Nature's strongest glue comes unstuck

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Over a 150 years since it was first described by Darwin, scientists are finally uncovering the secrets behind the super strength of barnacle glue.

Still far better than anything we have been able to develop synthetically, barnacle glue – or cement - sticks to any surface, under any conditions.

But exactly how this superglue of superglues works has remained a mystery – until now.

An international team of scientists led by Newcastle University, UK, and funded by the US Office of Naval Research, have shown for the first time that barnacle larvae release an oily droplet to clear the water from surfaces before sticking down using a phosphoprotein adhesive.

Publishing their findings this week in the prestigious academic journal *Nature Communications*, author Dr Nick Aldred says the findings could pave the way for the development of novel synthetic bioadhesives for use in medical implants and micro-electronics. The research will also be important in the production of new anti-fouling coatings for ships.

"It's over 150 years since Darwin first described the cement glands of barnacle larvae and little work has been done since then," says Dr Aldred, a research associate in the School of Marine Science and Technology at Newcastle University, one of the world's leading institutions in this field of research.

"We've known for a while there are two components to the bioadhesive

but until now, it was thought they behaved a bit like some of the synthetic glues - mixing before hardening. But that still left the question, how does the glue contact the surface in the first place if it is already covered with water? This is one of the key hurdles to developing glues for underwater applications.

"Advances in imaging techniques, such as 2-photon microscopy, have allowed us to observe the adhesion process and characterise the two components. We now know that these two substances play very different roles – one clearing water from the surface and the other cementing the barnacle down.

"The ocean is a complex mixture of dissolved ions, the pH varies significantly across geographical areas and, obviously, it's wet. Yet despite these hostile conditions, barnacle glue is able to withstand the test of time.

"It's an incredibly clever natural solution to this problem of how to deal with a water barrier on a surface it will change the way we think about developing bio-inspired adhesives that are safe and already optimised to work in conditions similar to those in the human body, as well as marine paints that stop barnacles from sticking."

Barnacles have two larval stages – the nauplius and the cyprid. The nauplius, is common to most crustacea and it swims freely once it hatches out of the egg, feeding in the plankton.

The final larval stage, however, is the cyprid, which is unique to barnacles. It investigates surfaces, selecting one that provides suitable conditions for growth. Once it has decided to attach permanently, the cyprid releases its glue and cements itself to the surface where it will live out the rest of its days.

"The key here is the technology. With these new tools we are able to study processes in living tissues, as they happen. We can get compositional and molecular information by other methods, but they don't explain the mechanism. There's no substitute for seeing things with your own eyes. " explains Dr Aldred.

"In the past, the strong lasers used for optically sectioning biological samples have typically killed the samples, but now technology allows us to study life processes exactly as they would happen in nature."

The research will also be of interest to the shipping industry. Biofouling – the accumulation of marine life on ship's hulls – increases drag on ships and costs the global industry an estimated $7.5 billion a year in wasted fuel.

Other implications include the movement of invasive species around the world and increased emission of greenhouse gases.

More information: "Synergistic roles for lipids and proteins in the permanent adhesive of barnacle larvae." N V Gohad, N Aldred, C M Hartshorn, Y Jong Lee, M T Cicerone, B Orihuela, A S Clare, D Rittschof and A S Mount. *Nature Communications* July 2014. DOI: 10.1038/ncomms5414

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