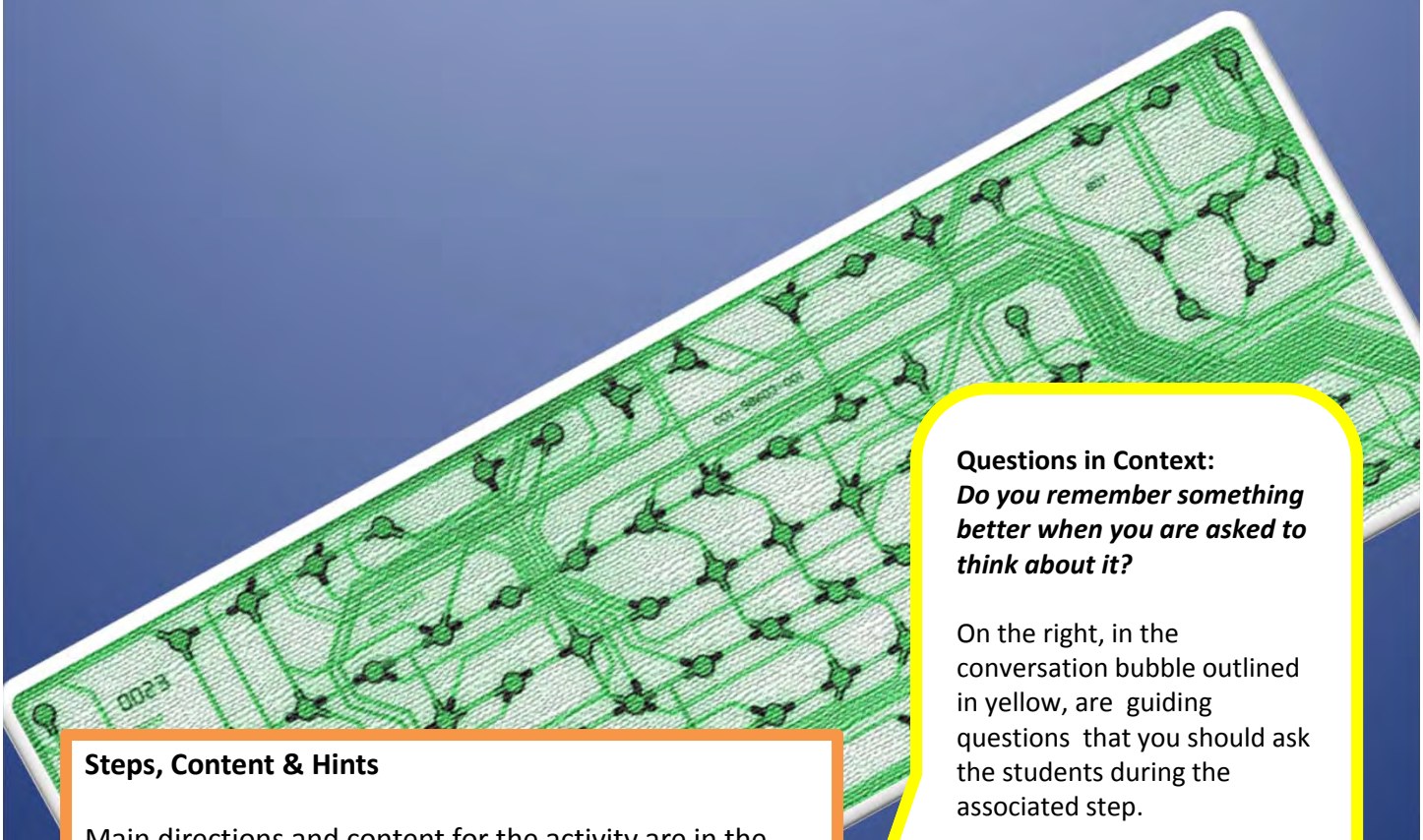
VBT/VBEA
Bio-inspired Co-Polymer



Steps, Content & Hints

Main directions and content for the activity are in the boxes to the left with the orange border, like this one.

In a classroom setting, you will lead the students through the activity with a series of questions, the students' own responses and brief explanations.

Whenever possible, find and affirm what's right about the students' answers.

Questions in Context:
Do you remember something better when you are asked to think about it?

On the right, in the conversation bubble outlined in yellow, are guiding questions that you should ask the students during the associated step.

Each question should be asked separately – and a short amount of time should be allowed for responses.

Green Chemistry Introduction:
Defining Green Chemistry

Have students work in pairs for 30 seconds to come up with a definition for green chemistry. Break down the meaning of both words.

Establish that Chemistry is the science of making products.

Eco-friendly, good for the environment, sustainable.

What is green chemistry? What is Chemistry? What does chemistry mean to you? Do you think of good things or bad things?
What does it mean to "go green"? Who has heard of companies going green? What does that mean?

Green chemistry is pollution prevention at the molecular level, the basic design stage. So what is it that green chemists do?

What do Chemists do?

Use wait time . Build off of their prior knowledge. Acknowledge student responses and prompt them for more information. Control the conversation by asking for a certain number of answers.

Chemists are inventors. They help to design just about every product out there.

Traditionally chemists were not taught about the environmental impact or toxicology. We have had many advances and helpful inventions but we have also had inventions that have caused harm to the environment. Green chemists design products taking into account the entire process, energy efficiency, renewable resources, the product itself along with the end-of-life impact of the product.

Is there anything in this room that a chemist invented? What about the desks, paint, floor, etc. Who has taken medicine? Does anyone use an iPod or an mp3 player? What about a computer or a cell phone?

Set the Scene:
Connect the Dots & Introduce the Activity Topic

Connect the dots for them: they are the future scientists who will help to discover and invent the solutions to the environmental challenges.

3 Criteria of Green Chemistry
Introduce the 3 criteria of green chemistry: safety, cost and performance

Would you buy a "traditional" cleaner that costs $1 or a "safer" cleaner that costs $5 for the same bottle size?
Would you buy a "traditional cleaner" that cleans well, or a "safer" cleaner that leaves streaks behind?
Green chemists think about safety, cost and performance in their product design

Set the Scene:

Biomimicry

Introduce biomimicry

Scientists have figured out that the natural world has the most efficient processes on Earth. Learning how to manufacture or create products that mimic how nature operates is called biomimicry.

Biomimicry is learning from nature how to design products that are sustainable. This aligns with green chemistry closely because that is what green chemists are trying to do.

Biomimicry studies nature's best ideas and then imitates these designs and processes to solve human problems.

What is biomimicry?
What does "bio" mean?
What does "mimic" mean?

What are some links between biomimicry and green chemistry?

What is DNA?
What makes up DNA?
Who can name the 4 different nucleotides found in DNA?
What type of bond holds our DNA together?
Which nucleotides pair together with these bonds?

Background:

<u>Thymine photodimerization</u>

When we are exposed to UV light (the type of radiation that comes from the sun), our thymine molecules in DNA bond together. This is called "thymine photodimerization".

Scientists have copied this natural occurrence by making a greener photoresist that has thymine in it, and we will be using that greener photoresist today.

What do you think "photodimer" means?
Let's break up the word into two parts:
"photo" = light
"dimer" = a molecule made up of two smaller identical molecules

<u>Photoresists</u>

Photoresists are chemicals that resist washing away when light is shone on them.

In manufacturing processes, they are commonly used with highly corrosive acids to etch conductive patterns onto different types of substrates.

What industries might use photoresists in their manufacturing processes?
What types of materials may have photoresists coated on them to form conductive patterns?
Can these materials be reused or recycled?

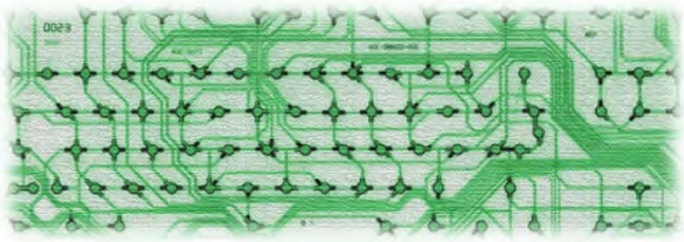
Often times, photoresists are so hard to remove from substrates that they cannot be separated from them.

What are some disadvantages of using traditional photoresists?

Let's get started

As green chemists today, you will use green chemistry and biomimicry to learn about a technology that improves manufacturing process using photoresists

Hold up plastic printed circuit film



We are going to make a circuit film that looks like this using a greener thymine based photoresist. It is called the VBT/VBEA Bio-inspired co-polymer, or just "VBT" for short.

Can you guess what electronic device this printed circuit film came from?

What are some ways that greener photoresists may be better than traditional photoresists?

For younger audiences, using "thymine copolymer" as the name of the greener photoresist makes a clearer connection to the biomimicry concept

SAFETY FIRST

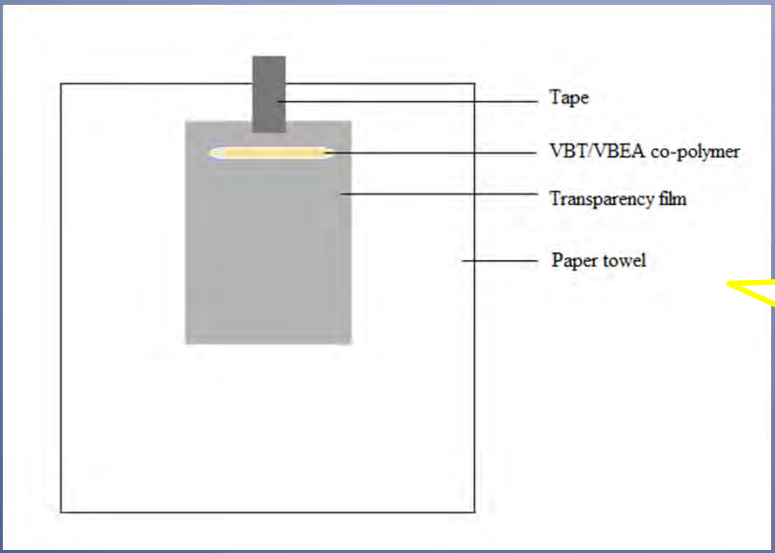
Safety for this Experiment:

In our activity today, we are working with safe chemicals and materials which will not require you to wear gloves and safety glasses, but please do not touch anything then put your hands near your mouth or eyes. We will also ***wash our hands very well after the activity***.

Only instructors place films under UV lamps & remove them when they're done!
We will be working with ultraviolet light lamps. Please do not look directly into the lamps or put your hands directly under the light, because UV rays can be harmful.

1. Open up the paper towel (if it is the folded type)
2. Tape the paper towel vertically to the table, and tape the transparency film on top of the paper towel.
3. Fill a plastic transfer pipette with the thymine copolymer and apply a thin straight line of liquid at the top of the film, below the tape.

Creating a tab (non-stick side) on the top of the piece of tape will ease pulling the transparency film off of the paper towel

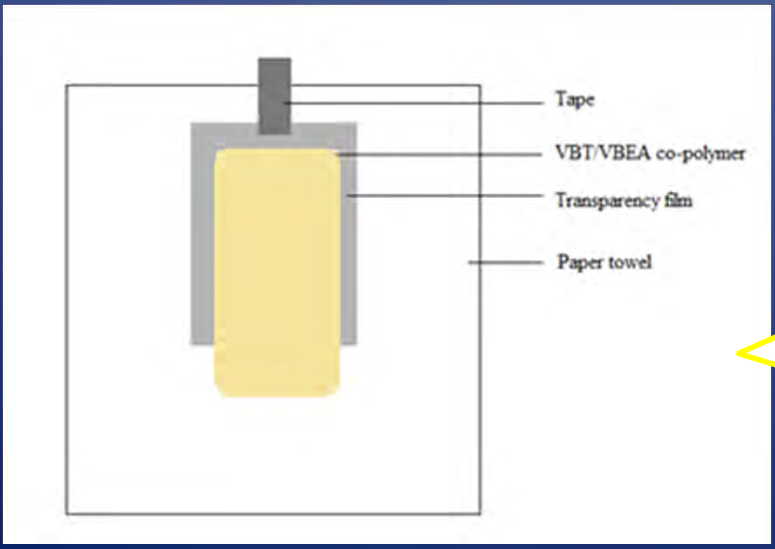


This is what the layout should look like

4. To coat the film with the VBT/VBEA copolymer, place the coating rod horizontally above the line of the copolymer, and draw straight down so the liquid covers the film, without rolling the rod
5. Allow to dry for five minutes.

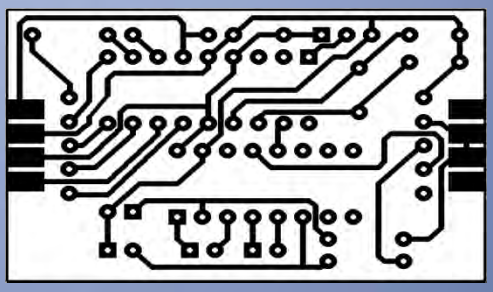
Emphasize that one smooth motion will result in the best coating.

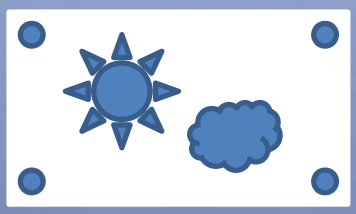
Test tubes or other smooth cylindrical rods can be used to coat the film

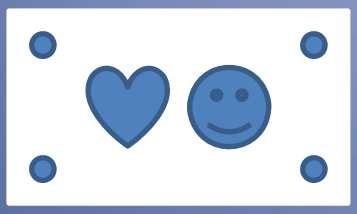


The co-polymer should be pulled down past the bottom of the film so the extra liquid goes on the paper towel.

6. While drying, make a UV blocking mask using the provided hole punchers and scissors to design your own circuit pattern
   Your circuit pattern should have at least four informational points to mimic chips and then circuits between them – you may be as artistic as you want!







7. Place the dried film under the short wave UV lamp with the paper mask on top.
8. Wait two minutes, then remove the mask and rinse in a plastic bowl of water.

Make sure that the film and mask are directly under the UV light. Hold a white sheet of paper under the light to look for the blue glow.
USE SHORT WAVELENGTH!

How does short wavelength compare to long wavelength? Which is safer for humans?

If the film is completely dry, best results come from placing the lamp directly on top of the dried film and mask.

9. Place film into the plastic bowl with the food coloring mixture and leave submerged for two minutes.
10. If you keep the tape on the film, you can tape the film to the side of the container of food dye. After this, rinse the film in the water bowl and return to the paper towel to dry.

11. Have the class display their developed images

What are some safe materials we used in this activity?
What dangerous materials did we avoid having to use?
What are some common items we used?
Do you think common items are expensive or inexpensive?
How was the performance of your experiment? Were you able to visualize the pattern you designed?
Are we able to reuse or recycle any materials?

12. Discuss how the green chemistry safety, cost and performance criteria were achieved

13. Discuss how this activity showcased biomimicry

How was this green chemistry technology an example of biomimicry?
What did we copy?
What else can we use this type of technology for?

Great Job! Scientists ask questions and seek out answers. Who here asks questions about how products are made or why we have certain problems?
Who thought that this was easy? Who had fun doing this? Do you think that science is something that you can do?

In closing:

Green chemistry provides the tools needed for creating solutions to environmental challenges.

As a green chemist you can be a part of the solution by inventing better technologies for the future. Also remember that you do not need to be a scientist to make a difference in this world. As an informed citizen you have the power to influence change with your decision making, voting power and purchasing choices.

Any questions?
Wrapping up is always a good time to talk a little more about why you are in the classroom, what you are studying, researching or pursuing as a career.