefore assumed by the user and we expressly disclaim all warranties of every kind of nature, including warranties of merchantability and fitness for a particular purpose in respect to the use or suitability of this product. Appropriate warnings and safe handling procedures should be provided to handlers and users.

OSHA HAZCom Label for Combustible Dust Hazard:

Ravago Americas LLC
1900 Summit Tower Blvd.
Orlando, FL 32810
(407)875-9595
Chem-Trec (800)424-9300

Warning: May Form Combustible Dust Concentrations in Air
Use Caution as Dust Clouds may be Explosive
Product is Static Accumulator
Avoid Heat, Sparks and Open Flame
Earth Whenever Possible

7. HANDLING AND STORAGE

Handling:	Avoid skin and eye contact. Wash thoroughly after handling. Empty container precaution: Attention! This container can be hazardous when empty. Follow label cautions even after the container is empty since empty containers could retain product residues. Do not re-use empty containers for food, clothing, or products for human or animal consumption, or where skin contact can occur.
Storage:	Store in original container until ready to use. Keep in a cool, well ventilated area away from heat, sparks and open flame. Keep container tightly closed until ready for use.

For information on product shelf life, please review labels on container or check the Technical Data Sheet.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Employers should complete an assessment of all workplaces to determine the need for, and selection of, proper exposure controls and protective equipment for each task performed.

Hazardous Component(s)	ACGIH TLV	OSHA PEL	AIHA WEEL	OTHER
Talc	2 mg/m3 TWA Respirable fraction.	0.1 mg/m3 TWA Respirable. 0.3 mg/m3 TWA Total dust. 2.4 MPPCF TWA Respirable. 20 MPPCF TWA	None	50 ppm
Glass, oxide, chemicals	10 mg/m3 TWA Inhalable dust. 3 mg/m3 TWA Respirable fraction.	15 mg/m3 TWA Total dust. 5 mg/m3 TWA Respirable fraction.	None	None
Epichlorohydrin-4,4'-isopropylidene diphenol resin	None	None	None	None
Triethylenetetramine	None	None	1 ppm (6 mg/m3) TWA (SKIN)	None
Quartz (SiO2)	0.025 mg/m3 TWA Respirable fraction.	2.4 MPPCF TWA Respirable. 0.1 mg/m3 TWA Respirable. 0.05 mg/m3 TWA (Respirable dust.) (Respirable dust.) 0.025 mg/m3 OSHA_ACT (Respirable dust.) 0.05 mg/m3 PEL Respirable dust.	None	None

Engineering controls:	Use local exhaust ventilation if heated above 38°C (100°F) to maintain concentrations below occupational exposure limits.
Respiratory protection:	Use NIOSH approved respirator if there is potential to exceed exposure limit(s).
Eye/face protection:	Safety goggles or safety glasses with side shields.
Skin protection:	Chemical resistant, impermeable gloves.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical state:	Solid
Color:	Blue
Odor:	Sulphurous
Odor threshold:	Not available.
pH:	Not applicable
Vapor pressure:	Not determined
Boiling point/range:	230 °C (446°F)
Melting point/ range:	Not available.
Specific gravity:	2.25
Vapor density:	Not applicable
Flash point:	> 93.3 °C (> 199.94 °F)
Flammable/Explosive limits - lower:	Not applicable
Flammable/Explosive limits - upper:	Not applicable
Autoignition temperature:	Not applicable
Flammability:	Not applicable
Evaporation rate:	Not applicable
Solubility in water:	Not miscible
Partition coefficient (n-octanol/water):	Not available.
VOC content:	< 0.1 %
Viscosity:	Not available.
Decomposition temperature:	Not available.

10. STABILITY AND REACTIVITY

Stability:	Stable
Hazardous reactions:	Will not occur.
Hazardous decomposition products:	Aldehydes. Oxides of carbon. Oxides of nitrogen. Oxides of sulfur. Acids.
Incompatible materials:	None
Reactivity:	Not available.
Conditions to avoid:	None known

11. TOXICOLOGICAL INFORMATION

Relevant routes of exposure:	Skin, Inhalation, Eyes, Ingestion

Potential Health Effects/Symptoms

Inhalation:	Abrasion of cured material such as by sanding or grinding could release respirable particles of silica quartz, a cancer hazard by inhalation. Normal use of this product causes no such release.
Skin contact:	Causes skin irritation. May cause allergic skin reaction.
Eye contact:	Contact with eyes will cause irritation.
Ingestion:	May be harmful if swallowed.

Hazardous Component(s)	LD50s and LC50s	Immediate and Delayed Health Effects
Talc	None	Irritant, Lung, Some evidence of carcinogenicity
Glass, oxide, chemicals	None	Allergen, Respiratory
Epichlorohydrin-4,4'-isopropylidene diphenol resin	None	Allergen, Irritant
Triethylenetetramine	None	Allergen, Corrosive, Developmental, Irritant, Mutagen
Quartz (SiO2)	None	Immune system, Lung, Some evidence of carcinogenicity

Hazardous Component(s)	NTP Carcinogen	IARC Carcinogen	OSHA Carcinogen (Specifically Regulated)
Talc	No	Group 2B	No
Glass, oxide, chemicals	No	No	No
Epichlorohydrin-4,4'-isopropylidene diphenol resin	No	No	No
Triethylenetetramine	No	No	No
Quartz (SiO2)	Known To Be Human Carcinogen.	Group 1	Yes

12. ECOLOGICAL INFORMATION

Ecological information:	Not applicable

13. DISPOSAL CONSIDERATIONS

Information provided is for unused product only.

Recommended method of disposal:	Follow all local, state, federal and provincial regulations for disposal.
Hazardous waste number:	It is the responsibility of the user to determine if an item is hazardous as defined in the Resource Conservation and Recovery Act (RCRA) at the time of disposal. Product uses, transformations, mixtures, processes, etc., may render the resulting material hazardous, under the criteria of ignitability, corrosivity, reactivity and toxicity characteristics of the Toxicity Characteristics Leaching Procedure (TCLP) 40 CFR 261.20-24.

14. TRANSPORT INFORMATION

The transport information provided in this section only applies to the material/formulation itself, and is not specific to any package/configuration.

U.S. Department of Transportation Ground (49 CFR)

Proper shipping name:	Not regulated
Hazard class or division:	None
Identification number:	None
Packing group:	None

International Air Transportation (ICAO/IATA)

Proper shipping name:	Not regulated
Hazard class or division:	None
Identification number:	None
Packing group:	None

Water Transportation (IMO/IMDG)

Proper shipping name:	Not regulated
Hazard class or division:	None
Identification number:	None
Packing group:	None

15. REGULATORY INFORMATION

United States Regulatory Information

TSCA 8 (b) Inventory Status:	All components are listed or are exempt from listing on the Toxic Substances Control Act Inventory.
TSCA 12 (b) Export Notification:	None above reporting de minimis
CERCLA/SARA Section 302 EHS:	None above reporting de minimis.
CERCLA/SARA Section 311/312:	Immediate Health, Delayed Health
CERCLA/SARA Section 313:	None above reporting de minimis.
California Proposition 65:	This product contains a chemical known in the State of California to cause cancer.

Canada Regulatory Information

CEPA DSL/NDSL Status:	All components are listed on or are exempt from listing on the Canadian Domestic Substances List.

16. OTHER INFORMATION

This safety data sheet contains changes from the previous version in sections: This Safety Data Sheet contains changes from the previous version in Section(s): 2, 11

Prepared by: Donna Houston, Regulatory Affairs Specialist

Issue date: 03/24/2017

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HIGH PURITY
FOOD GRADE d-LIMONENE

BLUBONIC INDUSTRIES®

Blubonic Industries
1905 Wilcox Ave Ste 311
Los Angeles CA 90068
323-762-5551

MATERIAL SAFETY DATA SHEET

Section 1: PRODUCT IDENTIFICATION

Product Name: High Purity (HP) Food Grade d-Limonene
Synonyms: Orange Terpenes, Terpene Hydrocarbons

Description: High Purity Food Grade d-Limonene is a highly refined grade of d-Limonene (>98% purity). It has less non-volatile residue (NVR) and has a lower odor profile. High Purity d-Limonene can be used in it's pure form, blended with other solvents, or easily emulsified. It is 100% bio-based, contains no hazardous air pollutants (HAP), no ozone depleting chemicals (ODC), and is Generally Recognized As Safe (GRAS) rated by the FDA.

d-Limonene is a biodegradable solvent occurring in nature as the main component of orange peel oil.

Section 2: HAZARDS IDENTIFICATION

Emergency Overview
Appearance/Odor: Colorless liquid with citrus aroma. Product is Combustible. Slippery when spilled.

Likely Routes of Exposure: Eye contact, skin contact, inhalation.

Eye: Causes moderate to severe irritation.

Skin: May cause slight redness. Prolonged or repeated exposure may cause drying of the skin.

Inhalation: May cause nose, throat, and respiratory tract irritation, coughing, headache.

Ingestion: Not likely to be toxic, but may cause vomiting, headache, or other medical problems.

Medical Conditions Aggravated By Exposure: May irritate the skin of people with pre-existing skin conditions.

This product does not contain any carcinogens or potential carcinogens as listed by OSHA, IARC, ACGIH or NTP.

Section 3: COMPOSITION/INFORMATION ON INGREDIENTS

Component	**CAS #**	**% by Wt.**
Orange Terpenes	138-86-3	100

Section 4: FIRST AID MEASURES

Eye Contact: Remove contact lenses at once. Flush with water for at least 15 minutes. If irritation persists, seek medical attention.

Skin Contact: Wash affected area with copious amounts of soap and water. If irritation develops, seek medical attention.

Inhalation: If symptoms of overexposure are experienced, move to fresh air. If symptoms persist, seek medical attention.

Ingestion: Seek medical attention immediately. DO NOT induce vomiting. Rinse mouth with water. DO NOT administer anything by mouth to an unconscious person. DO NOT leave victim unattended.

General: As with any chemical, employees should thoroughly wash hands with soap and water after handling this material.

Section 5: FIRE FIGHTING MEASURES

Suitable Extinguishing Media: Carbon dioxide, foam or dry chemical. Caution: Carbon dioxide will displace air in confined spaces and may create an oxygen deficient atmosphere.
Unsuitable Extinguishing Media: Water.
Products of Combustion: Forms acrid fumes, carbon monoxide, and carbon dioxide.
Protection of Firefighters: Vapors may be irritating to eyes, skin and respiratory tract. Firefighters should wear self-contained breathing apparatus (SCBA) and full fire-fighting turnout gear.

Section 6: ACCIDENTAL RELEASE MEASURES

Personal Precautions: Use personal protection recommended in Section 8. Product is slippery when spilled. Isolate the hazard area. Deny entry to unnecessary and unprotected personnel.
Environmental Precautions: Keep out of drains, sewers, ditches and waterways.
Methods for Containment: Dike spill area and cap leaking containers as necessary to prevent further spreading of spilled material. Absorb spilled liquid with suitable material such as dirt or sand.
Methods for Clean Up: Eliminate all ignition sources. Use equipment rated for use around combustible materials. Oil soaked rags may spontaneously combust; place in appropriate disposal container.
Other Information: There are no special reporting requirements for spills of this material.

Section 7: HANDLING AND STORAGE

Handling
Keep away from heat, sparks and flame. Open container slowly to release pressure caused by temperature variations. Do not allow this material to come in contact with eyes. Avoid prolonged contact with skin. Use in well-ventilated areas. Do not breathe vapors. Drum lining may occasionally chip and fall to the bottom of container; product should be filtered or strained before blending or repackaging. As with any chemical, employees should thoroughly wash hands with soap and water after handling this material.
Storage
Product may be packaged in phenolic-lined steel containers or fluorinated plastic containers. Store in a well ventilated area with proper sprinkler/fire deterrent system. Storage temperature should not exceed the flash point for extended periods of time. Keep container closed when not in use. Air should be excluded from partially filled containers by displacing with nitrogen or carbon dioxide. Do not cut, drill, grind or weld on or near this container; residual vapors may ignite.

Section 8: EXPOSURE CONTROLS/PERSONAL PROTECTION

Exposure Guidelines

Orange Terpenes	8h TWA=30 ppm (AIHA Standard)

TWA –Time Weighted Average

Engineering Controls: Provide ventilation. Keep away from sparks and flames.
Eye/Face Protection: Wear safety glasses or goggles.
Skin Protection: Nitrile gloves are recommended. Boots, apron, or bodysuit should be worn as necessary.
Respiratory Protection: Not normally required. If adequate ventilation is unavailable, use NIOSH approved air-purifying respirator with organic vapor cartridge or canister.
General Hygiene Considerations: Wash hands thoroughly after handling. Have eyewash and emergency shower facilities immediately available. Launder contaminated clothing before reuse.

Section 9: PHYSICAL AND CHEMICAL PROPERTIES

Color: Colorless.
Odor: Citrus aroma.
Physical State: Liquid.
Boiling Point: 349ºF (176ºC)
Melting Point: -140ºF (-96ºC), thickens at -108ºF (-78ºC)
Specific Gravity: 0.838 to 0.843 @ 77ºF (25ºC)
Refractive Index: 1.471 to 1.474 @ 68ºF (20ºC)
Optical Rotation: +96º to +104º @ 77ºF (25ºC)
Vapor Pressure: <2mmHg @ 68ºF (20ºC)
Flammable Limits: LEL approx. 0.7%, UEL approx. 6.1%
Autoignition Temperature: 458ºF (237ºC)

Solubility in Water: Insoluble
Evaporation Rate: 0.2(BuAc=1)
Volatile Organic Compound (VOC) Content: >95% by volume.
Note: These specifications represent a typical sample of this product, but actual values may vary. Certificates of Analysis and Specification Sheets are available upon request.

Section 10: STABILITY AND REACTIVITY

Stability: Stable.
Conditions to Avoid: Keep away from heat, sparks and flames.
Incompatible Materials: Strong oxidizing agents and strong acids, including acidic clays, peroxides, halogens, vinyl chloride, and iodine pentafluoride.
Hazardous Decomposition Products: Oxides of orange terpenes, which can result from improper storage and handling, are known to cause skin sensitization.
Possibility of Hazardous Reactions: To prevent oxidation, avoid long-term exposure to air. If storing partially filled container, fill headspace with an inert gas such as nitrogen or carbon dioxide.

Section 11: TOXICOLOGICAL INFORMATION

Acute Effects
Orange terpenes have been shown to have low oral toxicity (LD_{50}>5 g/kg) and low dermal toxicity (LD_{50}> 5g/kg) when tested on rabbits. Orange terpenes also showed low toxicity by inhalation (RD_{50}>1 g/kg) when tested on mice. The skin irritancy of limonene in guinea pigs and rabbits is considered moderate and low, respectively. Inhalation may cause irritation of the nose, throat, and respiratory tract.

Chronic Effects
This product is not classified as a carcinogen by OSHA, IARC, ACGIH or NTP. This product has not been shown to produce genetic changes when tested on bacterial or animal cells. This product does not contain known reproductive or developmental toxins. Prolonged or repeated exposure can cause drying or dermatitis of skin. Improper storage and handling may lead to the formation of a possible skin sensitizer.

Section 12: ECOLOGICAL INFORMATION

Ecotoxicity: There is no information available at this time for this product. However, a spill may produce significant toxicity to aquatic organisms and ecosystems. Some studies have shown that certain bacteria and fungus have the ability to degrade terpenes, decreasing their toxicity to fish. When spilled, this product may act as an oil, causing a film, sheen, emulsion or sludge at or beneath the surface of a body of water.
Persistence/Degradability: Product is expected to be readily biodegradable.
Bioaccumulation/Accumulation: No appreciable bioconcentration is expected in the environment.
Mobility in Environment: Orange terpenes volatilize rapidly.

Section 13: DISPOSAL CONSIDERATIONS

Disposal: Incinerate or dispose of in accordance with Local, State, and Federal Regulations. Taking regulations into consideration, waste may be incinerated or handled through EPA Spill Control Plan via landfill or dilution. Commercially clean containers prior to disposal. Oil soaked rags should be disposed of properly to prevent spontaneous combustion.

Section 14: TRANSPORT INFORMATION

US DOT Shipping Classification
Proper Shipping Name: TERPENE HYDROCARBONS, N.O.S
Identification No.: UN2319
Packing Group: III
Label/Placard: exception §173.150(f) applies.

Section 15: REGULATORY INFORMATION

Global Inventories
This product is included in the following inventories:
USA (TSCA)$_{1,2}$
Canada (DSL)$_{1,2}$
Europe (EINECS/ELINCS/Polymer/NLP)
Australia (AICS)
Korea (KECL)
Philippines (PICCS)
Japan (ENCS)$_{2}$
China (IECSC)
New Zealand (HSNO)

$_{1}$ Listed as CAS 68647-72-3 (terpenes and terpenoids, sweet orange-oil)
$_{2}$ Listed as CAS 5989-27-5 (d-limonene)

The United States FDA lists d-limonene as GRAS in 21 CFR section 182.20 and 182.60.

****

This product was produced with Good Manufacturing Practices. This product is a by-product of citrus and entirely of natural origin. This product has not been adulterated or misbranded.

****

Proposition 65: California Safe Drinking Water and Toxic Enforcement Act of 1986
This product is not known to contain any chemicals currently listed as carcinogens or reproductive toxins under California Proposition 65 at levels which would be subject to the proposition.

SARA Title III (Section 313)
This substance contains no materials subject to the reporting requirements of SARA Title III (Section 313).

Section 16: OTHER INFORMATION

NFPA 704: National Fire Protection Association
Health – 1 (slight hazard) Fire – 2 (moderate hazard) Reactivity – 0 (minimal hazard)

EINECS Number: 232-433-8

d-Limonene is the major component of orange terpenes, with the balance consisting of other terpene hydrocarbons and oxygenated compounds - octanal, myrcene, alpha-pinene, linalool predominant. d-Limonene is a by-product of citrus, entirely of natural origin, and to the best of our knowledge contains no artificial flavors, sulfites, nitrites, or pesticide residue exceeding tolerances established by the FDA. d-Limonene does NOT contain lead, cadmium, mercury, or hexavalent chromium or come in contact with these chemicals since it is an citrus derived essential oil produced by steam/vacuum distillation. Further, d-Limonene is packaged in food grade containers with inert liners that do NOT contain lead, cadmium, mercury, or hexavalent chromium. d-Limonene does NOT contain and is NOT manufactured with any of the Class I or II ozone-depleting substances listed under the United States Clean Air Act of 1990.

Legend
ACIGH – American Conference of Governmental Industrial Hygienists
AIHA – American Industrial Hygiene Association
BHT – Butylated Hydroxytoluene
EPA – United States Environmental Protection Agency
FDA – United States Food and Drug Administration
GRAS – Generally Recognized as Safe
IARC – International Agency for Research on Cancer
NIOSH – National Institute for Occupational Safety and Health
NTP – National Toxicology Program
OSHA – United States Occupational Health and Safety Administration

Caution: The user should conduct his/her own experiments and establish proper procedures and control before attempting use on critical parts.

MSDS

Material Safety Data Sheet

Samples Name: Activated Charcoal Powder by Sagano - Raw Organic Coconut Charcoal Bulk Food Grade - Premium Activated Charcoal Face Mask Coconut Powder - Natural Charcoal Teeth Whitening Toothpaste Detox

ASIN: B01CHDOY1I

Model: /

Item Number:/

Brand Name: Sagano

Client Name: Guangdong Hanyan Activated Carbon Manufacturing Co., LTD.

Address: No.674,Xingnan Road, Nancun town, Panyu Distict, Guangzhou

Post Code: 511400

Prepared by: 曾梅岚
Report Clerk
2017.09.20

Checked by: 王晓虹
Lab Senior Engineer
2017.09.20.

Approved by: 徐海健
Lab Supervisor
2017.9.21

MSDS

Material Safety Data Sheet

Section 1 - Chemical Product and Company Identification

Product Name: Activated Charcoal Powder by Sagano - Raw Organic Coconut Charcoal Bulk Food Grade - Premium Activated Charcoal Face Mask Coconut Powder - Natural Charcoal Teeth Whitening Toothpaste Detox

Manufacture: Guangdong Hanyan Activated Carbon Manufacturing Co., LTD.

Address: Nancun Industrial Zone, Nancun Town, Panyu District, Guangzhou

Tel:13533535566

Fax: 202-39972520

Email: hanyancarbon@hyhxt.net

Section 2 - Hazards Identification

Fatalness grade: In accordance with Regulation (EC) No. 1272/2008, the sample isn't divided into dangerous article. The product ingredients noit hazardous substance over in agreement with Local and National regulations.

Invasion route:. No

Health hazards:. No known significant effects or critical hazards

Environment hazards:. No known significant effects or critical hazards

Burn & burst danger: This product is flammable

Section 3 – Composition/Information on Ingredient

Pure ☐

Admixture■

Composition:

Chemical name	The molecular formula	Molecular weight	Component ratio（%）	CAS No.	EC No.
Carbon	C	12	94%	7440-44-0	240-383-3
Ash	-	-	3%	-	-
Water	H2O	18	3%	7732-18-5	231-791-2

Section 4 - First Aid Measures

Skin touch: If ill, medical treatment

Eyes touch: If ill, medical treatment

Inhalation: Without this may

Ingestion: If swallowed, it thoroughly with water gargle, medical treatment

Section 5 - Fire Fighting Measures Danger

Characteristic: This product is not flammable.

Hazardous combustion products: No

Fire-Fighting method & media:. No

Firefighters special protective equipment: No

Section 6 –Accidental Release Measures

Emergency treatment: It is suggested that the staff wear dust respirator and dress in work clothes. Shut off the divulgence source as soon as possible. Prevent the spillage flowing into restrictive space like the sewer and the drainage channel. Small amount of divulgence: clean off. Massive divulgence: recycle or transport to waste treatment place for handling..

Section 7 - Handling and Storage

Handling:. Supply with sufficient partial air exhaust. The operating staff must have received special training and abide by the operating regulations. It is advised that the staff wear respirator, wear work clothes, and wear gloves. Keep away from the fire source, heat source, no smoking in the work place. Avoid producing dust. Use explosion-proof type ventilation system and device. Avoid contacting with oxidizer and strong acid. Equip with relevant types and quantities of extinguishment instruments and device for divulgence handling. Empty the container which may include harmful material

Storage: Stored in a cool, ventilation of the treasury. Away from fire, heat source. With the oxidant and acid stored separately, avoid mixing reservoir. Equipped with the appropriate variety and quantity of fire equipment. Storage areas should be equipped with emergency treatment equipment for leakage and suitable housing materials.

Section 8 - Exposure Controls, Personal Protection

Maximum admissible concentration: No standard yet..

Monitoring Method: /

Engineering Control: Not applicable

Respiratory Protection: Wear self-inhalation filter type dust respirator if the dust density exceed in the air.

Eyes Protection: Generally do not need special protection.

Body Protection: Generally do not need special protection.

Hands Protection: Generally do not need special protection.

Other Protections: No smoking, dining and drinking water in the workplace. Keep good habit of hygiene

Section 9 - Physical and Chemical Properties

Appearance: Powder

Color: Black

Odor: No smell

Density： 0.43g/cm^3

Boiling Point: No data

Melting Point: 3500℃

Flashpoint： No data

Vapour pressure： No data.

Solubility in water： Insoluble in water

Partition coefficient (n-octanol / water): No data.

Viscosity: Not applicable

pH Value: 9-11

Permission of solvent inhalation: No data.

Solubility: Insoluble in water

Ignition temperature： No data

Section 10 - Stability and Reactivity

Stability: Stable under normal temperature and pressure.

Distribution of Ban: Strong oxidizer, strong acid.

Conditions to Avoid: Not applicable.

Hazardous Polymerization: No data

Hazardous Decomposition Products: Under normal conditions of storage and use, hazardous decomposition products should not be produced.

Section 11 - Toxicological Information

Acute Toxicity: No data.

Sub-acute and Chronic Toxicity: No data.

Irritation: No data.

Sensitization: No data.

Mutagenicity: No data.

Carcinogenicity: No data.

Others: / .

Section 12 - Ecological Information

Eco-toxicity: No known significant effects or critical hazards.

Biodegradable: No applicable.

Non-biodegradable: No applicable.

Bioconcentration or biological accumulation: No applicable.

Other harmful effects: No known significant effects or critical hazards.

Section 13 - Disposal Considerations

Waste disposal method: No special requirements

Section 14 - Transport Information

This product is not considered hazardous for transportation

Number of dangerous goods: No applicable.

UN Number: No data.

Packaging Mark: According to customer requirements

Packaging Method: No special requirements.

Transport Attentions: Examine whether the package of the containers are integrate and tighten closed before transport. No divulgence, no collapse, no precipitation or no damage during the course of transportation. Don't put the goods together with oxidizer, acid and so on. The transport vehicle and ship must be cleaned and sterilized otherwise it is not allowed to assemble articles. During transport, the vehicle should prevent exposure, rain and high temperature. For stopovers, the vehicle should be away from fire and heat sources. Don't use device and tools which can easily produce spark for loading. When transported by sea, the assemble place should keep away from bedroom and kitchen, and isolated from the engine room, power and fire source. Under the condition of Road Transportation, the driver should drive in accordance with regulated route, don't stop over in the residential area and congested area. No slipping up in rail road. According to the IMDG Code (inc Amdt 34-08) 2014 Edition, The sample is not regulated for transport of dangerous goods. Meets requirements of 49 CFR 173.185 to be transported as non-dangerous goods for road, rail, air, and vessel.

Section 15 - Regulatory Information

Regulatory Information:

ISO 11014-2009 Safety data sheet for chemical products - Content and order of sections.

Regulation (EC) No.1272/2008 Classification, Labeling and Packaging of Substances and Mixtures.

The International Maritime Dangerous Goods (IMDG) Code.

Section 16 - Additional Information

The above information is based on the data of which we are aware and is believed to be correct as of the data hereof. Since this information may be applied under conditions beyond our control and with which may be unfamiliar and since data made available subsequent to the data hereof may suggest modifications of the information, we do not assume any responsibility for the results of its use. This information is furnished upon condition that the person receiving it shall make his own determination of the suitability of the material for his particular purpose.

Note:

- Photo is included

Sample Description ：Activated Charcoal Powder by Sagano - Raw Organic Coconut Charcoal Bulk Food Grade - Premium Activated Charcoal Face Mask Coconut Powder - Natural Charcoal Teeth Whitening Toothpaste Detox

Photograph of Sample

Charcoal Powder

******End of MSDS******

Safety Data Sheet:
Material Name: Elmer's Disappearing Purple Glue Stick
SDS ID: SDS-89
Issue Date: 2015-04-22
Revision: .

Other Sections

01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16

Section 1 - PRODUCT AND COMPANY IDENTIFICATION

Material Name
Elmer's Disappearing Purple Glue Stick

Synonyms
E1558, E1559, E1560, E1573, E1591, E238, E239, E310, E4051, E4053, E4055, E4057, E5007, E5009, E502, E503, E5042, E5051, E506, E508, E513, E514, E520, E522, E5223, E523, E524, E543, E546, E555, E558, E261, E562, E576, E578, E60520, E64051, E64523, 60320, 60554, 60555, 61576, 61592, 61665, 61667, 61668, 61669, 61715, 62428, 60307, 61665, 61666, 61669, 62428

Product Use
Adhesive

Restrictions on Use
None known

Manufacturer Information

Elmer's Products, Inc
460 Polaris Parkway, Suite 500
Westerville, OH 43082
USA
Phone:1-888-435-6377
Fax:1-800-741-6046
Email:comments@elmers.com

Emergency Phone Number:
Poison Control Center
1-888-516-2502

For additional product information, access our website at www.elmers.com. To place an order, call 1-800-848-9400.

Section 2 - HAZARDS IDENTIFICATION

Classification in accordance with paragraph (d) of 29 CFR 1910.1200.

None needed according to classification criteria

GHS Label Elements

Symbol(s)

None needed according to classification criteria

Signal Word

None needed according to classification criteria

Hazard Statement(s)

None needed according to classification criteria

Precautionary Statement(s)

Prevention

None needed according to classification criteria

Response

None needed according to classification criteria

Storage

None needed according to classification criteria

Disposal

Dispose of contents/container in accordance with local/regional/national/international regulations

Statement of Unknown Toxicity

100% of the mixture consists of ingredient(s) of unknown acute toxicity.

Other Hazards

No data available

Section 3 - COMPOSITION / INFORMATION ON INGREDIENTS

CAS	Component Name	Percent
Not available	Non-hazardous substance	100

Section 4 - FIRST AID MEASURES

Inhalation

If adverse effects occur, remove to uncontaminated area. If discomfort persists, contact a physician.

Skin

If on skin, wash immediately with plenty of soap and water. Get medical attention if irritation develops.

Eyes

Remove contact lenses, if present and easy to do. IMMEDIATELY wash with large amounts of warm water, occasionally lifting upper and lower lids, until no evidence of chemical remains (at least 15-20 minutes). Get medical attention immediately.

Ingestion

Rinse mouth thoroughly with water. Never give anything by mouth to an unconscious or convulsive person. Do NOT induce vomiting. Immediately call a POISON CENTER or doctor/physician.

Indication of any immediate medical attention and special treatment needed

Treat symptomatically and supportively.

Most Important Symptoms/Effects

Acute

No information on significant adverse effects.

Delayed

No information on significant adverse effects.

Section 5 - FIRE FIGHTING MEASURES

Extinguishing Media

Suitable Extinguishing Media

Use carbon dioxide, regular dry chemical, regular foam or water.

Unsuitable Extinguishing Media

None known.

Special Hazards Arising from the Chemical

Slight fire hazard.

Hazardous Combustion Products

oxides of carbon

Special Protective Equipment and Precautions for Firefighters

Wear full protective fire fighting gear including self contained breathing apparatus (SCBA) for protection against possible exposure.

Fire Fighting Measures

Move container from fire area if it can be done without risk. Avoid inhalation of material or combustion by-products. Stay upwind and keep out of low areas.

Section 6 - ACCIDENTAL RELEASE MEASURES

Personal Precautions, Protective Equipment and Emergency Procedures

See Section 8 for Personal Protective Equipment recommendations.

Methods and Materials for Containment and Cleaning Up

Stop leak if possible without personal risk. Small spills: Absorb with sand or other non-combustible material. Collect spilled material in appropriate container for disposal.

Section 7 - HANDLING AND STORAGE

Precautions for Safe Handling

Wash thoroughly after handling.

Conditions for Safe Storage, Including any Incompatibilities

None needed according to classification criteria
Store in accordance with all current regulations and standards. Keep separated from incompatible substances.

Incompatible Materials

oxidizing materials

Section 8 - EXPOSURE CONTROLS / PERSONAL PROTECTION

Component Exposure Limits

ACGIH, NIOSH, EU, OSHA (US) and Mexico have not developed exposure limits for any of this product's components

Biological limit value

There are no biological limit values for any of this product's components.

Engineering Controls

Based on available information, additional ventilation is not required. Ensure compliance with applicable exposure limits.

Individual Protection Measures, such as Personal Protective Equipment

Eye/face protection

Eye protection not required under normal conditions.

Skin Protection

Protective clothing is not required under normal conditions.

Respiratory Protection

No respirator is required under normal conditions of use.

Glove Recommendations

Protective gloves are not required under normal conditions.

Section 9 - PHYSICAL AND CHEMICAL PROPERTIES

Appearance	purple solid	**Physical State**	solid
Odor	mild odor	**Color**	purple
Odor Threshold	Not available	**pH**	10.2 - 10.7
Melting Point	Not available	**Boiling Point**	100 ^{0}C
Freezing point	0 °C	**Evaporation Rate**	Not available
Boiling Point Range	Not available	**Flammability (solid, gas)**	Non-Flammable
Autoignition	Not available	**Flash Point**	None
Lower Explosive Limit	Not available	**Decomposition**	Not available
Upper Explosive Limit	Not available	**Vapor Pressure**	Not applicable
Vapor Density (air=1)	Not applicable	**Specific Gravity (water=1)**	1.01 - 1.02
Water Solubility	Miscible	**Partition coefficient: n-octanol/water**	Not available
Viscosity	Not available	**Solubility (Other)**	Not available
Density	8.4 - 8.5	**Physical Form**	solid

Section 10 - STABILITY AND REACTIVITY

Reactivity

Not known to occur.

Chemical Stability

Stable at normal temperatures and pressure.

Possibility of Hazardous Reactions

Will not polymerize.

Conditions to Avoid

Avoid heat, flames, sparks and other sources of ignition. Avoid contact with incompatible materials.

Incompatible Materials

oxidizing materials

Hazardous decomposition products

oxides of carbon

Section 11 - TOXICOLOGICAL INFORMATION

Information on Likely Routes of Exposure

Inhalation

No information on significant adverse effects.

Skin Contact

No information on significant adverse effects.

Eye Contact

No information on significant adverse effects.

Ingestion

No information on significant adverse effects.

Acute and Chronic Toxicity

Component Analysis - LD50/LC50

The components of this material have been reviewed in various sources and no selected endpoints have been identified

Immediate Effects
No information on significant adverse effects.

Delayed Effects
No information on significant adverse effects.

Irritation/Corrosivity Data
No information on significant adverse effects.

Respiratory Sensitization
No data available.

Dermal Sensitization
No data available.

Component Carcinogenicity
None of this product's components are listed by ACGIH, IARC, NTP, DFG or OSHA

Germ Cell Mutagenicity
No data available.

Reproductive Toxicity
No data available.

Specific Target Organ Toxicity - Single Exposure
No data available.

Specific Target Organ Toxicity - Repeated Exposure
No data available.

Aspiration hazard
No data available.

Medical Conditions Aggravated by Exposure
None known.

Section 12 - ECOLOGICAL INFORMATION

Component Analysis - Aquatic Toxicity
No LOLI ecotoxicity data are available for this product's components

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Section 13 - DISPOSAL CONSIDERATIONS

Disposal Methods

Dispose of contents/container in accordance with local/regional/national/international regulations.

Component Waste Numbers

The U.S. EPA has not published waste numbers for this product's components

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Section 14 - TRANSPORT INFORMATION

US DOT Information:
UN/NA #: Not regulated

IATA Information:
UN#: Not regulated

TDG Information:
UN#: Not regulated

Section 15 - REGULATORY INFORMATION

U.S. Federal Regulations

None of this products components are listed under SARA Sections 302/304 (40 CFR 355 Appendix A), SARA Section 313 (40 CFR 372.65), CERCLA (40 CFR 302.4), TSCA 12(b), or require an OSHA process safety plan.
SARA Section 311/312 (40 CFR 370 Subparts B and C)
Acute Health: No **Chronic Health:** No **Fire:** No **Pressure:** No **Reactivity:** No

U.S. State Regulations

None of this product's components are listed on the state lists from CA, MA, MN, NJ or PA

Not listed under California Proposition 65

Canadian WHMIS Ingredient Disclosure List (IDL)

The components of this product are either not listed on the IDL or are present below the threshold limit listed on the IDL.

Section 16 - OTHER INFORMATION

NFPA Ratings

Health: 1 Fire: 1 Reactivity: 0
Hazard Scale: 0 = Minimal 1 = Slight 2 = Moderate 3 = Serious 4 = Severe

Summary of Changes

Updated SDS: 12/02/2014

Key / Legend

ACGIH - American Conference of Governmental Industrial Hygienists; ADR - European Road Transport; AU - Australia; BOD - Biochemical Oxygen Demand; C - Celsius; CA - Canada; CAS - Chemical Abstracts Service; CERCLA - Comprehensive Environmental Response, Compensation, and Liability Act; CLP - Classification, Labelling, and Packaging; CN - China; CPR - Controlled Products Regulations; DFG - Deutsche Forschungsgemeinschaft; DOT - Department of Transportation; DSD - Dangerous Substance Directive; DSL - Domestic Substances List; EEC - European Economic Community; EINECS - European Inventory of Existing Commercial Chemical Substances; EPA - Environmental Protection Agency; EU - European Union; F - Fahrenheit; IARC - International Agency for Research on Cancer; IATA - International Air Transport Association; ICAO - International Civil Aviation Organization; IDL - Ingredient Disclosure List; IDLH - Immediately Dangerous to Life and Health; IMDG - International Maritime Dangerous Goods; JP - Japan; Kow - Octanol/water partition coefficient; KR - Korea; LEL - Lower Explosive Limit; LLV - Level Limit Value; LOLI - List Of LIsts™ - ChemADVISOR's Regulatory Database; MAK - Maximum Concentration Value in the Workplace; MEL - Maximum Exposure Limits; NFPA - National Fire Protection Agency; NIOSH - National Institute for Occupational Safety and Health; NJTSR - New Jersey Trade Secret Registry; NTP - National Toxicology Program; NZ - New Zealand; OSHA - Occupational Safety and Health Administration; PH - Philippines; RCRA - Resource Conservation and Recovery Act; REACH- Registration, Evaluation, Authorisation, and restriction of Chemicals; RID - European Rail Transport; SARA - Superfund Amendments and Reauthorization Act; STEL - Short-term Exposure Limit; TDG - Transportation of Dangerous Goods; TSCA - Toxic Substances Control Act; TWA - Time Weighted Average; UEL - Upper Explosive Limit; US - United States.

Other Information

Disclaimer:

Supplier gives no warranty whatsoever, including the warranties of merchantability or of fitness for a particular purpose. Any product purchased is sold on the assumption the purchaser shall determine the quality and suitability of the product. Supplier expressly disclaims any and all liability for incidental, consequential or any other damages arising out of the use or misuse of this product. No information provided shall be deemed to be a recommendation to use any product in conflict with any existing patent rights.

SAFETY DATA SHEET

Creation Date 22-Feb-2010 **Revision Date** 17-Jan-2018 **Revision Number** 3

1. Identification

Product Name	**Methylene Blue Trihydrate**
Cat No. :	**M235-100; M291-25; M291-100**
CAS-No	7220-79-3
Synonyms	C.I. 52015 trihydrate; Basic Blue 9 trihydrate
Recommended Use	Laboratory chemicals.
Uses advised against	Not for food, drug, pesticide or biocidal product use

Details of the supplier of the safety data sheet

Company
Fisher Scientific
One Reagent Lane
Fair Lawn, NJ 07410
Tel: (201) 796-7100

Emergency Telephone Number
CHEMTREC®, Inside the USA: 800-424-9300
CHEMTREC®, Outside the USA: 001-703-527-3887

2. Hazard(s) identification

Classification

This chemical is considered hazardous by the 2012 OSHA Hazard Communication Standard (29 CFR 1910.1200)

Acute oral toxicity	Category 4

Label Elements

Signal Word
Warning

Hazard Statements
Harmful if swallowed

Precautionary Statements
Prevention
Wash face, hands and any exposed skin thoroughly after handling
Do not eat, drink or smoke when using this product

Ingestion
IF SWALLOWED: Call a POISON CENTER or doctor/physician if you feel unwell
Rinse mouth
Disposal
Dispose of contents/container to an approved waste disposal plant
Hazards not otherwise classified (HNOC)
None identified

3. Composition/Information on Ingredients

Component	CAS-No	Weight %
Methylene blue trihydrate	7220-79-3	>95
Methylene blue	61-73-4	-

4. First-aid measures

General Advice	If symptoms persist, call a physician.
Eye Contact	Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes. Get medical attention.
Skin Contact	Wash off immediately with plenty of water for at least 15 minutes. If skin irritation persists, call a physician.
Inhalation	Move to fresh air. If not breathing, give artificial respiration. Get medical attention if symptoms occur.
Ingestion	Clean mouth with water and drink afterwards plenty of water. Get medical attention if symptoms occur.
Most important symptoms and effects	None reasonably foreseeable.
Notes to Physician	Treat symptomatically

5. Fire-fighting measures

Suitable Extinguishing Media	Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.
Unsuitable Extinguishing Media	No information available
Flash Point	No information available
Method -	No information available
Autoignition Temperature	
Explosion Limits	
Upper	No data available
Lower	No data available
Sensitivity to Mechanical Impact	No information available
Sensitivity to Static Discharge	No information available

Specific Hazards Arising from the Chemical
Thermal decomposition can lead to release of irritating gases and vapors. Keep product and empty container away from heat and sources of ignition.

Hazardous Combustion Products
Hydrogen chloride gas Nitrogen oxides (NOx) Carbon monoxide (CO) Carbon dioxide (CO_2)
Protective Equipment and Precautions for Firefighters
As in any fire, wear self-contained breathing apparatus pressure-demand, MSHA/NIOSH (approved or equivalent) and full

protective gear.

NFPA

Health	**Flammability**	**Instability**	**Physical hazards**
2	1	0	N/A

6. Accidental release measures

Personal Precautions	Use personal protective equipment. Ensure adequate ventilation. Avoid dust formation.
Environmental Precautions	Should not be released into the environment.
Methods for Containment and Clean Up	Sweep up or vacuum up spillage and collect in suitable container for disposal. Keep in suitable, closed containers for disposal.

7. Handling and storage

Handling	Wear personal protective equipment. Ensure adequate ventilation. Avoid dust formation. Do not get in eyes, on skin, or on clothing. Avoid ingestion and inhalation.
Storage	Keep containers tightly closed in a dry, cool and well-ventilated place.

8. Exposure controls / personal protection

Exposure Guidelines	This product does not contain any hazardous materials with occupational exposure limitsestablished by the region specific regulatory bodies.
Engineering Measures	Ensure adequate ventilation, especially in confined areas. Ensure that eyewash stations and safety showers are close to the workstation location.

Personal Protective Equipment

Eye/face Protection	Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.
Skin and body protection	Long sleeved clothing.
Respiratory Protection	No protective equipment is needed under normal use conditions.
Hygiene Measures	Handle in accordance with good industrial hygiene and safety practice.

9. Physical and chemical properties

Physical State	Solid
Appearance	Dark green
Odor	Odorless
Odor Threshold	No information available
pH	3 - 4.5
Melting Point/Range	100 - 110 °C / 212 - 230 °F
Boiling Point/Range	No information available
Flash Point	No information available
Evaporation Rate	Not applicable
Flammability (solid,gas)	No information available
Flammability or explosive limits	
Upper	No data available
Lower	No data available
Vapor Pressure	negligible
Vapor Density	Not applicable
Specific Gravity	No information available

Solubility	Slightly soluble in water
Partition coefficient; n-octanol/water	No data available
Autoignition Temperature	
Decomposition Temperature	190 °C
Viscosity	Not applicable
Molecular Formula	C16 H18 Cl N3 S . 3 H2 O
Molecular Weight	373.89

10. Stability and reactivity

Reactive Hazard	None known, based on information available
Stability	Stable under normal conditions.
Conditions to Avoid	Avoid dust formation. Incompatible products. Excess heat.
Incompatible Materials	Strong oxidizing agents
Hazardous Decomposition Products	Hydrogen chloride gas, Nitrogen oxides (NOx), Carbon monoxide (CO), Carbon dioxide (CO_2)
Hazardous Polymerization	Hazardous polymerization does not occur.
Hazardous Reactions	None under normal processing.

11. Toxicological information

Acute Toxicity

Product Information

Component Information

Component	LD50 Oral	LD50 Dermal	LC50 Inhalation
Methylene blue	LD50 = 1180 mg/kg (Rat)	Not listed	Not listed

Toxicologically Synergistic Products No information available

Delayed and immediate effects as well as chronic effects from short and long-term exposure

Irritation	Irritating to eyes, respiratory system and skin
Sensitization	No information available
Carcinogenicity	The table below indicates whether each agency has listed any ingredient as a carcinogen.

Component	CAS-No	IARC	NTP	ACGIH	OSHA	Mexico
Methylene blue trihydrate	7220-79-3	Not listed	Not listed	Not listed	Not listed	Not listed
Methylene blue	61-73-4	Not listed	Not listed	Not listed	Not listed	Not listed

Mutagenic Effects	No information available
Reproductive Effects	No information available.
Developmental Effects	No information available.
Teratogenicity	No information available.
STOT - single exposure	None known
STOT - repeated exposure	None known
Aspiration hazard	No information available

Symptoms / effects,both acute and delayed	No information available
Endocrine Disruptor Information	No information available
Other Adverse Effects	The toxicological properties have not been fully investigated.

12. Ecological information

Ecotoxicity

Do not empty into drains.

Persistence and Degradability	Soluble in water Persistence is unlikely based on information available.
Bioaccumulation/ Accumulation	No information available.
Mobility	Will likely be mobile in the environment due to its water solubility.

13. Disposal considerations

Waste Disposal Methods	Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. Chemical waste generators must also consult local, regional, and national hazardous waste regulations to ensure complete and accurate classification.

14. Transport information

DOT	Not regulated
TDG	Not regulated
IATA	Not regulated
IMDG/IMO	Not regulated

15. Regulatory information

International Inventories

Component	TSCA	DSL	NDSL	EINECS	ELINCS	NLP	PICCS	ENCS	AICS	IECSC	KECL
Methylene blue	X	X	-	200-515-2	-		X	-	X	X	X

Legend:
X - Listed
E - Indicates a substance that is the subject of a Section 5(e) Consent order under TSCA.
F - Indicates a substance that is the subject of a Section 5(f) Rule under TSCA.
N - Indicates a polymeric substance containing no free-radical initiator in its inventory name but is considered to cover the designated polymer made with any free-radical initiator regardless of the amount used.
P - Indicates a commenced PMN substance
R - Indicates a substance that is the subject of a Section 6 risk management rule under TSCA.
S - Indicates a substance that is identified in a proposed or final Significant New Use Rule
T - Indicates a substance that is the subject of a Section 4 test rule under TSCA.
XU - Indicates a substance exempt from reporting under the Inventory Update Rule, i.e. Partial Updating of the TSCA Inventory Data Base Production and Site Reports (40 CFR 710(B).
Y1 - Indicates an exempt polymer that has a number-average molecular weight of 1,000 or greater.
Y2 - Indicates an exempt polymer that is a polyester and is made only from reactants included in a specified list of low concern reactants that comprises one of the eligibility criteria for the exemption rule.

U.S. Federal Regulations

TSCA 12(b)	Not applicable
SARA 313	Not applicable
SARA 311/312 Hazard Categories	See section 2 for more information
CWA (Clean Water Act)	Not applicable

Clean Air Act	Not applicable

OSHA Occupational Safety and Health Administration
Not applicable

CERCLA	Not applicable
California Proposition 65	This product does not contain any Proposition 65 chemicals

U.S. State Right-to-Know Regulations

Component	Massachusetts	New Jersey	Pennsylvania	Illinois	Rhode Island
Methylene blue trihydrate	-	-	-	X	-

U.S. Department of Transportation

Reportable Quantity (RQ):	N
DOT Marine Pollutant	N
DOT Severe Marine Pollutant	N

U.S. Department of Homeland Security
This product does not contain any DHS chemicals.

Other International Regulations

Mexico - Grade	No information available

16. Other information

Prepared By	Regulatory Affairs Thermo Fisher Scientific Email: EMSDS.RA@thermofisher.com
Creation Date	22-Feb-2010
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Print Date	17-Jan-2018
Revision Summary	SDS sections updated. 2. 4. 8. 11. 16.

Disclaimer
The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text

End of SDS