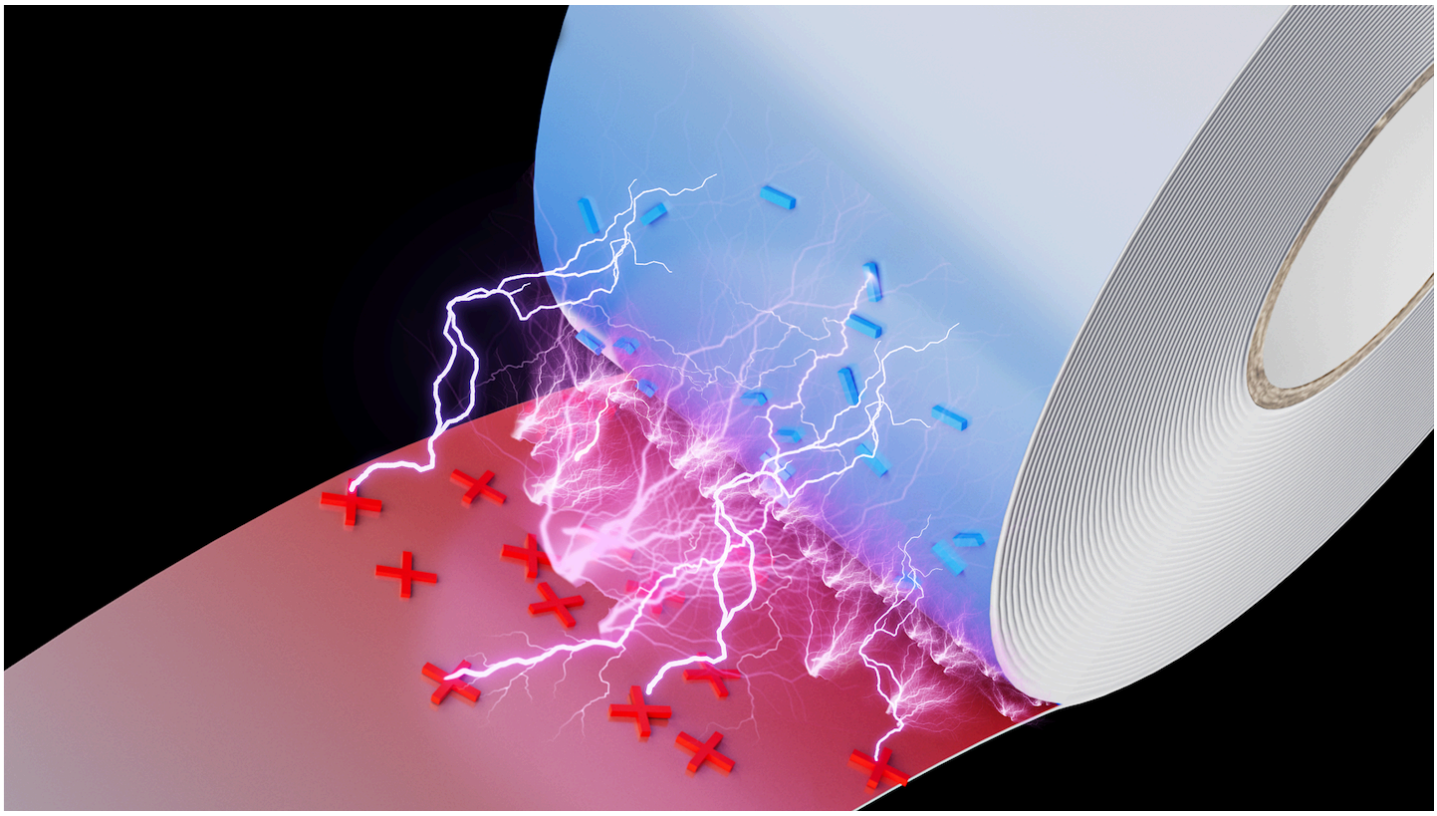
PHYSICS

Zap! Peeling off tape can spark chemical reactions in the air

This ‘micro-lightning’ might one day be used to power greener chemistry



Peeling tape can create a separation of positive and negative charges that triggers lightning — micro-lightning. These sparks of energy, illustrated here, may one day be put to useful work.

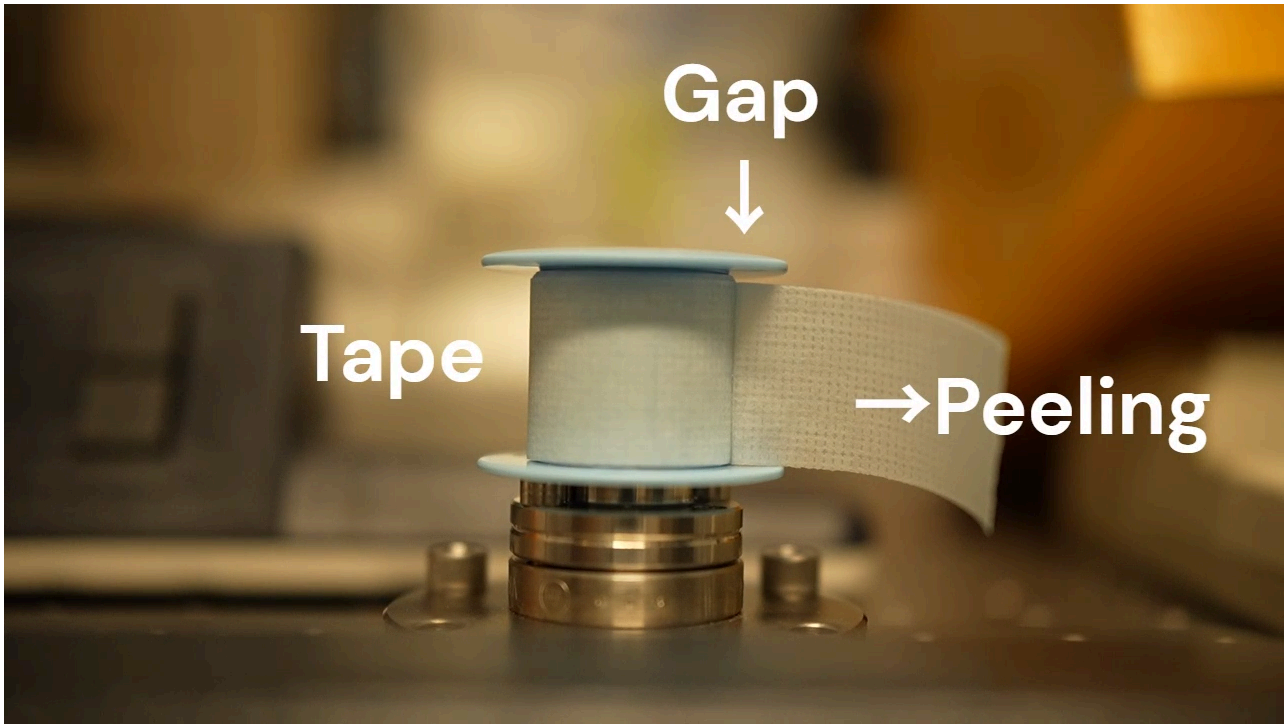
By **Laura Allen**

11 hours ago

Rip off a piece of tape in a dark room and you may see a flash of light. This happens because the peeling tape releases energy that creates tiny sparks. It might seem like just a neat little trick. But scientists have now shown this “micro-lightning” is shockingly powerful. In fact, it can be strong enough to drive chemical reactions in the air.

One day, such micro-sparks could help make some chemicals in a more sustainable way.

“I’ve been very interested in the idea of micro-lightning,” says Richard Zare. A chemist, he works at Stanford University in California. His team recently showed sprays of water release tiny sparks that can drive chemical reactions. Now, working with Xinxing Zhang, a physical chemist in China, his team is studying micro-lightning sparked by peeling tape.



Watch the glow from electrons jumping as tape is peeled off a roll in the dark.

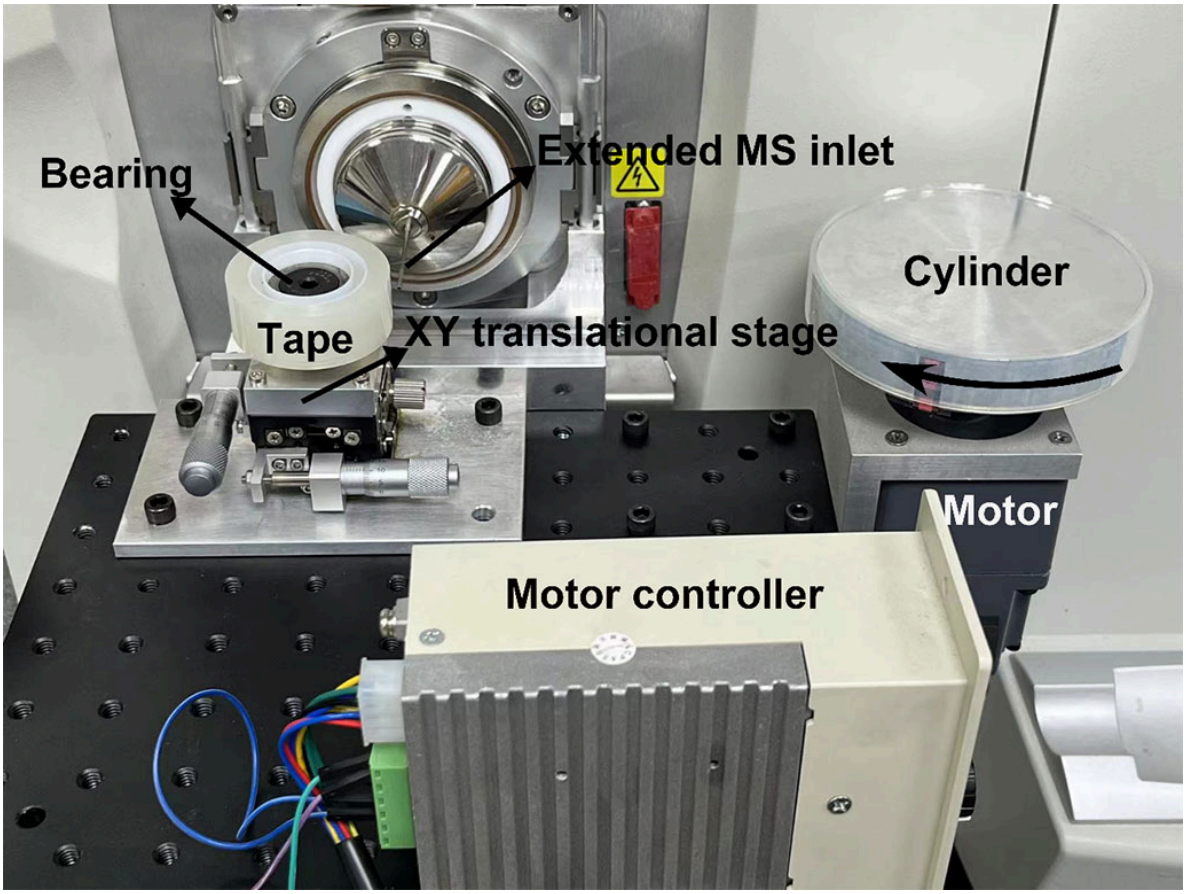
YIFAN MENG

Using tape was Zhang’s idea. Ripping tape loose from its roll releases visible light. But Zhang knew it also, surprisingly, generates X-rays. He wondered how high this electric charge was and if it sparked chemical reactions. To find out, his team at Nankai University in Tianjin set up an experiment.

They started with a roll of sticky tape placed on a bearing. With a motor, they pulled off the tape and wound it around a cylinder. Along the way, the team measured the strength of the electric field that the peeling tape created. They also looked for any changes in the chemistry of the surrounding air.

Testing tape

The test setup pulls tape off a roll and onto a cylinder. A motor controls its speed. The unrolling tape sits on a device (XY translational stage) that can move back and forth. This positions the peeling point in front of a mass spectrometer (Extended MS inlet), which identifies chemicals formed as the zapping triggers air chemicals to react.



XUFENG GAO

Peeling the tape slowly, at 12.5 centimeters (5 inches) per second, created a small electric field. But when the motor sped up to 50 centimeters (20 inches) per second, the space where the tape left the roll became very highly charged. Zhang's group tallied a billion volts per meter across this tiny space!

That's an astonishing voltage — far beyond what's usually achieved in the lab, Zare points out. (For perspective, lightning shoots from a storm cloud when the voltage is 3 million volts per meter. In the tape experiment, the high voltage is across too small of a space for the micro-lightning to hurt us.)

Let's learn about static electricity

The peeling tape's zap illustrates the triboelectric effect. This is the generation of an electric charge as materials come into contact and then separate. It's like static electricity, when two objects are rubbed together then moved apart. One object becomes positively charged, meaning it loses electrons. The other gains those lost electrons and becomes negatively charged. (This can make a negatively charged balloon repel electrons from a wall, then "stick" to the positively charged surface. Or, it can send out a tiny zap of electricity.)

Sticky tape, big zaps

The triboelectric effect is at work all around us — in things as simple as a sliding raindrop and the rustle of our clothes. But the tape experiment created a much higher voltage than most other everyday triboelectric events. Why? Being sticky, the tape peeled off the roll in a jerky way. Scientists call this a "stick–slip" event. It leads to higher charges than when things just rub together or touch.

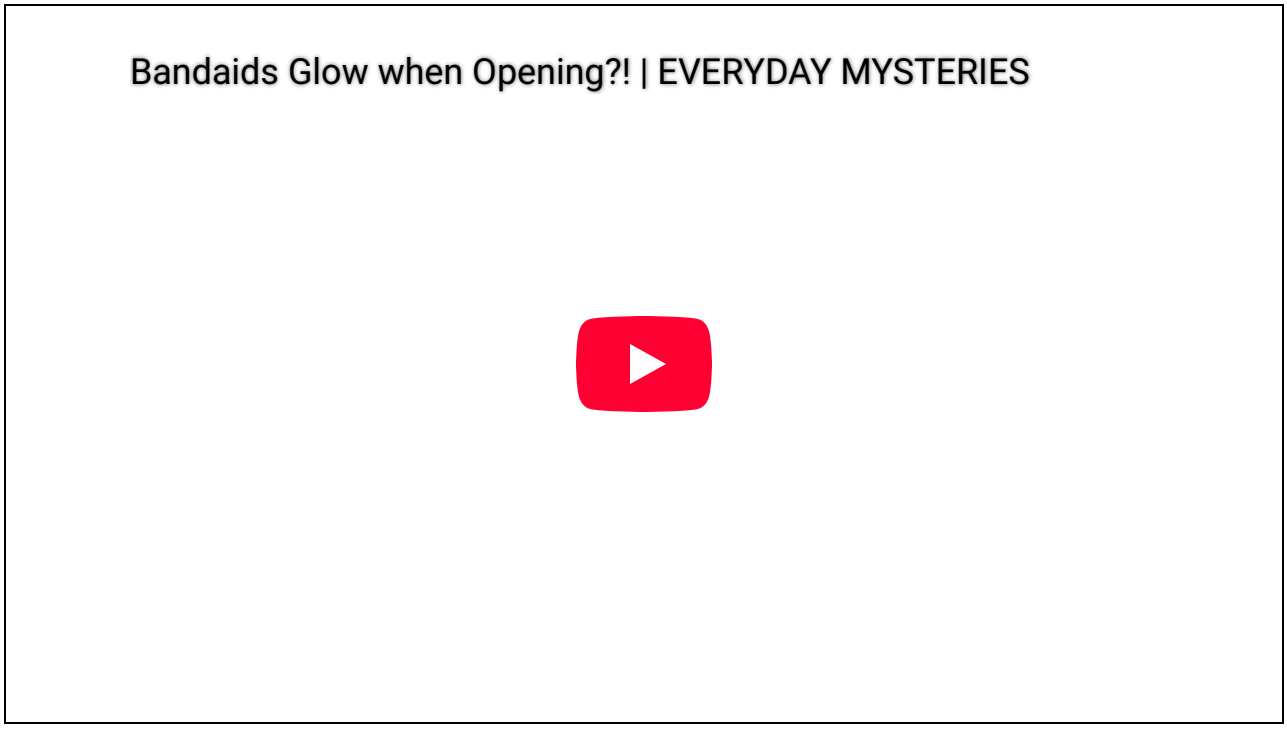
A high electric field emerged only when the tape was pulled quickly, Zare says. If that electric field is high enough, electrons from the tape will speed up and smash into air molecules or other molecules in the tape. This "leads to a spark that drives chemical reactions," says Zare. Those electrons flowing between the tape's surfaces can create a high enough voltage around the tape to break down molecules in the air, he says — turning them into ions.

Explainer: Understanding electricity

Zare's team repeated what Zhang's team had done. This time, they also looked to see if molecules of water vapor in the air near the tape would break up and form into new molecules. They did.

Next, Zare's group put chemicals they suspected would react as vapors in the electric field next to the peeling tape. This was to test a common reaction used in industrial chemistry. (It's one where pyridine and methyl iodide are reacted to form something new.) Right away, Zare's group detected new products as these chemicals now reacted.

The team shared its new findings June 25 in *Proceedings of the National Academy of Sciences*.



Adhesive bandages can spark a glow in air as they're peeled off a substance — such as their wrapper or our skin. Now watch it happen and learn about the physics processes that explain what's happening to electrons in and around the bandage.

Electric tape may lead to greener chemistry

“This is a fabulous discovery,” says Thalappil Pradeep. A chemist, he studies triboelectricity at the Indian Institute of Technology Madras in Chennai. There is a lot to discover about what’s happening at the tiny space where the peeling tape first makes contact with the air, he says.

Daniel Lacks agrees. This chemical engineer works at Case Western Reserve University in Cleveland, Ohio. “People don’t usually look at what’s happening in that little, teeny distance” between two nearly touching surfaces, he says. His own work has focused on particles that pick up an electric charge after rubbing against each other.

Lacks finds it “very cool” that the electric fields created by tape get so high they can drive chemical reactions.

Simone Ciampi works with triboelectric effects at Curtin University in Perth, Western Australia. What surprised him was the beauty and simplicity of the new experiment.

Guiding chemical reactions with triboelectricity is one type of green chemistry, Ciampi notes. Here, electricity can do work typically done by chemicals that may be toxic. So this approach, he concludes, can be more environmentally friendly.

Chemicals often react through a series of steps. Some may require separating positive and negative charges within a molecule. By controlling those electric charges, you can manage the reaction’s steps to help choose what product you end up with, Ciampi explains.

Indeed, a huge number of chemical reactions are sensitive to electric fields. But there’s often a challenge in using an electric field to guide reactions. The problem, Ciampi says, is the electrically conducting materials used to make the field. Those materials can interfere with the reacting chemicals, which could prevent the desired results.

That's why Ciampi is excited about this new research. It shows how a material that's not electrically conductive, such as tape, can create an electric field — and drive reactions without interfering with them. This, he says, could open "an entirely new space in chemistry."

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CITATIONS

Journal: X. Gao et al. Peeling tape produces strong electric fields via stick–slip friction that drive chemical reactions. *Proceedings of the National Academy of Sciences.* Vol. 122, June 25, 2025. doi: 10.1073/pnas.2510504122.

Journal: C.G. Camara et al. Correlation between nanosecond X-ray flashes and stick–slip friction in peeling tape. *Nature.* Vol. 455, October 23, 2008, p. 1089. doi: 10.1038/nature07378.