Innovation can sometimes come from an unexpected angle. ‘The story begins about a year ago’, recounts Prof. Stephen Picken (Applied Sciences). A PhD student (Jure Zlopasa, CEG) was trying to find a water-proof coating. Zlopasa’s search led him to Picken, who is known as the polymer and coating expert at TU Delft. At the Microlab, where fundamental research is conducted in order to improve concrete, the young Croatian explained what he was looking for: a polymer with clay plates. These clay plates emerge when a small amount of clay is ultrasonically dissolved in water. They are discs with a thickness of 1 nanometre and a diameter between 100 and 500 nanometres. Binding these tiny, invisible but impermeable discs into a polymer creates a nano-coating that could be very useful in the concrete industry.

Contrary to what some may think, concrete should not actually dry, but harden completely. This process can take up to 28 days. For the hardening process, it is extremely important that there is enough water in the concrete mixture (gravel, sand, cement and water). As the outside of the concrete dries, small cracks appear in the surface. This will make it easier for water and salt to penetrate to the iron reinforcement bars, after which concrete degradation can occur.

On warm summer days, people at construction sites can be seen using large hoses to keep freshly poured concrete wet. In some cases, a water-repellent layer is added as well, although the result is sub-optimal, in addition to polluting the environment. This is one of the many issues being addressed in the STW concrete research program.
me ‘Integral Solutions for Sustainable Construction’ (IS2C).

As a solution to excessively rapid drying, Zlopasa and his PhD supervisor, Dr Eduard Koenders (CiTG) developed an idea for a polymer with nano-clay particles. With this polymer, water vapour from the concrete would have to take a long detour in order to circumnavigate the clay discs. One question remained: which polymer would be suitable? It was with this question that Zlopasa approached Picken a year ago in the former chemistry building.

Hydrophilic
Picken knew that the polymer would have to be water-based (hydrophilic), given that the nano-particles are dissolved in water. ‘From cooking, I remembered that sodium alginate could be mixed with calcium chloride to form a gel layer’, he notes.

According to Wikipedia, alginate is a natural hydrophilic polymer extracted from seaweed. Its primary component, alginic acid, is a polysaccharide, like starch. Rapidly hardening, inexpensive and non-toxic, it is used in the food industry as a thickening agent. Dentists use it to make dental casts, and it is used to bandage wounds in the emergency room.

Another use has thus been found: as a water-sealant layer on hardening concrete, which could last at least 20 years longer, according to Koenders’s estimation.

Picken uses the presence of calcium in the cement to explain the polymer formation. Because calcium is bivalent, it links the two alginic acid molecules to each other, forming a closed network bound together by the clay plates to form a water-tight layer. This happens very quickly.

‘The alginate hardens as soon as it touches the surface of the fresh concrete surface’, explains Zlopasa. The water-tight, insoluble layer is only one tenth of a millimetre thick. It turns into a tough, yet flexible pale-yellow foil. Its transparency depends upon the amount of clay particles. ‘The concentration of clay particles can be as high as 80%.’

Such a high concentration of neatly arranged clay particles results in special properties. Consider the example of natural mother-of-pearl: impenetrable, strong as concrete and non-combustible.

Protective coating
Picken predicts that alginate with nano-clay would also polymerise on iron (which is trivalent). This could provide a foundation for an extremely tough protective coating for offshore constructions. The valorisation centre is busily charting the various applications and patenting some of them.

The water-tight, insoluble layer is only one tenth of a millimetre thick

Examples include the use of alginate in optical products (in order to make cast lenses) and in the paper industry (using alginate from self-produced waste as a paper-surface treatment).

Alginate is an end product of the widely acclaimed Nereda waste-water purification system developed by Prof. Mark van Loosdrecht and Royal HaskoningDHV. At the end of the purification process, the bacteria pellets contain 15%–20% alginate. Zlopasa presents a small plastic bottle containing a black liquid: alginate from sewage waste. Although the origins can still be recognised in the odour, this should not pose any problems for non-food applications.

The clay alginate is a new, purely natural product with surprising properties and a growing list of possible applications. It can literally be used to create value from waste. ‘If TU Delft plays its cards right, this could become huge’, predicts Picken.

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**What is plastic**

In common usage, ‘plastic’ is a relatively generic and mildly derogatory term for synthetic materials. It refers however, to the property of malleability, which is a property of what chemists refer to as thermoplastics. These are synthetic materials or polymers that can be softened by heating, because their long molecules have little or no branching. A plastic object can be hot sprayed or pressed in a mould, and will retain its shape after it cools. It can easily be recycled by melting it. Other polymers (i.e. molecules consisting of a series of identical or similar parts) form a strongly branched network when a hardening agent is added or when they are exposed to ultraviolet radiation, thus hardening permanently.

For this reason, not all polymers melt, but plastics do. Finally, composites are compound materials consisting of a strong layer of fibres or metal embedded in a polymer. One well-known example is the aircraft material Glare, which is composed of several extremely thin layers of aluminium, glass fibre and epoxy.