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Plastic Paint

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Abstract

Paint is necessary to protect structures against the weather and give buildings a nice look. However, many paints emit volatile substances that damage the atmosphere and can cause health problems. To counter this problem, paint was made through a mixture of polyethylene terephthalate (PET), peanut oil, and polycaprolactone (PCL) since they don't emit volatile substances. Six different paints were made with different mole ratios. It was predicted that a mole ratio of 1:1:2-with order PET, peanut oil, PCL-would have the best qualities: flexible but not breakable. The paint mixtures were made by melting PET and PCL in peanut oil in a beaker on a hot plate. Once the mixture was melted, the solid paint was preserved in a plastic bag and part of the paint was spread onto a wooden stick. Paints A, B, and C had similar qualities. They were all hard but a little flexible. Paint D reached the solubility point of PET and came out as part liquid and part solid. Paint E was the most flexible. It had a thin spread but good qualities. Paint F was the softest paint and was able to be broken. All of the paints were oily and easy to remove, and they had a high freezing point. This is due to the lack of a binder and water. Future experiments could include school glue in the mixture to account for the binder.

Plastic Paint

Painting is one of the most common activities to do today. Paint is one of the most popular mediums in art history. In addition to contributing to creativity, paint is also used in facilities and buildings to give support and color to the walls and prevent corrosion of metal structures. (Paints, 2013). Although paint is very useful, it produces toxic chemicals and pollutes the environment (Christenson, 2018).

Oil and alkyd paints emit benzene, xylene, naphthalene, and heavy alkanes (Interior paints, 2013). Acrylic paint releases ammonia, formaldehyde, water, and propylene glycol into the environment (Christenson, 2018). It can also emit ethylene glycol, texanols, butoxyethoxy ethanol, butyl propionate, alcohols, and aldehydes (Interior paints, 2013). All of these chemical emissions are volatile organic compounds (VOCs) that are very toxic to humans and the environment (Interior paints, 2013). Due to this, there is a rising demand for paints that contain no VOCs in the industry and from consumers.

Many research facilities have tried to accomplish this feat through the use of recycled plastic, the use of oxazoline chemistry, and the blending of polymers. Bardelline discusses how Sherwin-Williams made paint from recycled plastic bottles, which reduced the use of petroleum during the production (2011). Another company also used this method of melting plastic to form paint (How they turn, 2018). Although this method is efficient in reducing the amount of fossil fuels and petroleum used, it melts plastic that emits toxic chemicals, such as Bisphenol A (Gardner, 2008).

Other researchers made a non-volatile paint by combining a co-dispersant and oil-based fatty acids to form oxazolines (Oxazoline chemistry, 2008). This method succeeded in making a non-volatile paint, however, the paint is highly sensitive to bases due to the usage of acids during the production. This makes the paint very susceptible to cleaning products and other bases, reducing the paint's chemical resistance.

Another group of researchers made a non-volatile paint by blending a hard and a soft polymer together (Geurts, Bouman, & Overbeek, 2008). They made a non-volatile paint that had a high hardness, 100% flexibility, and the ability to dry at cold temperatures on a rough surface. However, they did not check the volatility of the products they used-many products that claim to be "VOC-free" usually still emit some VOCs-so the paint may still emit VOCs (Interior paint, 2013).

All of the experiments described have succeeded in making paint but may have problems with stability and VOC emission. This experiment focused on making a paint that was flexible, durable, and emitted no VOCs during creation or drying. The purpose was to reduce the amount of pollution emitted into the environment while keeping the qualities of the paint the same. This was to be accomplished by using non-volatile substances to create the paint.

Organic paint is known for emitting volatile substances, so plastic material was used as the main component of the paint, specifically low-density polyethylene terephthalate (PET) due to its low toxicity and ability to be recycled (Everything you need, 2016).

In this experiment, different combinations of PET plastic, soybean oil, and polycaprolactone (PCL) were used to make six different paint mixtures to determine which mole ratio makes the best paint. PCL was a component in the paint due to its biodegradability, low melting point, and hydrophilic properties (Sims, 2015). It is predicted that the substance would bond well with PET since both of the substances are mostly nonpolar and do not mix with water

(Gewert, Plassmann, & MacLeod, 2015; Sims, 2015). Since PET has a higher melting point, it was labeled as the harder polymer. The molecule diagram of PET and PCL is shown in Figure 1. Peanut oil was used in the mixture as well to lower the freezing point of the plastics, making the mixture a liquid at room temperature.

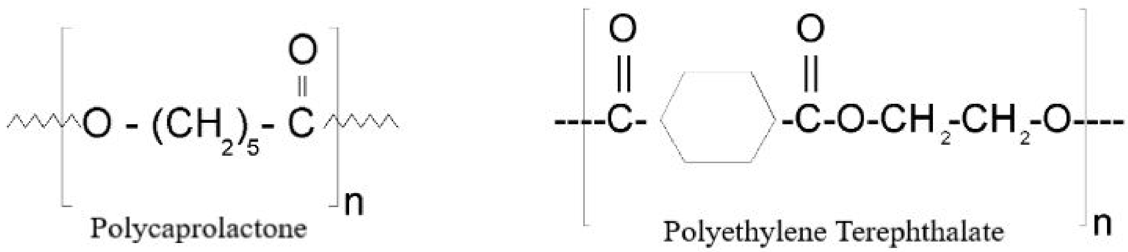

Figure 1

The six different paint mixtures were labeled as Paints A through F. Paint A had a mole ratio of 1:1:1-in moles and in the order PET, soybean oil, and PCL. Paint B contained a ratio of 1:1:2. Paint C consisted of a ratio of 2:1:4. Paint D had a ratio of 1:4:8, Paint E consisted of a ratio of 1:2:1, and Paint F contained a ratio of 1:2:2. Due to the composition of the greatest amount of softer polymer having the best qualities, it was predicted that Paint B and Paint F would make the best paints (Geurts, Bouman, & Overbeek, 2008). This was because the small amount of the hard polymer was predicted to allow the polymer to be very flexible while keeping the polymer's hardness. It was also predicted that Paint B would be better than Paint F, since the extra water in Paint F might not be absorbed, causing the paint to be too watery.

All of the paints were measured for their texture, covering, and peeling qualities right after they were made in order to see which one had the best qualities.

Methods

PET is not especially harmful to humans when solid. When PET is a liquid, it can cause severe burns and release carbon dioxide (CO2) and carbon monoxide (CO) during decomposition (see SDS sheets). This liquid can also cause eye irritation and inhalation problems. PCL can cause skin, eye, and respiratory irritation. It may also emit CO2, CO and nitrogen oxides, which have the potential to cause many health problems, when decomposed (Oxides of nitrogen, n.d.). Due to all of these safety hazards, the experiment was performed under 200℃ to avoid the decomposition of PCL. In case of decomposition, the experiment was performed under a fume hood, beaker tongs used, and nitrile gloves along with safety goggles were worn. Due to PET's high flammability, a CO2 fire extinguisher was nearby along with water. All the paint and waste materials were brought to the 3rd precinct in Montgomery County in a container to be disposed of properly.

Materials

- Carbon dioxide fire extinguisher
- Beaker tongs
- Glass stir rod
- Thermometer
- Scale that measures to the nearest hundredth of a gram
- 18 weigh boats
- 100 g of low-density polyethylene terephthalate (PET) plastic bags
- 120 g polycaprolactone (PCL)

- 350 g peanut oil
- Hot Plate that can be turned to fixed temperatures
- Two 600 mL beakers
- Two 10 by 10 inch sheets of aluminum foil
- A pair of scissors
- Black marker
- Twelve wooden stir sticks, 10 centimeters in length and 2 centimeters in width

Procedures

For each plastic ziplock bag that was used, the seal was cut off in order to make sure that the polyethylene is uniform. It is also to allow the substance to melt faster.

For Paint A, 12.02 grams of plastic bags were weighed on a scale and placed in a 600 mL beaker. Then a weigh boat was used when weighing 7.12 grams of PCL. This was poured into the beaker. Lastly, 38.26 grams of peanut oil was weighed on a weigh boat and poured into the beaker.

After pouring all the chemicals into the beaker, the beaker was placed on the hot plate. The hot plate was turned to a temperature of 305℃. Since the hot plate doesn't account for the temperature of the chemicals inside the beaker, a thermometer was used to regulate the temperature. If the contents were above 150℃, then the hot plate was turned down. If the contents were below 120℃, then the hot plate was turned up.

The contents of the beaker were stirred with a glass rod to help break the bonds. Once all of the contents melted and the solution looked uniform, the hot plate was turned off and the beaker was removed from the hot plate and set down to cool on the table. The glass rod was used to cover a wooden stir stick with the paint. This stick was labeled “A” with a marker.

As Paint A was left to cool down, Paint B was set up in another beaker. In a beaker, 12.00 grams of plastic bags, 38.27 grams of peanut oil, and 14.26 grams of PCL were placed. They were measured the same way Paint A’s contents were measured. The hot plate was turned back on to 305℃ and the beaker with Paint B was placed on it.

As Paint B was melting, Paint A was pulled out of its beaker and placed in a plastic bag. This is because the paint solidified. This beaker was then used to prepare Paint C. Before Paint C was prepared, the same procedures were performed for Paint B that were performed for Paint A.

Paint C was prepared with 24.01 grams of plastic, 38.24 grams of peanut oil, and 28.54 grams of PCL. Then it was placed on the hot plate and given the same procedures as Paint A once Paint B had melted. The same thing was done for Paint D, E, and F, altering the beaker used. Paint D had 6.00 grams of plastic bags, 76.51 grams of peanut oil, and 28.52 grams of PCL. There was 12.02 grams of plastic, 76.52 grams of peanut oil, and 7.13 grams of PCL in Paint E. Paint F consisted of 12.04 grams of plastic bags, 76.44 grams of peanut oil, and 14.26 grams of PCL.

Once all the sticks with the paint on them dried, they were wrapped in aluminum foil. Paint D turned out liquidy and solid, so the solid was saved in a ziplock bag and the liquid was saved in a cup for disposal.

Results

PET, PCl, and soybean oil were mixed in different mole ratios to determine which ratio was best in making the optimal paint. It was planned to measure the viscosity and elasticity of the paint; however, the paint did not stay a liquid. Due to this, only the qualities of the paint on the stick were determined. No measurements were taken for any of the paints.

Paint A had a very smooth texture. It covered the stick very easily, but it was removed easily. Paint B was also quite smooth but had a thinner spread. It was harder to remove. Paint C had good texture but had a very thin spread and was easy to remove. In Paint D, the plastic did not dissolve completely in the peanut oil. This caused Paint D to have two separate parts: liquid and solid. The solid was a mixture of the PET, PCL, and peanut oil. The liquid was a mixture of peanut oil and PCL. The solid part was still tested. It had a rough texture and a thin spread. It was also easy to remove. Paint E had a smooth texture. It turned out to be clearer but more oily than Paint A and B. It had terrible coverage ability. It was also harder to remove than the others; it was flaky. Paint F also turned out to be quite liquidy. However, unlike D, it was formed into a complete solid. Paint F had a good texture and a thin spread. It was also harder to remove.

The solid plastic formed was also observed. Paints A, B, and C all had a hard covering that was slightly flexible. Paint D was very hard. Paint E was quite flexible but was not able to be broken. Paint F was breakable and very soft.

Discussion

In this experiment, different mole ratios of PET, PCL, and peanut oil were mixed together in order to form an ideal non-VOC paint. Only the qualities of the paint were examined, as the paint did not have a low enough freezing point. Due to this, the hypothesis was not supported and was rejected.

In the experiment, the Paint F was seen to be the most fragile and the thinnest. Although this means that the freezing point is lower, it also means that the polymer is weak and not strong enough to support structures. Paint E had quite desirable qualities, as it was flexible but hard to break. It also stuck to the stick more than the other paints. However, it was still quite weak on the stick and wasn't very thick. Paint D turned out to be very hard. Although it was comprised mostly of oil, it separated into two parts: the plastic and the oil. This might have been caused by the overabundance of oil aggregating the mixture. Paints A, B, and C were all quite similar in qualities. They were all hard but still a little flexible. Although all the paints had a thin spread, they were thick enough to be hard to move, meaning that the polymer was very hard and not flexible.

An error in the experiment could be from the usage of the same beakers for all of the paints. The beakers were not entirely cleaned for the next paint, which may have altered the mole ratio. The same beakers were used in order to reduce the amount of beakers that would need to be thrown away. However, for more accurate results, new beakers should be used for each new paint.

Throughout the experiment, the molar mass ratio was adjusted to try to lower the freezing point of the mixture and make it more flexible. However, no matter the change, all of the paints had an oily feel to them and turned into a solid. This resulted because the PET was not able to completely dissolve within the oil. Even when more oil was used in Paint D, the PET was unable to absorb the increased amount of oil, resulting in a hard plastic and an oily liquid.

Furthermore, this type of paint dried because of the high freezing point. It did not have a resin or binder to dry the water in the paint and bind the paint to the surface. Water is a necessary component for paints, and it was left out of this experiment because of its incompatibility with the plastics (Binny & Smith n.d.). However, it is that incompatibility that allows the paint to be a liquid while stored and solid once exposed to the sun. The water keeps the components apart. Once the water dries, the base of the paint will come together and form a big polymer (Binny & Smith n.d.). Binders can also be used for glue.

Paints are able to adhere to a substance due to intermolecular bonds (Why does an adhesive bond? n.d.). The paint on the stick did not adhere well to the surface. It was very easy to take off, meaning that the paint was fragile and not strong. This happened because of the lack of a binder. For future experiments, a binder should be added to the mixture. Since binders are used in glues, future projects can be done to experiment the qualities of paint made from regular everyday glue. The oil would be replaced with water in order for the mixture to solidify due to evaporation. Acetic acid would be used in place of peanut oil due to its better compatibility with PET and water(Celanese 2013). Acetic acid is hydrophilic and is a component in PET so it would make a good solvent. Replacing PET with another, more soluble plastic could help the paint be more uniform. Furthermore, a different beaker should be used for each paint in order to reduce cross-contamination. In order to determine whether the paints are better than the standard paints used, VOC emissions should be measured along with the amount of force to break the paint.

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