PRIMARY + STEM

Teaching Resource

ACTIVITY: Slime

ACTIVITY OVERVIEW

Developed only in the last 100 years or so, plastic is a 'new' material and doesn't have a natural life cycle like living things, water, or rocks. Or even stars. This means that, generally speaking, it doesn't break down naturally and, instead, sticks around in the environment for a long time – something that causes us all sorts of problems. And that is why we have had to create ways to recycle them.

Reframing the view of plastics as resource, rather than rubbish, is one way to tackle the issue of plastic waste. In using slime to learn about plastics, students experience the empowering process of product design, learn about the nature of polymers and how to manipulate them to create a new material. More importantly, students also cross the divide between slime fun and being ecologically aware, by making PVA glue-free slime.

SYNOPSIS

Developed only in the last 100 years or so, plastic is a 'new' material and doesn't have a natural life cycle like living things, water, or rocks. Or even stars. This means that, generally speaking, it doesn't break down naturally and, instead, sticks around in the environment for a long time – something that causes us all sorts of problems. And that is why we have had to create ways to recycle them.

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The focus of this activity is on the 'Generate', 'Produce' and 'Evaluate' components of the design process.

Foundation – Year 2

- Explore the characteristics and properties of materials and components that are used to create designed solutions (VCDSTC017)
- Use materials, components, tools, equipment and techniques to produce designed solutions safely (VCDSCD020)

Year 3 – 4

- Explore the characteristics and properties of materials and components that are used to create designed solutions (VCDSTC017)
- Investigate the suitability of materials, systems, components, tools and equipment for a range of purposes (VCDSTC027)
- Select and use materials, components, tools and equipment using safe work practices to produce designed solutions (VCDSCD030)
- Evaluate design ideas, processes and solutions based on criteria for success developed with guidance and including care for the environment and communities (VCDSCD031)

Year 5 - 6

- Critique needs or opportunities for designing, and investigate materials, components, tools, equipment and processes to achieve intended designed solutions (VCDSCD038)
- Apply safe procedures when using a variety of materials, components, tools, equipment and techniques to produce designed solutions (VCDSCD040)

ACTIVITY, MATERIALS AND INSTRUCTIONS

Activity

There is a high likelihood that students already have their favourite way of making slime, but have they considered making it like a chemical engineer – mixing different combinations of ingredients and product-testing their slime on a group of children?

Materials for 30 students (working in 10 groups)

There should be enough material for students to make two batches each of the PVA slime a glue-free alternative.

Base recipe for fluffy slime (For one quantity)

- ½ cup (125mL) PVA glue (can be white or colourless)
- ½ tsp bicarbonate of soda (baking soda/bicarb soda)
- ¼ cup water
- 1 tablespoon contact lens solution*
- Paper cup
- Mixing stick/spoon
- Measuring cup
- Measuring spoon

Note on 'activator' solutions:

1. Contact lens solution with boric acid (e.g. PureMoist -but avoid Reclens) OR

2. Store-bought 'activator' solution (e.g. Elmer's Glue Magical Liquid Slime Activator Solution)

Watch out!

Precautions when making and playing with slime:

- Do not touch the face, eyes, and mouth
- Wash hands after the activity
- Clean work surface and equipment
- Work on surfaces that can be cleaned down easily
- Do not work on carpeted floors

Theory

The teacher explains the chemistry behind the basic slime recipe.

Polymers

Slime is a type of plastic because it is made of polymers. Polymers are large molecules made of identical smaller units (monomers). There are natural polymers like starch and protein, but plastics are man-made (synthetic).

A giveaway that a material is plastic is in its name. Every plastic has the prefix 'poly', which tells us that it is many of that type of monomer (e.g. polyvinyl acetate (PVA) is the glue that we use for making slime).

Changing glue into slime

By changing how the polyvinyl acetate polymers attach to one another, we make slime. PVA molecules can be imagined as looking like cooked spaghetti, and, like spaghetti strands that move freely but slowly glide over one another when they are transferred, PVA glue is very viscous.

To turn glue into slime, we add a chemical to hold these spaghetti strands together. The boric acid in the contact lens solution is the chemical that forms links between the PVA strands. The more contact lens solution is added, the more cross-links form - and the more rigid the slime becomes.

Other additives

By adding other ingredients in the process, the characteristics of the slime changes (e.g. becomes stretchier, stiffer, fluffier).

Likewise, when manufacturers make plastics, they add additives to make their product stronger, more colourful, lighter.

Demonstration

The teacher shows how to make the base recipe. For the demonstration, it's best to double the quantities and use a bigger bowl, instead of a cup.

1. Pour the PVA glue in the paper cup and highlight its viscous nature.

2. Add *water and baking soda. Mix.
   Water makes the slime 'gooier' and baking soda helps the boric acid in the contact lens make the cross-links.
   Consider omitting water during the demo, leaving it to the students to discover the role of water in the process.

3. Show the 'activator' solution and explain its role in slime-making.
   It contains boric acid, which is responsible for making the cross-links between the PVA glue strands.

4. Add the tablespoon of contact lens solution into the glue mixture and stir.
   Add more of the solution a bit at a time and keep stirring until the glue pulls away from the sides of the cup and onto the stick. This is the slime stage.
   If it still appears to be too tacky, add a pinch more of baking soda.

5. Pick up the slime and stretch it. Knead the slime – this step further entangles the strands, making the polymer harder.
   How does the slime feel? How does the stickiness and stretchiness change when you work it for a while?

6. Things to do with the slime.

- Squeeze the slime together into a round shape and pull it apart quickly. Repeat this step but do it slowly the next time.

Does it tear apart like a solid or stretch out and elongate?

- If possible, drop or bounce it onto a surface and watch it lose its shape when it stops bouncing.
  It behaves like a non-Newtonian fluid by bouncing like a solid and losing its shape like a liquid when at rest.

Activity

The aim of the activity is for students to come up with a PVA slime recipe that they think would appeal to most children. They then try to recreate a similar slime by substituting PVA glue with other ingredients.

Students display their creations in a 'Slime Gallery', where they get to product-test, critique other recipes, and vote on their favourite.

Investigate

In groups of two or three, students discuss their favourite slime characteristics and critique the base recipe that the teacher has demonstrated. They decide on the type of PVA slime that they would like to make (e.g. something fluffier? Something stiffer? Something stretchier? Something opaque or translucent?).

Generate

Students make changes to the base recipe, to produce the type of PVA slime with qualities they want. Which ingredients should they add/modify?

They should document the recipes for each of the different types of slime in the worksheet.

Produce

In their groups, students gather materials and make the slime. They take turns to make, document, and keep their stations clean.

They should do this one slime recipe at a time, so that they can adjust ingredients or modify quantities to achieve the desired slime-type.

They should ensure that they've got the ingredients and notes documented on their worksheet, for reference.

Evaluate

This is the part of the process where students do product-testing of all the slimes in the class! It will look somewhat like play, but students are looking to compare characteristics of every slime and vote on their favourite.

Extension

Interested students could go one step further and make a glue-free alternative slime recipe, without PVA glue, and compare its qualities to the base recipe.

They could do some research for some recipes available online in this stage of the process.

Glue-free slimes

Depending on the ingredients used, these slimes may not necessarily contain plastics and undergo the same chemical process as PVA glue (i.e. cross-linkages to achieve a slime-like consistency). Some changes may be brought about by changing the acidity of the ingredient (e.g. baking soda is a weak base and toothpastes may also work in the same way). Others, using cornflour, behave more like Oobleck, where it's the size and shape of the cornflour particles in a slurry that bring about the behaviour.

Instructions

HOW TO USE THIS ACTIVITY WITH YOUR STUDENTS

Foundation - Year 2

This activity could be used to help students explore the characteristics and properties of materials, as described in both the Science and Design and Technologies curricula. Emphasis could be placed on slime as being a new product they have made through chemical reactions when they mixed different ingredients together. Slime is a new material because it has very different properties to the original ingredients, and it cannot be separated easily into its original ingredients. Note: Students in this year group will require a lot of assistance.

Years 3/4

Slime exhibits behaviour of both solids and liquids under different conditions. It flows like a liquid under low stresses and pressure but breaks like a solid under higher stresses and pressures. Another common and popular material is the cornflour slurry Oobleck, which turns rock hard when hit but flows like a liquid when at rest.

Can students use the selection of solid and liquid ingredients to make a slime without PVA glue? Does their version of slime also exhibit properties of both solids and liquids?

Years 5/6

In addition to voting for their favourite slime based on qualitative observations (e.g. stretchiness, fluffiness, how rubbery it is, etc.), students can create an investigation to quantitatively compare all the slime the class has made.

For example, students find the gloopiest/stretchiest slime in class, by comparing how much it spreads on a table in one minute. With a ruler, and a tablespoon of slime rolled into a ball, students will be able to collect their data easily. Can students study the recipes of the different slimes to explain why some are gloopier or stiffer than others? How do the non-PVA glue slimes compare to the ones made with plastic?

DISCUSSION SECTION AND KEY THEMES

KEY THEMES

Matter and plastic

Matter is anything we can think of that has substance (mass) and takes up space. Matter is made up of tiny building blocks that we cannot see with our eyes. Scientists call these building blocks atoms and molecules. One of these blocks is an atom. More than one block joined together is called a molecule.

Monomers and Polymers

When repeated units of identical molecules (called monomers) join to form a much larger molecule, they form a special group of chemicals known as polymers. Polymers can be natural or synthetic (man-made).

Natural polymers are often water-based. Examples include starch, cellulose, silk, rubber, wool, DNA, and proteins. Synthetic polymers include plastics like nylon, polyethylene, polyester, and Teflon.

Making polymers

Polymers are made when monomers are chemically joined together by one of two chemical reactions: addition polymerisation or condensation polymerisation.

In addition polymerisation, monomers join together by adding a new monomer onto the end of the last one in the chain - similar to making a chain of paperclips. These plastics tend to be thermoplastic, meaning that they soften when heated and harden when cooled. This allows the plastic to be easily reformed and recycled.

In condensation polymerisation, a small molecule (e.g. water) is eliminated as monomers join together.

These kinds of plastics can be either thermoplastic or thermosetting. The latter cannot be remelted or reformed once it has been made, and, therefore, cannot be recycled easily.

Polymer structure

The properties of plastics also depend on how the monomers are arranged in a polymer. The same monomers, arranged differently, will result in very different properties. Polymers can be linked in a linear, branched, or cross-linked manner:

a) Linear polymers

The monomers are connected end-to-end, like a chain of paperclips in a line. The polymers are fairly flexible and because the shape is so compact (without any branching), they can be tightly packed. They can be described as a 'mass of spaghetti'. Examples of this type of polymer are Teflon, polypropylene, etc. PVA glue is an example of a linear polymer.

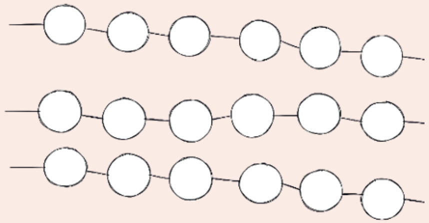

Figure 1. Linear Polymer. Adapted from Callister, William D. Materials Science and Engineering: An Introduction. New York: Hohn Wiley & Sons, 2007

b) Branched polymers

Some monomers extend away from the linear arrangement, resulting in polymers that look branched. Branched polymers are harder to pack together and, therefore, have lower density. This arrangement produces a softer and more flexible polymer because they have a looser structure. In nature, branched polymers include starch and glycogen. Examples of synthetic polymers include low-density polyethylene plastic in clingwrap and sauce squeeze bottles.

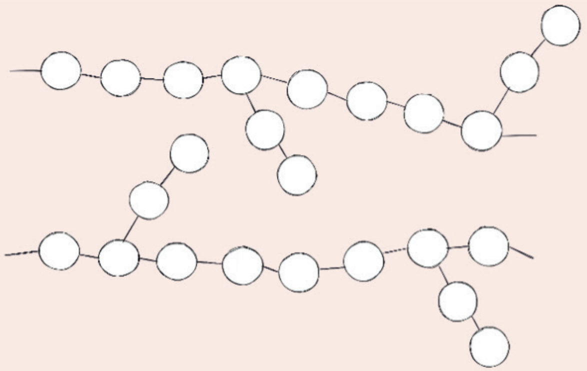

Figure 2. Branched polymer. Adapted from Callister, William D. Materials Science and Engineering: An Introdution. New York: Hohn Wiley & Sons, 2007

c) Cross-linked polymers

These polymers are held together in places by chemical bonds referred to as cross-linkages. The cross-links prevent the individual chains from sliding past each other too far. The more cross-links a polymer has, the more rigid it becomes. In slime, the cross-links are brought about by borate ions connecting the PVA glue strands together.

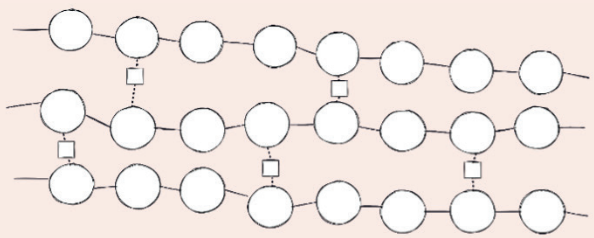

Figure 3. Cross-linked polymer. Adapted from Callister, William D. Materials Science and Engineering: An Introdution. New York: Hohn Wiley & Sons, 2007

Making slime from PVA glue

PVA or polyvinyl acetate is the primary ingredient in PVA glue. The monomer vinyl acetate is first polymeried to form linear chains of PVA. When either borax or boric acid is added to PVA glue, a chemical reaction takes place to make a new product (i.e. slime). The borate ions from borax or boric acid form links between the long strands of PVA glue. When more cross-links are formed between the glue polymers, the slime becomes stiffer.

major industrial polymers - Polyvinyl chloride (PVC) | Britannica

QUESTIONS AND ANSWERS

Can I make my own 'activator' solution?

The answer is a yes and a big BUT. Yes, making our own boric acid solution is possible and it is the most cost-effective option, BUT special precautions need to be taken when handling borax powder.

Solid Borax Powder is TOXIC - it may cause infertility and harm to the unborn child. People who are pregnant should not handle it, and it should be kept out of children's reach. Tips to handling it include the following:

- Avoid touching the powder directly or breathing in fine particles.
- Wear gloves, use a spoon and make up the solution in a well-ventilated area.
- Wash hands immediately, following handling of the powder.
- Wash and rinse all equipment used to prepare solution with plenty of water before reuse.

Even after borax has been made into a dilute solution, it should still be treated with care.

The best way to do this is to only make a small amount at a time and keep borax solution and slime out of reach of very young children.

Other precautions when making and playing with slime include not touching the face, eyes, and mouth, washing hands, and cleaning work surface and equipment.

Does chewing gum have plastic in it?

The answer is yes! Chewing gum is made from a polymer, which is the same type of molecule plastics are made from. Polymers are large molecules made up of smaller identical units. When chewing gum was first produced, it was made from natural sources of polymer (e.g. sap (resin) from sapodilla trees). However, since chemists learnt to make plastics, plastic-based gum has become the norm because of its low cost. Common plastics used for chewing gum include polyethylene and polyisobutylene polyvinyl acetate. There are some brands that produce chewing gum with natural polymers.

Watch how it is mass-produced here: https://youtu.be/2kttVyakHN4

Does chewing gum have plastic in it? - The Future is Plastic Free

Can slime be recycled?

Although the PVA glue (which is used to make slime) is, in theory, a thermoplastic that is recyclable, it is only done by specialised recycling companies in some countries. Slime, on the other hand, generally cannot be recycled by recycling facilities at the moment. It is best to dispose of used slime in the bin.

Can PVA Be Recycled? | eHow .

Should we be making slime if it's non-recyclable and the materials used to make the glue are not renewable?

That making and disposing of glue-based slime is not great for the environment is an unfortunate truth. When we make slime, we are essentially turning one form of plastic into another. That is the reason why students are asked to make eco-friendly versions of slime in this activity. Just be prepared that while they may be stretchy and squeezable, they are not as oozy as the traditional slime.

There are also recipes online for food-based slime from ingredients like icing sugar, flour, and marshmallows.

Here are two non-plastic recipes for slime:

How To Make Metamucil Slime - Little Bins for Little Hands

[Edible Marshmallow Slime Recipe with 3 Ingredients - Busy Little Kiddies (BLK)]

Perhaps some students in the class will come up with a way to recycle PVA slime soon!

What is a non-Newtonian fluid, and why is slime a non-Newtonian fluid?

It's just a big word for saying that slime doesn't behave the way we think fluids, like water and oil, behave. Whether we apply pressure on them by squeezing or stirring, or not, water and oil do not change the way they flow (viscosity).

Slime, on the other hand, becomes harder and flows less easily when we apply pressure by squeezing or stirring. This happens because of the cross-linkages in the slime. When we squeeze it, the polymers became even more entangled, making it harder for the slime to flow. But when we leave the slime alone, the polymers relaxed and can slide over one another.

When was slime invented?

Slime was the name given to the extremely stretchy material by Mattel Toys when it sold it as a toy in 1976. It was light green in colour and sold in a little green trash can. The original Mattel slime formula was made from guar gum and borax, but it now uses synthetic (man-made) plastics instead. Guar gum is a common food additive made from guar gum and is used for thickening things like milkshakes.

Another similar toy is the 'Silly Putty' and the history of this bouncy and slightly stretchy material goes back earlier than 'Slime'. An engineer at a company called General Electric may have invented this material in 1943 when he accidentally dropped boric acid into silicone oil. Another company called Dow Corning had also made something similar at that time. The polymer resulting from this chemical reaction eventually became a toy known as Silly Putty (1950s).

[The Chemistry and History of Silly Putty (thoughtco.com)]

What are some animals that make slime?

Mucous is a type of slime… so the answer to this question must include humans, because we make a lot of snot. According to some sources, we make around one litre a day! Many of our cells make slimy mucous but the one we see most often the clear, and sometime green stretchiness that makes its way out of our noses.

Other animals that make slime include slugs and snails, parrotfish, and opossums. Slugs and snails use slime when they move and to stop them from slipping on vertical surfaces. These are the silvery slime trails we see in the garden. Parrotfish burp out enough slime every night to make a slime sleeping bag to sleep in at night!

Watch the parrotfish here: https://youtu.be/HsdwuQn_K9k

I used a contact lens solution but it doesn't work – why not?

The contact lens solution must contain boric acid for the glue to turn into slime. It won't work without it. Baking soda is also added to help turn boric acid into borate ions, which is what makes the cross-links between the long strands of PVA glue. If the slime is still too gloopy, add a pinch more baking soda to encourage more borate ions to form.

Can I eat slime?

It is never safe to eat non-foods. Therefore, it is not safe to eat slime made from non-food ingredients. The good news is that there are many recipes on the Internet that use food ingredients, like marshmallows, oil, condensed, cornflour (cornstarch in USA), jelly crystals, and even lollies. The reason it is possible to make edible slime is because many ingredients in these edible recipes (e.g. starch and corn syrup), are polymers. Just like plastics!

Here are two recipes to try at home:

- Easy and Completely Edible Slime Recipe (thoughtco.com)
- Edible Chocolate Slime Recipe - No Nutella! - Little Bins for Little Hands

Why does white liquid glue dry clear and hard?

The white liquid PVA glue we use at school does exactly this. The glue contains water, which makes the glue opaque. Once the water evaporates and leaves the glue, the PVA will turn clear.

OUTSIDE OR SUPPLEMENTARY READING

Slime

- How slime is made - material, production process, making, history, used, dimensions, composition, structure (madehow.com)
- How to Make Slime with Baking Soda | Arm & Hammer (armandhammer.com)

Uses of Polymers

- https://youtu.be/HS0nMly6yt0

Plastics

- Science of Plastics | Science History Institute

TOPIC WORDS

- Slime
- Stretchy
- Elastic
- Non-Newtonian
- Material
- Plastic
- Polymer
- Monomer
- Cross-links
- Borax

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