BBC Bitesize – Chemistry

Episode 7 – Extracting metals using electrolysis

TULELA: I'm Tulela Pea, a science communicator and podcaster.

SUNAYANA: And I'm Dr Sunayana Bhargava, scientist and poet.

TULELA: And this is Bitesize Chemistry.

SUNAYANA: This is the seventh episode in an eight-part series on chemical changes.

TULELA: In this episode, we'll be looking at how we extract metals from their ores using electrolysis.

SUNAYANA: Including aluminium?

TULELA: Especially aluminium.

SUNAYANA: Great – I'd better unwrap this sandwich from its aluminium foil and we can have a closer look.

TULELA: As always, it might be handy to write some notes or diagrams along the way. So hit pause where you need to. Don't worry, we'll wait for you to hit play again!

SUNAYANA: And also hit rewind if you need to go over some of those key facts. And remember to head over to BBC Bitesize on the web for more useful information and diagrams.

TULELA: On the previous episode we introduced electrolysis, the process of how we can separate ionic compounds into their elements by passing an electric current through the compound when it is molten, or melted. If you need a quick reminder, have a relisten to that episode as we'll be continuing with that idea in this episode which is about how we can extract pure metals from their ores by using electrolysis.

SUNAYANA: And we talk about extracting metals from their ores using carbon in redox reactions in episode 4 of this series.

TULELA: We did indeed. And if you also remember, we said that these redox reactions using carbon could only be used if the metal in question was less reactive than carbon. However, where the metal is more reactive, we need another method. And that is electrolysis.

SUNAYANA: Gotcha. And one of those metals is aluminium. How about a quick background on extracting aluminium from its ore from NNICK, our AI chat bot.

TULELA: He's more like Old McDonald's chat bot – AI AI Oh.

SUNAYANA: Know what you mean, Tulela. Hi NNICK! Can you give some useful background on extracting aluminium from its ore.

NNICK: Aluminium ore is called bauxite. It is purified to alumina using the Bayer process, which was invented by Carl Josef Bayer. The alumina is then dissolved in another aluminium compound with a lower melting point called cryolite. From this molten solution, aluminium is extracted using electrolysis.

SONG

NNICK: Bauxite is taken out of the ground

CHORUS: Y?

NNICK: Because it's aluminium ore

CHORUS: O.K.

NNICK: Then it's purified to alumina, an aluminium compound

CHORUS: O, Y?

NNICK: Because alumina's more useful than the raw ore before

CHORUS: O. O.K.

NNICK: Next the alumina is dissolved in molten cryolite.

CHORUS: Y, O, Y?

NNICK: Because its ions are freed to move by doing this.

CHORUS: O. O.K. I.C.

NNICK: And electricity's passed through this molten electrolyte

CHORUS: Y?

NNICK: So aluminium can be released by electrolysis

CHORUS: E, L, E, C, T, R, O, L, Y, S, I, S

NNICK: Yes

SUNAYANA: Thanks NNICK. Lots going on in that process to extract aluminium so let's break them down one by one.

TULELA: Since aluminium doesn't occur naturally in nature, it has to be extracted from its ore, aluminium oxide Al_2O_3 – also called bauxite. But, problem 1. Bauxite has many impurities – at best it's around 50% pure.

SUNAYANA: Solution! The bauxite is purified by the Bayer process that NNICK mentioned and from that we get the pure aluminium oxide in a white powder called alumina. You won't need to know any details about this for GCSE, and although Bayer invented this process over 140 years ago, it's still used today.

TULELA: But before we can use the alumina for electrolysis, it needs to be molten. Remember we can only use electrolysis on ionic compounds in their liquid state – so we need to melt the alumina first.

SUNAYANA: But, problem 2. Aluminium oxide has a really high melting point – around 2000 degrees Celsius. And that means it would take loads of energy and therefore a high cost to melt it.

TULELA: Solution – instead we first dissolve it in molten cryolite which is another aluminium compound. And this reduces the melting point of the mixture to around 900 degrees Celsius which takes less energy to achieve and is therefore less expensive. And we can now use it as an electrolyte.

SUNAYANA: Which is the name of the ionic liquid used in electrolysis.

TULELA: We now have our molten ionic aluminium electrolyte Al_2O_3 which we contain in a lined steel case, called the cell. Into this we immerse carbon electrodes, connect to a power supply and allow an electric current to flow.

SUNAYANA: So, I suppose at this point we could continue to explain what happens next. Or perhaps dear podcast listening friend, why don't you have a think about what happens to the ions in the molten liquid? Which ions migrate to the cathode, and which ions to the anode?

TULELA: Press pause and that will give us a chance to finish off that sandwich and you a chance to write down the answer. And see how you did when you press play again.

SUNAYANA: Still got a couple of bites left, which I'll leave for later. But let's continue with that process. As with all electrolysis of ionic compounds, the positive metal ions, in this case aluminium 3 plus, migrate to the negative cathode where they combine with electrons and so are reduced to aluminium atoms.

TULELA: Remember OIL RIG, where R-I-G stands for reduction is gain of electrons.

SUNAYANA: The molten aluminium sinks to the bottom of the cell, where it is tapped off.

TULELA: And the oxygen ions are attracted to the positive anode where they lose electrons – so are oxidised – to form oxygen atoms.

SUNAYANA: O-I-L – oxidation is loss of electrons.

TULELA: And this is where it gets more interesting as this oxygen reacts with the carbon electrode forming carbon dioxide and in doing so burning the electrode away. And this means that we need to continually replace this electrode. That's an important thing to remember. There's a diagram of the whole process on the Bitesize website for extra revision help.

SUNAYANA: Noted. And now that pure aluminium has been extracted it can be used in many processes in industry – from construction, electricity power lines, cans for packaging and foil to wrap up the last bits of my sandwich lunch. Hey, where's it gone?

TULELA: Sorry Sunayana, it was really tasty.

The uses of aluminium are hugely important in our world today and so the process of extracting it from its ore bauxite is vital. But as with any process in chemistry, it has its pros and cons.

SUNAYANA: The pro is that aluminium extracted in this way is over 99% pure. What about cons?

TULELA: The cons include the huge amount of heat needed in the process to melt the ore and in trying to generate this from environmentally-friendly energy rather than from burning fossil fuels.

SUNAYANA: Talking of which, the carbon dioxide produced as oxygen combines with the carbon anode adds to greenhouse gas, as well adding to costs as anodes are constantly replaced.

TULELA: Time for a quick aluminium extraction-related quiz then.

SUNAYANA: Three questions, five seconds…hit pause if you need to and write those answers down. Here goes.

TULELA: Question 1. Why can't we simply use carbon to extract aluminium from its ore as we can with some other metals?

SUNAYANA: Because aluminium is more reactive than carbon, and we can only use carbon to extract metals from their ores when the metals less reactive than carbon.

TULELA: Question 2. Why must we first dissolve the purified aluminium oxide, alumina, with cryolite?

SUNAYANA: Because pure alumina has a melting point around 2000 degrees Celsius and that would take huge amounts of energy. Dissolving in cryolite reduces this to 900 degrees Celsius.

TULELA: And question 3. Why does the carbon anode burn away and need to be replaced continually?

SUNAYANA: Because it reacts with the oxygen produced to form carbon dioxide.

TULELA: How did you do? Everyone's a winner and you all get an aluminium can and Sunayana's now crumpled up lunchbox sandwich foil.

SUNAYANA: Hey – I still want to recycle that, Tulela.

TULELA: Summary from today's episode first.

SUNAYANA: We can extract aluminium from its ore aluminium oxide, also known as bauxite, using electrolysis.

TULELA: Its high melting point means that we dissolve it first in cryolite to make an electrolyte with a lower boiling point.

SUNAYANA: Pure aluminium is tapped off at the cathode and oxygen forms at the anode…

TULELA: …which reacts with the carbon to form carbon dioxide and therefore the anodes need to be regularly replaced.

SUNAYANA: You can learn more about this process on the Bitesize webpages and you can listen on BBC Sounds to all our other Bitesize Chemistry podcasts.

TULELA: In the final episode of this series, there's one more exciting electrolysis process to look at. That is the electrolysis of aqueous solutions.

SUNAYANA: Thanks for listening!

TULELA: Bye.