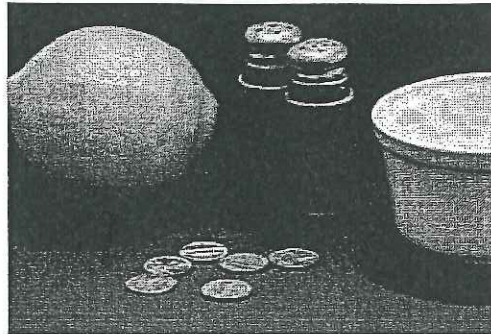


The Penny Experiment

By Kyria Abrahams



Paola is 12 years old. She lives in Seville, Spain. The streets of her city are lined with beautiful orange trees. The oranges that grow here are sometimes called *Bitter Oranges*, because they are sharp to the taste. Tourists often come to Seville to see the beauty of Spain. They like to see flamenco, a colorful style of Spanish dancing, or visit a royal palace called the Alcázar.

But while all the tourists were coming to Spain, Paola and her family were off visiting New York City. They had many things to see while they were there, and seeing the Statue of Liberty was on the top of the list.

The Statue of Liberty is made of copper, but Paola noticed the statue didn't look much like copper. It was more of a bluish-green color. Once Paola noticed this, she started seeing this same color of copper all over the place. She noticed a green copper statue of the composer Beethoven in Central Park and a green copper roof on a famous old building called The Dakota.

There must be two kinds of copper, Paola thought to herself. I guess one kind of copper is green.

When Paola returned to Spain from New York, she brought home some souvenirs. One of the souvenirs wasn't something you could buy in a store, though. Paola is something of an amateur coin collector. So every time she travels, she brings home some money from that part of the world.

From this particular trip, she brought home about 30 pennies she had saved. She put them in a velvet pouch and packed it neatly in her suitcase. She had never held pennies before. In Spain, they use *euros*.

Paola spread all the pennies out on her kitchen table. She noticed they all had different dates on them. Some were old, and some were brand new. One of the pennies was from 1953, which

happened to be the year Paola's grandmother was born. Paola started to organize the pennies by date when she noticed something else: the pennies were all slightly different colors.

The newer pennies were copper-colored and shiny. But the older pennies were dull and had green spots on them. This was the same kind of green color she had seen on the Statue of Liberty.

Maybe there weren't two different kinds of copper, after all. Maybe the copper was just dirty. Or maybe the copper was painted green!

Paola asked her mother why the pennies were green. Her mother explained that the pennies had gone through a process called *oxidation*. This is a chemical reaction that can take place on metal. In this case, it creates a substance on metal. This substance on copper is green. It is called *verdigris*.

Paola said, "In Spanish, the word for green is *verde*."

"That's right. Now let's see if we can recreate *verdigris* on these pennies," Mom said. "We need a glass bowl, some salt, and some vinegar."

Together, they mixed a $\frac{1}{2}$ cup of vinegar and two teaspoons of salt together in the bowl. They mixed the vinegar around until the salt dissolved. Then they put 10 of the shiny new pennies into the mixture.

"What are we doing, cooking pennies?" Paola asked.

"In a way," said Mom, laughing. "I promise I won't make you eat pennies for dinner, though."

After about five minutes, Paola emptied the bowl of vinegar, salt, and pennies into a colander over the sink, and let all the liquid drain out. Then she spread two paper towels out on the counter.

"Now separate out the pennies into two groups of five," said Mom. "Wash half with water, and leave half the way they are."

Since there were 10 pennies, Paola placed five on each paper towel. She placed the washed pennies on the right side so that she wouldn't get confused later.

The next (and hardest) part was waiting for the results. They had to let the pennies dry for about an hour while the chemistry experiment worked its magic. To pass the time, Paola went for a bike ride.

She rode her bike up the street to the *Giralda*, a very old bell tower in Seville. It was completed in the year 1198. As she passed the tower, Paola remembered it used to have a copper sphere on the top. She had learned in school that the sphere fell off during an earthquake in the year 1365. She wondered whether that sphere would also be green today if it hadn't fallen off in the earthquake.

When she returned home, she ran to the kitchen to check on her pennies. She was so excited she almost forgot to close the front door.

Here's what had happened: the pennies that had been rinsed off in water looked really shiny and not at all green.

The five unwashed pennies on the left, however, had started to turn green.

Paola hadn't painted the pennies. The vinegar mixture created a chemical reaction between the copper and the air. This is also known as *redox*, or what happens whenever atoms change their *oxidation* state. A substance of copper oxide mixed with chlorine from the salt had formed on the penny, and the substance looked green.

But, if this was how you oxidize copper, how did the Statue of Liberty turn green? Had an airplane dumped a giant bowl of vinegar over her head?

"There is more than one way for a metal to oxidize," Mom explained.

Paola's mom continued to explain that vinegar is a mild acid. When combined with salt (a neutral base), it can form hydrochloric acid, which both cleans and oxidizes copper.

When you wash it off, the penny looks shiny. When you leave it on, the penny turns green.

There are also other ways of making copper turn green, however. For example, there could be products in the air that react in different ways when combined with oxygen, such as sulfur from coal. They will behave in a similar way to the vinegar. And that is why statues and buildings might have green-colored copper.

Paola decided to recreate the experiment. This time she used some of the bitter oranges from the tree in her backyard. Oranges are also mildly acidic, just like vinegar. She followed all the steps from the first experiment, only replacing vinegar with orange juice. She got the same result.

She called to her mother, who was relaxing on the porch, thumbing through a cookbook.

“Look, Mom, I made *verdigris* with oranges, too!”

“That’s great,” Mom said, pointing to the cookbook. “Because I’m about to make marmalade with the rest of the oranges.”

“Just make sure you leave out the pennies!” said Paola.