# Plastic repairs itself

**Researcher Sybren Schoustra has developed a magic new plastic that can change shape. The discovery is not just extraordinary, it is also promising. It could make hard plastic reusable, for instance.**

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Schoustra takes some scissors and cuts a rubbery piece of dark-red plastic in half. Like a magician, he holds the two pieces up to show his audience they really are separate, then pushes them together. A few minutes later, the two pieces have merged into one again. At the beginning of March, Schoustra got a PhD for his work in the Organic Chemistry chair group on this new, recyclable plastic. 'If you look carefully, you can still see the line where I cut the plastic,' says the researcher, pointing to the small piece of plastic. But 24 hours later, there is hardly any sign of the cut. 'We can make the plastic softer or harder, more elastic or more flexible by changing the mix of ingredients,' he elaborates.

The piece of plastic looks perfectly normal, but at the molecular level it is quite unusual. The building blocks of plastic form long chains that are kept in shape by strong crosslinks. 'You could compare it to how the strands of a football goal net are knotted together,' says Schoustra. In regular plastic, the knots are permanent, but not in Schoustra's new plastic. 'We can disconnect those crosslinks and then connect them again.' In fact, the plastic itself restores the crosslinks. And that's how broken pieces of plastic can grow back together.

## PROTOYPE

These kinds of self-healing polymers, which organic chemists call vitrimers, have been around since 2011. 'Mostly, they have only been described in the literature, and there was just one prototype,' explains Schoustra. The vitrimers described in the literature have varied characteristics, but what they have in common is the reversible crosslinks between the building blocks, thanks to which the material can be changed again and again.


Researcher Sybren Schoustra with the self-healing plastic: the snipped-off piece will 'grow back' on.

**‘I threw the chemicals together and it was an instant success’**

Schoustra embarked on his experiments four years ago bursting with ideas. ‘I combined the molecular structures of vitrimers that had been described in the literature with my own ideas.’ As an organic chemist, he thinks in terms of molecular structures. ‘I can tell right away from the structure what properties a material has. So I could picture the molecular structures of the plastic in my mind.’ With that picture in mind, the PhD candidate walked into the lab some six months after the start of his research and mixed four chemicals to make the plastic he had visualized. ‘It was an instant success.’ Schoustra is still astounded by this, three and a half years later. ‘The plastic regenerated itself automatically without me having to apply heat, pressure or anything else.’ He used that first version as his starting point for further work. ‘I came up with tricks to make the plastic more elastic or flexible, for example by replacing one of the ingredients.’

## BOX OF TRICKS

At the end of his PhD project, Schoustra had a box full of ingredients. ‘I sometimes call it my Lego box: I can use a handful of basic building blocks to make an endless range of new products.’ He might make a plastic that is malleable at room temperature, or one that stays hard up to temperatures of 150 degrees Celsius. The latter is useful for components that are exposed to heat, such as car parts. ‘The shape of the molecular network determines the maximum temperature at which the plastic remains solid.’ Schoustra refers again to the football net example: ‘Lots of knots make for strong material, while fewer knots lend the plastic flexibility.’

In future, this new plastic could help reduce the amount of plastic waste. ‘At present plastic waste gets incinerated, and outside Europe sometimes even buried,’ says Schoustra. With a bit of heat, you can remould the Wageningen plastic into a new shape and reuse it. And there will no longer be a need to replace the plastic in shoes or car tyres because of tears or minor damage. But we are not there yet, warns Schoustra. ‘Our plastic looks great in the lab and works as we want it to, but we’ve got to investigate whether the material behaves the same way when we incorporate it into cars, for example.’ Schoustra himself is taking a little break from science. ‘The time has come to be spontaneous. I’m moving to Sweden next month and I’ll see where life takes me.’ But that doesn’t mean Schoustra is hanging up his lab coat for good. ‘I can see myself combining creativity with science some time in the future.’ ■

*www.wur.eu/selfhealingplastic*