Metals + water article

**Why metals have a blast in water**

PHIL MASON

It's a classic chemistry experiment: A begoggled teacher drops a bit of metal into water — and KABOOM! The mixture explodes in a bright flash. Millions of students have seen the reaction. Now, thanks to images captured with a high-speed camera, chemists can finally explain it.

The experiment only works with elements that are alkali metals. This group includes sodium and potassium. These elements show up in the first column of the periodic table. In nature, these common metals occur only in combination with other elements. And that’s because on their own, they're very reactive. So they easily undergo reactions with other materials. And those reactions may be violent.

Textbooks typically explain the metal-water reaction in simple terms: When water hits the metal, the metal releases electrons. These negatively charged particles generate heat as they leave the metal. Along the way, they also break apart the water molecules. That reaction releases atoms of hydrogen, a particularly explosive element. When the hydrogen meets the heat — ka-POW!

But that’s not the whole story, cautions chemist Pavel Jungwirth, who led the new study: “There's a crucial piece of the puzzle that precedes the explosion.” Jungwirth works at the Academy of Sciences of the Czech Republic in Prague. To find that missing puzzle piece, he turned to videos of these high-speed events.

His team slowed down the videos and examined the action, frame by frame.

In the fraction of a second before the explosion, spikes appear to grow from the smooth surface of the metal. These spikes launch a chain reaction that leads to the blast. Their discovery helped Jungwirth and his team understand how such a big blast could erupt from such a simple reaction. Their findings appear in the January 26 *Nature Chemistry.*

**First came doubt**

Chemist Philip Mason works with Jungwirth. He knew that old textbook explanation of what caused the explosion. But it bothered him. He didn't think it told the whole story.

“I’ve been doing this sodium explosion for years,” he told Jungwirth, “and I still don’t understand how it works.”

Heat from the electrons should vaporize the water, creating steam, Mason thought. That steam would act like a blanket. If it did, that should wall off the electrons, preventing the hydrogen blast.

To probe the reaction in fine detail, he and Jungwirth set up a reaction using a mix of sodium and potassium, which is liquid at room temperature. They dropped a small glob of it into a pool of water and filmed it. Their camera captured 30,000 images per second, allowing for a very slow-motion video. (For comparison, the iPhone 6 records slow-motion video at a mere 240 frames per second.) As the researchers pored over their images of the action, they saw the metal form spikes just before the explosion. Those spikes helped solve the mystery.

When the water hits the metal, it releases electrons. After the electrons flee, positively charged atoms remain behind. Like charges repel. So those positive atoms push away from each other, creating the spikes. That process exposes new electrons to the water. These are from atoms inside the metal. The escape of these electrons from the atoms leaves behind more positively charged atoms. And they form more spikes. The reaction continues, spikes forming upon spikes. This cascade eventually builds up enough heat to ignite the hydrogen (before the steam can quash the explosion).

“It makes sense,” Rick Sachleben told *Science News*. He’s a chemist at Momenta Pharmaceuticals in Cambridge, Mass., who did not work on the new study.

Sachleben hopes the new explanation reaches chemistry classrooms. It shows how a scientist can question an old assumption and find a deeper understanding. “It could be a real teaching moment,” he says.

**Power Words**

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**atom**The basic unit of a chemical element. Atoms are made up of a dense nucleus that contains positively charged protons and neutrally charged neutrons. The nucleus is orbited by a cloud of negatively charged electrons.

**chemistry**The field of science that deals with the composition, structure and properties of substances and how they interact with one another. Chemists use this knowledge to study unfamiliar substances, to reproduce large quantities of useful substances or to design and create new and useful substances. (about compounds) The term is used to refer to the recipe of a compound, the way it’s produced or some of its properties.

**electron**A negatively charged particle, usually found orbiting the outer regions of an atom; also, the carrier of electricity within solids.

**element**(in chemistry) Each of more than one hundred substances for which the smallest unit of each is a single atom. Examples include hydrogen, oxygen, carbon, lithium and uranium.

**hydrogen**  The lightest element in the universe. As a gas, it is colorless, odorless and highly flammable. It’s an integral part of many fuels, fats and chemicals that make up living tissues

**molecule**  An electrically neutral group of atoms that represents the smallest possible amount of a chemical compound. Molecules can be made of single types of atoms or of different types. For example, the oxygen in the air is made of two oxygen atoms (O2), but water is made of two hydrogen atoms and one oxygen atom (H2O).

**particle**A minute amount of something.

**periodic table of the elements**A chart (and many variants) that chemists have developed to sort elements into groups with similar characteristics. Most of the different versions of this table that have been developed over the years tend to place the elements in ascending order of their mass.

**reactive** (in chemistry)  The tendency of a substance to take part in a chemical process, known as a reaction, that leads to new chemicals or changes in existing chemicals.

**sodium** A soft, silvery metallic element that will interact explosively when added to water. It is also a basic building block of table salt (a molecule of which consists of one atom of sodium and two atoms of chlorine: H2O).