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THE EFFECTS OF TEMPERATURE ON THE SIZE AND NUMBER OF PARTICLES FORMED THROUGH THE DEGRADATION OF POLYETHYLENE TEREPHTHALATE (PET) PLASTICDAHLIA ZEMMEL

EDITOR IN CHEIF	CRISTINA ELLIS
FACULTY ADVISOR	MS. BEATON
CONTENT ADVISOR	FRANCESCA MASTER



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WHAT ARE RAINBOWS?

Francesca Master



Source: National Geographic

Rainbows play a significant role in the story of Saint Patrick and, therefore, are one of the main symbols of his holiday. Almost everybody has heard stories of the leprechaun at the end of the rainbow and, perhaps, followed one with the goal of finding a pot of gold. But what is it that causes these majestic phenomena to happen?

A rainbow forms when sunlight travels through a

raindrop a t a 42-degree angle. Contrary to popular belief, rainbows don't actually exist in the sky but rather are a n optical illusion. Whether or not one sees one depends on where a person is standing, as well as the relative location of the sun.

A rainbow forms because of the refraction and reflection of light; both involve a change in the wave's direction. When light goes into a water droplet, it is refracted and then reflected by the back of the droplet. When the light leaves the droplet, it gets refracted at multiple angles, causing a spectrum of color, including red, orange, yellow, green, blue, indigo, and violet. Red has the longest wavelength of visible light, about 650 nanometers, while violet has 400 shortest, about nanometers.

Although people think

rainbows are just a curve, they are actually full circles! On the ground, you can only see the light's reflection above the horizon, and every viewer sees it differently. When you are in a plane, you are more likely to see it as circular.

There are also many variations of rainbows. Double rainbows occur when light gets reflected twice inside a rainbow, forming a second rainbow above the



A circular double rainbow! Source: Slate

first where the colors are rainbow is a reflected reversed, with red on the rainbow, which shows up on inside and violet on the a body of water. It's created outside. Another type of by light getting reflected on

the water's surface.

Rainbows have long been one of nature's most beautiful and inspiring symbols. And, while there may be no pot of gold sitting at the end of one, it is still worthwhile to take a moment and look up

when you see one.

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WHAT MAKES HAIR RED?

Cristina Ellis



Source: The House of Wellness

Every Saint Patrick's Day, bombarded with w e are images of red hair. The holiday is mainly associated Ireland with since Saint Patrick is the island's patron saint; therefore, it is only fitting that in turn, Saint Patrick's Day is represented by another of the isle's

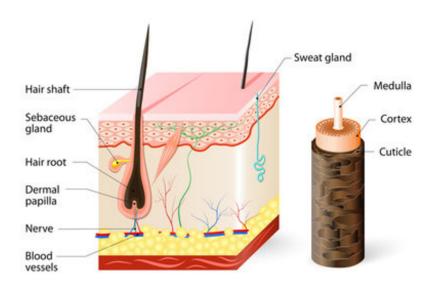
enduring symbols, red hair. Ireland has a higher percentage of redheads than any country in the world. 2% o f t h e world's Only population has red hair, but about 10% of the Irish are redheads. But why do some people have red hair? What determines hair color?

To understand what makes hair red, first, it is essential to understand the composition of hair. Hairs are thin strands of protein packed into hardened layers. The outer layer (the one we see) is called the cuticle, and its purpose is to protect the softer inner layers, called the cortex and the medulla.

Hair grows out of follicles, which are like small pits in a person's skin; attached to each follicle is a sebaceous gland, which produces oil to prevent the hair from becoming dry. Hair growth is driven by the dermal papilla (DP), which regulates follicle development and growth cycles.

The dermal papilla interacts with melanocytes, which are cells specialized that produce melanin, the pigment in our hair that regulates color. There actually two different types melanin i n our hair: eumelanin and pheomelanin. The eumelanin causes hair to appear brown or black, and pehomelanin causes i t look red or yellow.

The relative amounts of these two pigments determine the color of a person's hair. People with dark hair have a lot more eumelanin in their hair than pheomelanin, and for people with light hair, the reverse is true. But what is it that causes people to



A Diagram Depicting Parts of Hair Source: Adobe Stock Images



Saint Patrick's Day revelers celebrating with fake red beards Source: National Geographic Kids

have red hair instead of blonde? Once again, it is the level of pheomelanin in one's hair. While all light-haired people have more pheomelanin than eumelanin, they don't all have the same amount; redheads have more pheomelanin than blondes.

Hair is one of the human body's most diverse a n d compelling parts. It can be used as a form of selfexpression o r representation of pride for one's community. On Saint Patrick's day, it is used to show pride for one's Irish heritage and the isle's long history. If you're a natural redhead, go out and flaunt it next holiday; if not, well, there's always box dye.

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WHAT MAKES SNAKES SPECIAL?

Meredith Metz



Source: Humane Society

chases a w a y persisting frosts, birds, insects, and reptiles come back from shelters. their activity. The best way to gain appreciation for them is to understand their behavior a n d how their bodies function. Ultimately, snakes are an underappreciated gem of the natural world.

In temperate climates. reptiles and other coldblooded animals have developed different ways to cope with winter weather.

In early spring, as the sun Snakes at this latitude start brumating, meaning they slow their breath a n d metabolism when the Snakes are temperature drops among these animals, so be consistently below 60 degrees on the lookout for increasing Fahrenheit. Once the weather warm enough, gets become more active and start eating again. Most snakes use constriction t o incapacitate their food, but others use venom produced b v salivary glands paralyze o r damage cardiovascular operations. Almost snake a 11 species swallow their food whole. with few exceptions, contrary to popular belief

they are not able to dislocate their jaws. Instead, their mandibles, the sides of the lower jaw, connect with ligaments that allow the jaw to expand laterally. All of these traits work together to allow snakes to swallow large prey.

To hunt, snakes use a variety senses. Their primary sense is smell, felt primarily the Jacobson's through organ. The forked tongue brings samples of the air to this organ, which is in the roof of the mouth, in order recognize familiar t o molecules. The tongue's divergence lets snake t h e identify the direction of the

smell. This helps the snake locate prey, mates, predators, especially while in darkness. Many snakes have heat pits that let them detect infrared radiation. When the pit's membrane senses this radiation, sends i t a n electrical signal to the brain, which then processes it as an image. When there is enough light, snakes can also see in color. However, their eyes can only detect blue and green wavelengths, which is called dichromatic vision. Additionally, snakes less than we do because they d o not have earholes. Instead, vibrations travel from their jaw to their inner ear.



Source: iStock

In addition to having unique senses, snakes also possess distinctive anatomy. Their true tail is a lot longer than think. Ιt actually most ranges from 1-31% of their total length, with arboreal snakes having the longest terrestrial a n d ones possessing the shortest. Their body is outfitted with elongated organs protected by about 400 ribs. Another source of defense is scales, which not only act as shields but also as camouflage. They are dry, waxy, and made of keratin. They s h e d outermost layer when needed to remove parasites or to grow.

There's a lot more to snakes than meets the eye. Their unique structures, senses, and behavior paved the way for other developments, ultimately creating an almost alien creature.

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Source: Live Science

FSB FUN FACTS

FSB Staff



Source: The Pioneer Woman

Saint Patrick's Day is heavily associated with Ireland and has a number of distinct symbols and icons. Here are some fun facts about some of these icons and the Emerald Isle itself.

1. How rare is a four-leaf clover?

Clover is the name commonly used for plants of the genus Trifolium (from Latin tres 'three' and folium 'leaf'). There are about 300 species of clover, and they can be found in North America, Europe, South America, Africa, and even in the

tropics (on mountains a t high altitudes). Only about 1 out of 10,000 clovers have four leaves. Rare genetic mutations are responsible for four-leaf and higher-leaf o f versions clovers. According to the Guinness Book of World Records, the most leaves ever found on a clover are 18. This specimen was found by a man in Japan in 2002.

2. Why are emeralds green?

Emeralds are a variety of the mineral beryl (Be₃Al₂Si₆O₁₈), which is composed of beryllium and aluminum

silicate. Other members of the beryl family include the aquamarine gemstones and Emeralds morganite. are because they green have trace amounts of chromium and vanadium, which cause the stone to reflect green light. The shade of green depends upon the amount of each element that is present.

3. What is the "soda" in Irish soda bread?

Irish soda bread is a type of quick bread in which baking soda (sodium bicarbonate - NaHCO3) is used as a leavening agent instead of yeast. Traditionally, it has four ingredients: flour, baking soda, salt, and



Source: Serpentine

buttermilk. When soda bread is made, the lactic acid (C3H6O3) in the buttermilk reacts with the baking soda to produce carbon dioxide (CO2). The carbon dioxide bubbles cause the dough to rise and produce the series of interconnected pockets in the bread.

4. Why is Ireland so green?

Ireland has the ideal conditions for plant life. As a result of its location at the edge of the Atlantic Ocean, oceanic weather systems produce ample rainfall. It can rain 150-225 days a year, depending on the region. A



Source: iStock

warm ocean current known as the North Atlantic Drift keeps the climate mild. characterized cool b v summers and relatively warm winters. As a result, plants are not scorched by summer by winter heat or killed frosts. Finally, Ireland has rich fertile soil formed over thousands o f vears volcanic activity. glaciers, and ancient rivers.

5. Why is gold the most malleable metal?

Leprechauns are not the only ones who value gold. It has been popular for thousands of years, not just because of its beauty but also because of its physical properties. Gold is the most malleable and most ductile metal; it can be beaten into sheets as little as 0.00013 mm (.13

microns) thick and drawn in wires with diameters as small as 0.01 mm (10 microns). its Gold o w e s physical properties atomic to its structure and the way its atoms bond together. At an atomic level, it has a facecubic centered crystal structure (each is a to m surrounded bу 12 which neighboring atoms) permits atomic planes to glide over one another with little friction Additionally, it has metallic which bonds i n outermost electrons of each are free to move atom around the overall structure the material. This delocalized electron cloud allows atoms to move past each other without breaking off, which makes it possible to both stretch and flatten the metal.



Source: Gems of la Costa

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THE EFFECTS OF TEMPERATURE ON THE SIZE AND NUMBER OF PARTICLES FORMED THROUGH THE DEGRADATION OF POLYETHYLENE TEREPHTHALATE (PET) PLASTIC

Dahlia Zemmel

Abstract:

Polyethylene terephthalate (PET) plastic is one of the most commonly used types of plastic. Ιt i s semicrystalline polymer that degrade into smaller pieces when heated above transition glass temperature. The effects of nanoplastics the o n environment and human health are understudied experiments often because use engineered nanoparticles instead ofactual nanoplastics as they would occur in nature. The purpose of this experiment was to the effect measure o f temperature on the size and amount of particles formed in PET degradation. Another purpose of this lab was to determine if Sodium Lauryl Sulfate (a common cleaning surfactant) is an effective means of particle suspension.

The experiment studied samples held for 26 days (starting at day 0). It found that after day 14 PET held at \mathbf{C} 110 degrades into nanoplastics with the most common size of 70nm. The experiment also found that SLS was an effective means of particle suspension. The results of this experiment could be important in the future field of nanoplastic because research the procedure provides a n reproducible effective a n d method to create a stock nanoplastic solution.

Introduction:

Polyethylene terephthalate (PET) plastic is one of the most commonly used types of plastic. Plastic water bottles, containers, a n d packaging are typically made from PET. Over 82 metric tons of PET are produced each year t o make

single plastics. use ("Researchers Engineer Tackle Microorganisms to PET Plastic Pollution" 2021) PET is not a biodegradable plastic, thus it causes o f in excess waste the environment. (Hiraga et al. 2019) In theory, degradation of PET would reduce waste built up in landfills and be better for the environment. However, it is important to consider a11 the environmental effects o f plastic degradation.

Nanoplastics and microplastics form from larger pieces o f plastics degrading. Nanoplastics are with polymers dimensions ranging from 1 nm to 1 μ m. Because of their size, the effects of nanoplastics o n human health and the environment are an area with minimal research. One study found that nanoplastics consumed by fish were able to penetrate their blood-tobrain barrier leading behavioral disorders. (Mattsson al. 2017) e t Similar studies have found that nanoplastics have the potential to penetrate biological systems like the

intestinal barrier, blood-air barrier, and the placental barrier. (Lai, Liu, and Qu 2022) Humans are exposed to nanoplastics throughout almost their entire life. (Lai, Liu, and Qu 2022) The use of plastics in pipe construction, air pollution, wearing out car tires, touching or using skin products with nanoplastics, or consuming animals that previously consumed plastics are examples o f ways nanoplastics are absorbed into the human body. (Lai, Liu, and Qu 2022) It is important to note, however, that the extent of the impact of nanoplastics on health is unclear. This because of the difficulty to standardize an experimental procedure using nanoplastics (Maxine Swee-Li Yee et al. 2021).

One major issue in plastic research i s the use o f chemically engineered nanoparticles instead o f nanoplastics. Some studies use nanoparticles which are engineered to a certain size unlike nanoplastics which degraded from larger plastics. (Sharma et al. 2022) One issue with the use of nanoparticles is that they are engineered to fit a smaller size range than nanoplastics actually occur in nature. Nanoparticles range from 1-100 nm whereas nanoplastics can bе as large as 1μm. a1. (Sharma e t 2022). Nanoplastics are polydisperse (varied in particle size and surface properties), whereas nanoparticles are constructed bе more to homogenous (uniform throughout). Because nanoplastics form b y degradation o f larger plastics there is little data o n the amount nanoplastics that exist. Because of the amount of plastic waste in the world (320 million tons per year ("The Mobility of Plastic Nanoparticles i n Aqueous Soil Environments: A Critical Review" 2021)), it is likely that there are not engineered enough nanoparticles to accurately simulate the effects nanoplastics humans. o n (Sharma et al. 2022) One study on the mobility nanoplastics through different types of natural solutions was conducted using nanoparticles. ("The

Mobility o f Plastic Nanoparticles i n Aqueous Soil Environments: A and Review" 2021) Critical Another study drawing conclusions how o n nanoplastics move through the human gut was conducted using nanoparticles instead o f nanoplastics. (Maxine Swee-Li Yee et al. 2021) Both studies, however, recognized the importance researching nanoplastics a s they occur in nature in order fully understand their impact on the environment and human health. Without fully understanding the effects of nanoplastics it is crucial to b e wary considering degradable plastics a s more environmentally friendly than other plastics.

PET plastic is a semicrystalline polymer. polymer is a long chain of repeating units (monomers). The monomers that form PET acid are terephthalic and glycol.(Gomollónethylene Bel 2017) A semicrystalline polymer is a macromolecule in which the polymer chains exist in both semi crystalline and amorphous regions. The semi-crystalline regions are made of ordered polymer chains folded on top of one another called lamella. Lamella connected are disorder and tangled polymer chains called amorphous regions. A polymer's degree of crystallinity is determined by how orderly its monomer chains are aligned. The more crystalline the polymer, the more orderly its chains are ("Crystallinity" aligned. 2024)

important concept i n polymer research a transition polymer's glass temperature (Tg). The glass transition temperature is the where the thermal point energy is large enough break the intermolecular forces in the polymer. (Paul 2020) Since crystalline structures have strong intermolecular forces, greater amount of order in a polymer leads to a stronger overall structure that takes o f energy to break. Thus, the higher a polymer's Tg, the higher the degree of crystallinity. Polymers have different physical properties above and below Tg. Below Tg polymer chains are hard and brittle. This is because PET is amorphous and highly disordered. Above Tg,

disordered and entangled polymer chains in the amorphous region begin to unfold and straighten out, creating more ordered structure. This makes the softer more polymer and The malleable. process heating semi-crystalline a polymer above Τg its "Thermal known a s Crystallization". (Demirel, Yaraş, a n d Elçiçek Thermal crystallization allows the polymer transition from amorphous to semi-crystalline

Above the glass transition temperature, each polymer also has melting a temperature (Tm). The melting temperature is the where polymer point a changes from a rubbery state to a

liquid state. PET has a Tg between 340 to 353 K (67 to 80 °C) and a Tm of 540 K (267 °C). (Demirel, Yaraş, and Elçiçek 2011) This experiment used PET temperatures of 100 C 110 C because they between the glass transition temperature a n d melting temperature. Ιn theory higher temperatures would result in faster degradation

of PET, however, this experiment was limited to a range around the boiling point of water. If the PET was kept at temperatures too far above the boiling point of water there would be a risk of explosion.

This experiment also measured the effectiveness of SLS for particle suspension. SLSo r Sodium Lauryl Sulfate is a surfactant commonly used in cleaning products. It has an anionic which i s soluble water and a 12-carbon long hydrophobic tail. ("Sodium Lauryl Sulfate - Molecule of the Month - March 2010 -HTML-Only Version" 2024) SLSlowers the surface tension of liquid in solution. Since PET is hydrophobic and more dense than water it does not dissolve in solution, i t rather settles t o the The bottom. hydrophobic tails of SLS solvate the PET and suspend it in solution. ("Sodium Lauryl Sulfate -Molecule of the Month March 2010 - HTML-Only Version" 2024) Since SLS also has an anionic region, there are small repulsions between PET particles solution keeping small PET particles from aggregating.

The o f this purpose experiment was to measure the effect of temperature on size and the amount o f particles formed PET i n degradation. Another purpose of this lab was to determine if SLSi s effective means of particle suspension.

The purpose o f this experiment was to measure the effect of temperature on the size and amount o f PET particles formed in degradation. Another purpose of this lab was to if SLSdetermine is a n effective means of particle suspension.

Methods:

Lab-grade amorphous PET was crystalized by thermal crystallization. It was heated in an oven at a temperature of 120 C. Once cooled, five grams of plastic were massed on a precision scale with a box around it to prevent airflow. That PET was then cut into thin strips using scissors. The strips needed to be thin enough to fit into and rest on the bottom of rounded high pressure vials. Then, 50 mL of HPLC water was pipetted

into the vial. This created a concentration o f $.1 \,\mathrm{g/m}\,\mathrm{L}$ (See image 1.1) Then the sample was run through the DLS machine. (See DLS procedure) This vial was labeled vial 1. The process was repeated for another vial and labeled vial 2. Two oil baths were heated, one to 110 C and the other to 100 C. (See Image 1.2) Vial 1 was placed in the 110 C bath and vial 2 was placed in the 100 C. These samples were left for 24 hours. Every two days the vials were removed from the oil baths, placed to cool in an ice bath for around 10 minutes (see Image 1.3) and then run through the DLS procedure.

Dynamic light scattering (DLS) is a technique for measuring the size and count rate o f particles in DLS solution. machine laser through shoots a sample solution. The solution particles i n that reflect and scatter that light detector. onto photon (Basel 2022) Count rate is the signal strength of the scattered light measured in photons kilo-counts per second.(Ulf Nobbmann 2015) Most DLS machines can analyze particles between

0.3nm and 10µm ("Dynamic Light Scattering: DLS Particle Analyzer :: 2024) The DLS Microtrac" machine makes calculations based o n the Brownian motion o f particles determine particle size distributions. Brownian motion i s the random movement o f suspended particles in a solution. ("2.1: Brownian Motion: Evidence for Atoms" 2017) The rate of Brownian motion is represented b y the Translational Diffusion Coefficient (D). Smaller particles have a higher D larger particles. than machine DLS uses determine the hydrodynamic diameter of a particle. The hydrodynamic diameter (dh) is "the diameter of a perfect sphere that would exhibit the same hydrodynamic friction the molecule o f a s interest." ("How the Hydrodynamic Diameter Defined? Dynamic 2018) Biosensors" Hydrodynamic diameter is an estimation of particle size. When the DLSmachine shoots the laser through the solution, the particles move. Thus, the intensity of light reflected back onto the detector changes over time

into the vial. This created a concentration o f .1 g/m L. (See image 1.1) Then the sample was run through the DLS machine. (See DLS procedure) This vial was labeled vial 1. The process was repeated for another vial and labeled vial 2. Two oil baths were heated, one to 110 C and the other to 100 C. (See Image 1.2) Vial 1 was placed in the 110 C bath and vial 2 was placed in the 100 C. These samples were left for 24 hours. Every two days the vials were removed from the oil baths, placed to cool in an ice bath for around 10 minutes (see Image 1.3) and then run through the DLS procedure.

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Size Distributions:

Three types of size distributions were calculated in this experiment: Number size distributions, volume size distributions, and intensity size distributions.

Note: Na represents the number of particles with size a and Nb represents the number of particles with size b.

Number Distribution Equation:

 $%Na = (100 Na \times)/(Na + NB)$

The percent of particles with size a is equal to 100 times the number of particles with size a divided by the total number of particles or number of size a + number of size b.

Volume Distribution Equation:

% V a (100×Na×a^3)/(Na×a^3 Nb×b^3)

Thevolume percent o f particles with size a is equal to 100 times the number of particles with size a times the volume of a. That is divided b yt h e total volume ofparticles. Eveni f particles are few in number,

they are represented in the volume distribution. Say size a, for example, is very large but there are very few particles of size a. The number of particles with size a is being multiplied by a very large number (a^3).

Intensity Distribution Equation: %Ia = $(100 \times Na \times a^6)/(Na \times a^6 \times Nb \times b^6)$

The percent intensity of particles with size a is equal to 100 times the number of particles with

size a times the volume squared of a. That is divided by the total volume squared of particles.

Intensity distributions represent large particles even more than volume distributions. This is

because the number of particles of a certain size are multiplied by that size to the sixth power,

rather than that size to the third power.

DLS procedure:

400 microliters were pipetted from vial 1 into a cuvette. The cuvette was vortexed for approximately one minute. Then, the cuvette was run through the DLS machine.

Once DLSmachine the completed its run, the solution in the cuvette was poured back into the vial in order to complete the concentration o f PET to water constant. The s a m e process was repeated for vial 2. (See Image 1.4)

Electron Microscopy:

Both SEM(Scanning Electron Microscope) and TEM(Transition electron microscope) were used to take images of the freeze dried s a m p l e o f PET water. There are many differences between SEM and

Image 1.1:



Vial 1 and Vial 2 experimental setup Image 1.3:



Cooling method for Vial 1 and Vial 2

Image 1.2:



Storing and heating methods for vials at each temperature Image 1.4:

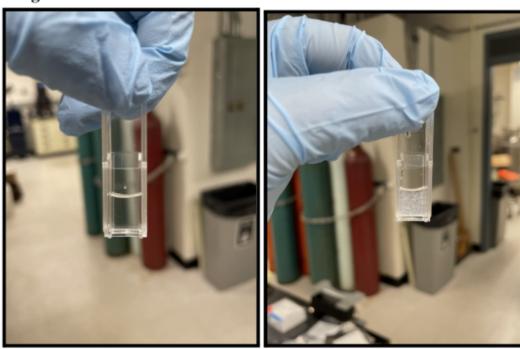


Cuvette in DLS Machine

TEM microscopy. TEMallows for more information about the physical properties of the sample like crystal properties and morphology. While TEM only produces 2D images of the sample, SEM 3 D produces images ("Electron Microscopy | TEM SEMThermo Fisher V S Scientific - NZ" 2020). The process of preparing samples SEMmicroscopy simple: relatively this experiment, the sample was pipetted onto aluminum

wafers and freeze dried. The process of preparing samples for TEM is more complex. Samples must bе very thin(typically less than 150 nm) and one must also insure that no outside precipitates enter the sample. In this experiment serial dilutions of SLS and nanoplastics were 10 made and μL were dropped onto TEM formvar/carbon grid. The grid was then left to evaporate completely before imaging in the TEM.

Image 2:



Vial 1 (110 C) Day 5

Vial 1 (110 C) Day 9

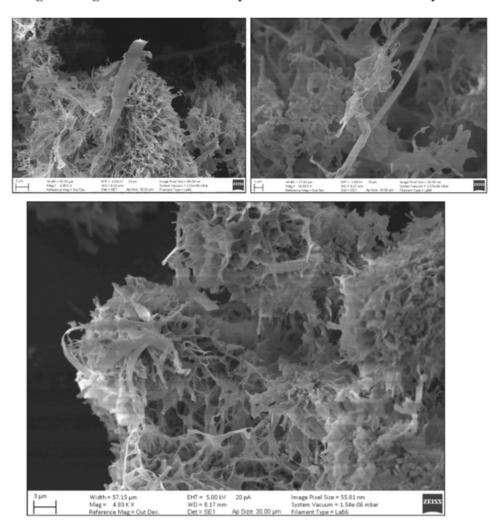
Image 3:



Day 9: 110 C (left) 100 C (right)

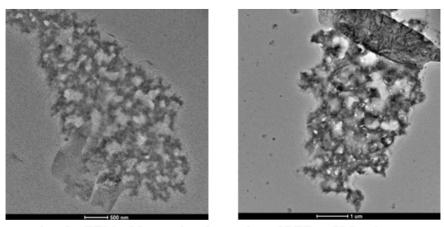
Results:

Image 4: Images of Freeze Dried Sample in SLS under SEM microscope



Images taken by SEM of freeze dried samples of PET in SLS solution.

Image 5: Images of Freeze Dried Sample in SLS under TEM microscope



Images taken by TEM of freeze dried samples of PET in SLS solution.

Fig 1: Average Count Rate of Samples Over 27 days

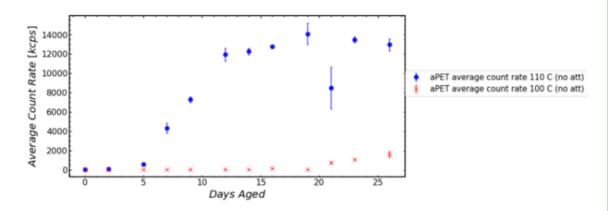


Figure 1 shows the average count rate from the DLS machine over time. On each day, the PET sample went through three runs on the DLS machine.

Fig 1.1: Average Count Rate of Samples Over 27 days (log scale)

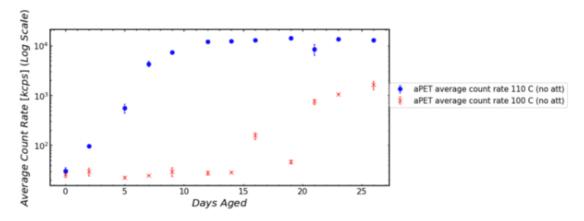


Figure 1.1 shows the average count rate from the DLS machine over time. On each day, the PET sample went through three runs on the DLS machine and the count rate is measured on the Log scale.

Fig 2. Intensity, Volume and Number Size Distributions of PET held at 110 C for 14 Days

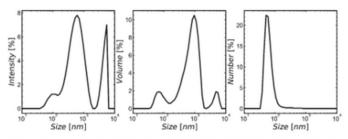


Figure 2 shows the size distributions of PET held at 110 C for 14 days. The figure on the far left shows the size-intensity graph, the figure in the middle shows the size-volume graph, and the figure on the far right shows the size-number graph. Data is taken from the first run of the DLS machine.

Fig 3. Number, Volume, and Intensity Size Distributions of Freeze Dried PET in Water and Freeze Dried PET in SLS Solution

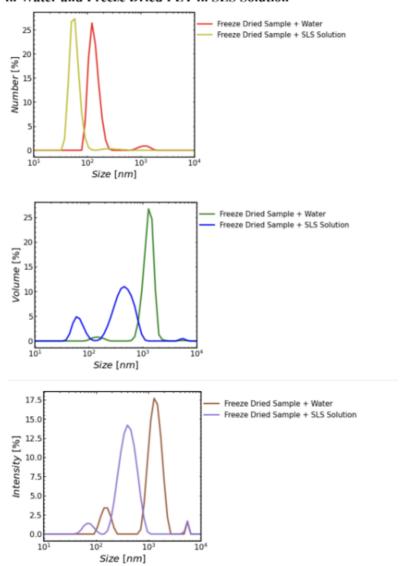
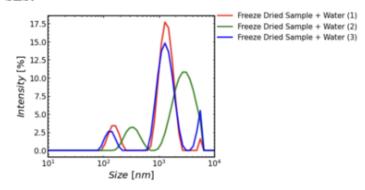


Figure 3 shows the number, volume, and intensity size distributions of a freeze dried sample of PET in water and PET in a SLS solution. Each sample was held at 110 C for 14 days. Data was taken from the first of three runs through the DLS machine.

Fig 4.1 Intensity-Size Distribution of Freeze Dried PET in Water and PET in SLS:



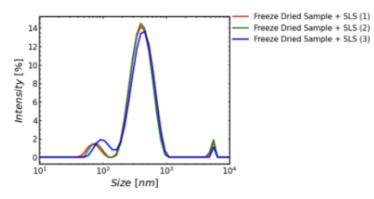


Figure 4.1 shows two intensity-size distributions of PET held at 110 C for 14 days. The top figure shows the intensity-size distributions of a freeze dried sample of PET in water. The three curves show the data from each run of the DLS machine. The bottom figure shows the intensity-size distribution of a freeze dried sample of PET in a SLS solution. The three curves show the data from each run of the DLS machine.

Fig 4.2 Volume-Size Distribution of Freeze Dried PET in Water and PET in SLS:

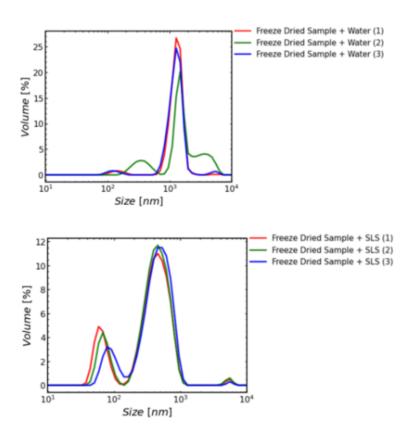
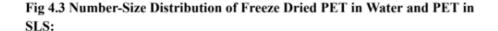


Figure 4.2 shows two volume-size distributions of PET held at 110 C for 14 days. The top figure shows the volume-size distributions of a freeze dried sample of PET in water. The three curves show the data from each run of the DLS machine. The bottom figure shows the volume-size distribution of a freeze dried sample of PET in a SLS solution. The three curves show the data from each run of the DLS machine.



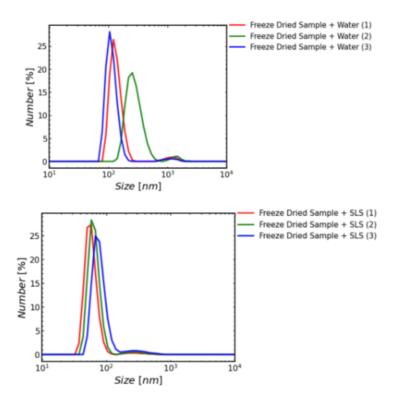


Figure 4.3 shows two number-size distributions of PET held at 110 C for 14 days. The top figure shows the number-size distributions of a freeze dried sample of PET in water. The three curves show the data from each run of the DLS machine. The bottom figure shows the number-size distribution of a freeze dried sample of PET in a SLS solution. The three curves show the data from each run of the DLS machine.

Discussion:

Figure 1 shows the average count rate of particles in PET samples held at two different temperatures for 26 days. Figure 1 should be used to determine when each sample began degradation and Figure 1.1 should be used to determine how many orders of magnitude higher one sample's count rate was than the others. This is

because Figure 1 uses numerical scale for count rate and Figure 1.1 uses a log scale. Figure 1 shows that the sample held at 110 C began degradation earlier than the sample held at 100 C. Figure 1 shows that the PET held at 110 C began degradation on day 5 because there is a jump in the count rate whereas the PET held at 100 C began degradation between day 15 and 22.

As shown on Figure 1.1, by day 5, the count rate for the PET held at 110 C is two orders of magnitude higher than the count rate for the sample held at 100 C. After around 15 days at 110 C, the degradation of the sample began to level out around 104 kcps. As shown by its large error bars, there is an outlier in the sample held at 110 C on Day 21. This was likely due to human error in the pitpetting portion of the experimental procedure thus improperly preparing sample to be run through the DLS machine. Figures 1 and 1.1 show that the sample held at 110 C degraded at a much faster rate than the sample held at 100 C. A visual ofrepresentation this degradation i s shown Image 3. On day 9, the vial containing the sample held at 110 C was completely opaque whereas the vial containing the sample held at 100 C was transparent. The reaction HPLC water between PET was constantly occurring, however, that reaction caused the sample held at 110 C to degrade much faster than the sample held at 100 C.

A major source of error in

experiment PET this was settling over time. The vials shown in Image 2 were the ones run through the DLS machine. Image 2 shows the higher concentration of PET in the vial run through the DLS machine on day 9 than on day 5. Since PET is more dense than water. particles would sink to the bottom and the DLS machine would not get an accurate reading of the count rate. To combat this the volume of liquid in the vial run through DLS machine was doubled on day 14. The double volume allowed for an accurate DLS reading even if the particles settled because they would still settle higher than where the laser reached.

Figure Shows the size distribution bу intensity, volume, and number of PET held at 110 C for 14 days. The size-number distribution shows the greatest number of particles found in solution had a size of 70nm. This is in the size range of a nano plastic, meaning after days PET degrades into mainly nano plastics. The size-volume sizeand intensity distributions that showed while most particles had a size of

around 70 nm, those particles did not take up the most volume in solution. This is because the largest peak on the center graph was around 900 nm. Particles of this size were both large and numerous enough to take up the highest amount of total volume of solution compared to particles of other sizes.

Figure 3 shows the number, volume, and intensity size distribution of PET in water and PET in a SLS solution. Figure 3 demonstrates effectiveness o f SLSo n particle suspension. In the volume size distribution, the singular curve on the freeze dried sample in water graph (green) is misleading because it implies that the particles that take up the most volume in solution are the particles around 103 nm. The curve (blue) shows that this is false. because it reveals two peaks on the SLS graph each with smaller sized particles than that on the water graph. Since the SLS graph had two peaks and the water graph only had one, in the water solution smaller particles likely aggregated larger particles with thus creating apparently larger particles.

This is evidence that SLS is useful for particle suspension because the two demonstrate peaks separation of the aggregated particles measured in water SLSgraph. helps differentiate the size classes of particles by keeping the majority o f particles separate from one another in The suspension. intensity distribution also supports the effectiveness of SLS. On the intensity distribution (bottom graph) the freeze dried sample in SLS curve is shifted to the left of the freeze dried sample in water. This supports the hypothesis that the freeze dried sample i n water curve shows aggregates o f particles forming seemingly larger particles. The number distribution (top graph) also supports this hypothesis. Since the SLS curve peaks at a lower number than water curve, the water curve likely also shows aggregates o f particles clumped together forming seemingly larger sizes.

Figure 4.1 supports the effectiveness of SLS for particle suspension. Since the DLS machine took three

runs a common issue in this experiment was the fact that the plastic would settle over i n the machine. The time in t h e top graph Figure 4.1 show data that are offset from each other, likely because i n water particles settled over time. The s a m e effect is not apparent for the runs on the solution. In the top graph of Fig 4.1 (the water sample), the red curve (run 1) green curve (run 2) and blue curve (run 3) were all spaced apart so there was likely movement of particles through all three DLS runs. The bottom graph in Figure 4.1 (the SLS sample) depicts curves that are almost perfectly stacked on top of one another. This is likely was 1ess because there particle movement in three runs of the DLS machine. It be inferred that the can particles were suspended and did not settle over time. Figures 4.2 and 4.3 support the same hypothesis that SLS effective for particle suspension. Figure 4.2 is the volume-size distribution, and similarly to Figure 4.1 the three curves on the bottom graph (SLS graph) are closer together than the three o n curves the top graph (water graph). This also

likely shows that there was less particle movement in the runs using SLS rather than SLSwater meaning was effective for particle suspension. Figure 4.3 is a number-size distribution and also supports the hypothesis. Because the three curves in (SLS the bottom graph graph) are closer together than the three curves on the (water graph graph) there was likely less particle movement meaning SLS was effective for particle suspension. It is important to note that on Figures 4.1, 4.2, and 4.3 the three curves on each SLS graph were not perfectly aligned. This shows that while SLS was effective for particle suspension it is not perfect and it is likely particles will that s o m e settle over time.

As seen in images 4 and 5 the PET particles were not spherical. Since the for calculations size distribution relies the particles being spherical one should note that the results of the size distributions are based on an estimation of particle size. The SEM and TEM images show that the PET particles likely take the layers o f PET shape o f

rather than spheres of PET.

Conclusion:

This 1ab determined that when held at temperatures in water of 110 C, after 14 days PET plastic will form both nano and micro plastics. PET will begin degradation much sooner in water held at 110 C than 100 C. PET will also degrade at a faster rate when held at 110 C than 100 C. SLS is an effective surfactant for particle suspension. This lab also determined that the greatest number of particles degraded after 14 days held at 110 C were nanoplastics with a size of 70nm.

The findings of this lab can be used to improve studies on microplastics in the future. Samples of PET held at 110 C for 14 days can be used to produce a stock amount of nanoplastics as they occur in nature. These can be other laboratories to with projects specializing in and microplastic nano research. If it is determined that degradation of PET is better for the environment than leaving PET as large waste, the findings of this lab show that PET can be successfully a n d quickly degraded at 110 C. Since SLS

was shown to be a successful means of particle suspension, perhaps it could be used to remove micro and nanoparticles from solution. Since the error of particles settling in solution was not remedied until Day 14, if one is trying to replicate the results of this experiment, then one should use SLS for particle suspension from Day 0. Future experiments may want to explore the smallest possible size of particles SLS suspend and perhaps determine a size range where SLS is effective.

The lack of research on the effects of nanoplastics humans and the environment can bе attributed to the difficulty with which nanoplastics are controlled in an experimental setting. SLS may be a helpful tool in future of nanoplastic the research because it can be used to control nanoplastics in solution by suspension. This experiment is a key stepping stone in answering question, is rapidly degrading plastic better than plastic which is left largely whole in landfills? Future research in the field plastic degradation is crucial to understanding the impacts o f plastic waste o n

environment and human health.

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