Bromine Production Overview v4

[MUSIC PLAYING]

Wes:

Most of South Arkansas is covered with trees, except for the parts of it that are under water. So it may be a bit surprising to discover that lurking in this forest is a major chemical enterprise. Just a few steps from here is a plant owned and operated by Great Lakes Solutions, part of the Chemtura Corporation. This plant behind me and the other ones like it scattered over about 500 square miles of South Arkansas produce about half of the world's supply of an element. That element is bromine.

[MUSIC PLAYING]

Bromine is one of the elements, of course. But more specifically, it's one of the halogens, right below chlorine and right above iodine. Now bromine, as one of the elements, has its own unique chemistry. But maybe bromine's more unique than most. It's one of the few elements that's liquid under standard conditions. But it's the only element that's a liquid that isn't a metal.

Bromine has a lot of other interesting chemistry that we're going to explore in other videos. But today we're going to concentrate on understanding how elemental bromine, Br2, is made here in this plant.

I talked with Patty Cardin and Jeremy Pratt of Great Lakes to find out why they are making bromine in South Arkansas.

Patty:

Actually the reason our facilities are here in South Arkansas is pretty unique. There is a natural resource that's a brine reserve over 7,000 feet beneath our feet right now. If you look closely, you can see it's a very porous rock. The formation is known as a Smackover limestone formation and the brine water is trapped in this rock.

Wes:

So I got a big limestone sponge full of saltwater with a lot of bromide in it, about a mile and a half down. And this pipeline here has that salt water in it. And it's not exactly hot. But it's definitely uncomfortably warm.

Jeremy:

The brine is actually close to 200 degrees Fahrenheit when it comes out of the reserve and when it makes its way into the plant for processing.

[MUSIC PLAYING]

Wes:

So joining us here is Jon Thomas, one of the operators at Great Lakes south plant. John's been an operator here for, I'm told, for about five years. So he knows a thing or two about making bromine. So Jon there's some pretty big pipes running through this rafter over here. How much brine are you guys using?

Jon:

We use about 3,500 gallons a minute.

Wes:

You get the brine here and you're good to go or—

Jeremy:

No, we actually use our H2S strippers to remove any H2S or natural gas that's left in the brine.

Wes:

What's the problem with those two things? Why you got to get rid of them?

Jeremy:

H2s will actually hurt us by fouling our packing in our tower and hurting the efficiency. It also forms sulfuric acid which we have to treat before it's disposed of in the tail brine system.

Wes:

What about natural gas, it cause a problem?

Jeremy:

No, natural gas actually helps us. We actually send all of our natural gas from all three fields to Line Oil. Line Oil processes the sulfur out of it and sends the sweet gas back to us to burn in our boiler at the central plant.

Wes:

So once you get rid of the H2S and you get rid of the natural gas, are you good to go?

Jon:

We are. We sure are.

Wes:

So you bring it in and where does it happen?

Jon:

We bring it in right over here.

Wes:

Great, can we go take a look at that?

Jeremy:

Absolutely. Grab your hardhat and your safety glasses and we'll take a look.

Wes:

Safety at plants like these is serious business. The crew and I had to get training before we could even come into the plant. And there are safety notices and warning signs everywhere.

So this big orange pipe is the brine coming into the reactor.

Jon:

Yeah, it's pumped down from the feed brine pump, goes up to the top of the tower.

We bring chlorine in as a liquid and vaporize it. And take it right here. And this is where it starts its process.

Jeremy:

It takes roughly 10 seconds for it to get 100 feet to the top of the tower. But the chlorine and bromine reaction is taking place as it goes all the way to the top of the tower.

Wes:

This whole process works for two reasons. The first, chlorine has a higher affinity for electrons than bromine does. It's more reactive. The elemental chlorine takes electrons from the bromide. Chlorine oxidizes the bromide. Turning it into bromine. And the chlorine is converted, reduced in chemical terms, into chloride. Think of it as chlorine "mugging" the weaker bromide for its electrons, if you will.

An equally important component, but perhaps not so obvious, is the fact that chloride has a higher affinity for water than bromide does. We make more chloride. And it's higher affinity for water provides an important driving force moving the reaction forward.

Jeremy told us that the bromide and chlorine solution takes about 10 seconds to travel up the orange pipe to the top of the tower. Chlorine is so reactive that 10 seconds is more than enough time for the chlorine to turn the bromide in the feed brine into elemental bromine. By the time it gets to the top, we've got a solution with a little bit of elemental bromine, a lot of table salt, and a few other minerals.

Next we need to separate the bromine from the rest of the solution. With our ear plugs securely in place, we climb all the way to the top of the tower where Jeremy explains how that separation is accomplished.

[RUSHING WATER]

At least he tried to tell me. Maybe if we go back down a few levels, we can hear what he's trying to tell us. Man, that was loud. What was that?

Jeremy:

That was actually the steam being ejected into the vacuum tower.

Wes:

So you're doing what with the steam in the vacuum?

Jeremy:

Well, we actually use steam and inject it across the conversion/diversion nozzle. And we use the Bernoulli equation to—

Wes:

Whoa! How did we get into a discussion about physics? The show is Chemistry at Work, not Physics at Work. So we're going to skip ahead.

[VIDEO FAST FORWARDING]

I guess, the key thing here is that you're ejecting steam, you're dropping the pressure and raising the temperature at the same time.

Jeremy:

Absolutely, the brine is about 180 degrees Fahrenheit when it hits the vacuum tower. And it's about a half an atmosphere. So the bromine actually flashes out of the brine solution.

Wes:

They pull most of the bromine out of the solution by boiling it out under reduced pressure. Now reduced pressure helps things to boil. But you still need heat to convert a liquid into a gas, whether the liquid you are boiling is something exotic like bromine or as mundane as water. So it turns out they don't just insulate those pipes holding the feed brine to keep absent minded professors from burning themselves.

Remember, the solution comes out of the ground at about 200 degrees Fahrenheit, 93 degrees Celsius, just under boiling. The insulated pipes prevent heat loss as the feed brine travels from underground wells to the plant, heat they're going to need to boil the bromine which cuts down on production costs.

Now they add the chlorine to the hot brine as it travels up the tower where steam is injected and a vacuum is created. One of the important tricks in this process is to not reduce the pressure so much or to get the temperature so high that too much of the water that's dissolving all that salt evaporates along with the bromine. At one atmosphere of pressure, bromine boils at 58.8 degrees Celsius, just under 138 degrees Fahrenheit.

Wait a second, 180 degrees in half an atmosphere. That's a lot more than the 138 degrees needed to boil bromine at one atmosphere. It seems like massive overkill.

Jeremy:

So the bromine actually flashes out of the brine solution.

Wes:

Flash, that's the key word. They want this done fast. 3,500 gallons a minute are being processed through this thing. That's more than this 55 gallon drum every second. You don't have time to mess around. High temperature and low pressure help get most of the bromine converted to a gas very quickly. But even so, there's still some bromine that's left in the solution that's now falling down inside the bromine tower.

Jeremy:

Well, we're trying to make sure we get all of the bromine out of the brine solution. So there's a 30 foot packed section that contains these three inch panel or cascade rings. And the brine trickles over those pieces of packing to make sure all the bromine is separated from the brine solution.

Wes:

All of the bromine vapor, no matter where it's formed in the tower, moves up to the top of the tower. And that bromine gas is then pulled off and sent to a condenser that's just cold enough to remove most of the water vapor that comes along for the ride. The bromine vapor is then sent to a second colder condenser that converts the bromine itself into a liquid.

Now that liquid bromine still has a little bit of chlorine, water, and a few other contaminants. So the liquid is then sent through a drying process that removes almost all of this trace contamination. Once the bromine is produced, they load it into tanker trucks or rail cars to send out to customers. But a lot of this bromine gets used right here on this site.

After the bromine is extracted from the brine any contaminants like chlorine or acid in the solution are taken care of and the leftover "tail brine." as they call it is put back into the same rock formation it came out of, but using a well far away from the well used to supply the plant.

Elemental bromine isn't something you go down to the store to buy. And bromine isn't in a lot of the products you buy. But it contributes at least indirectly into things that you do care a lot about. For example, materials made from elemental bromine are used to control mercury pollution from coal fired power plants. Bromine is also used to make the materials that make up the very dense salt solutions that are needed to drill high pressure oil wells.

You can find bromine in hydrobromic acid and intermediates used to synthesize pharmaceuticals. And you can even find bromine occasionally in final products that you do buy such as drugs or pesticides. But the most important use for bromine is almost certainly flame retardants. And you do buy flame retardants, whether you know it or not.

There's a lot of bromine used in the plastics you see in everyday products. You're watching this video on a monitor or screen right now. And the chances are very good that the plastic in that device contains a bromine product made right here in this plant. The upholstery and padding in the chair you're sitting on probably have similar bromine containing materials in them. The purpose of these organobromides is to make it harder for flammable materials to burn, a very important use.

So you're pumping the bromine up out of the ground here. The brine comes into the plant. Then over here you're taking that brine without the bromine and pumping it back into the ground. It makes a big circle under our feet.

Jeremy:

Exactly.

Wes:

Thanks so much for showing us around today, Jeremy. This has been really fascinating, learning how you guys make bromine. Please check out all of our other videos where we look at the details behind various aspects of this process, either on YouTube or on our website. Again thanks for watching Chemistry at Work. Thanks so much.

[MUSIC PLAYING]