

Force stabilizes a bond in bacterial adhesion

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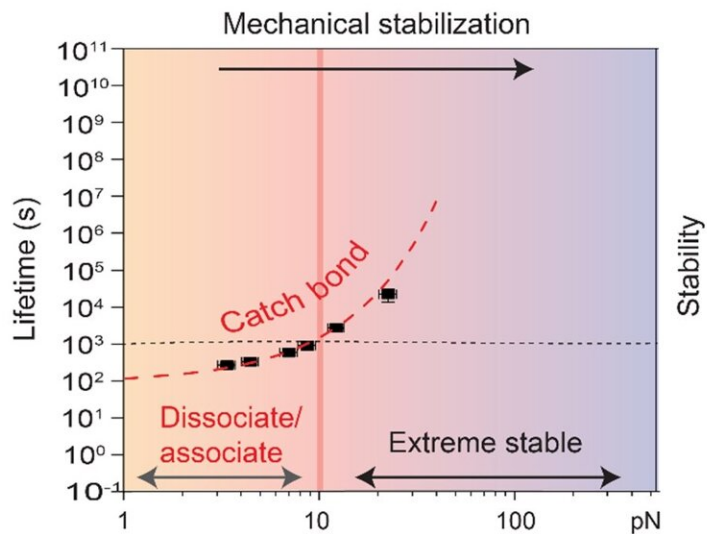
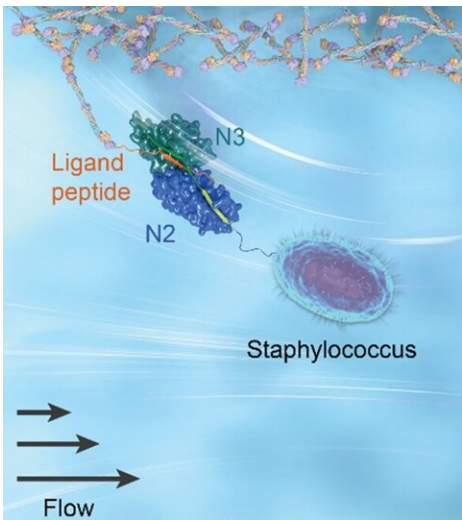


Illustration shows a staphylococcus bacterium adhered to human host ligand through the typical bacterial adhesion protein (left), and the counterintuitively catch-bond behaviour with increased lifetime under increasing forces. Credit: *Journal of the American Chemical Society*

National University of Singapore biophysicists have discovered how a special bacterial adhesion complex could be counterintuitively stabilized by mechanical stress at the single-molecule level.

A critical aspect of bacterium-host interactions is the [physical contact](#) between bacteria and hosts as well as their responses to local mechanical stimuli. The bacterial [adhesion](#) complexes formed with the hosts need to

be resilient to various [mechanical stress](#) conditions, associated with forces over a wide range from nanonewtons in the [urinary tract](#) down to piconewtons in the capillaries. On the other hand, the adhered bacteria need to retain the ability to spread, demanding sufficiently short lifetimes of the adhesion complexes at stress-free conditions.

A long-standing hypothesis is that bacterial adhesion complexes may have evolved with a unique mechanical property, conferring them a counter-intuitive force-dependent increase of lifetime, which is known as catch-bond kinetics. To some extent, this is analogous to the safety belts found in cars, which tighten up when there is a sudden increase in stresses.

The test of this important hypothesis has been hindered for years by the technological challenge of being able to quantify the force-dependent lifetimes of a single bacterial adhesion [complex](#) over a force range of up to tens of piconewtons for long durations.

A research team led by Professor Jie Yan from the Department of Physics, National University of Singapore has overcome the technological challenge and investigated the force-dependent lifetimes of a family of bacterial adhesion complexes using ultra-stable magnetic-tweezers. Strong catch-bond kinetics are observed for all these adhesion complexes, with the lifetimes increased by several thousands of folds when the applied forces increase from near-zero to tens of piconewtons. A highly sensitive temperature dependence of the lifetimes is also revealed. This is shown by a drastic decrease in the lifetime of more than 100 folds when the temperature increases from 23°C to the human body temperature of 37°C.

Prof. Yan said, "A unique force-dependent conformational change of the adhesion complexes is found to be the rupturing transition pathway of the adhesion complexes. With this, the team derived a [physical model](#)

that can quantitatively explain the observed catch-bond force-dependent lifetimes of the adhesion complexes, which is the first ever reported proof of this catch-bond kinetics in bacteria."

The study is published in the *Journal of the American Chemical Society*. In the future, the research team will extend their technology to examine the mechanical stability of a broader range of microbial adhesion complexes implicated in human diseases and explore possible intervening approaches to destabilize the bacterial adhesions.

More information: Wenmao Huang et al, Mechanical Stabilization of a Bacterial Adhesion Complex, *Journal of the American Chemical Society* (2022). [DOI: 10.1021/jacs.2c03961](https://doi.org/10.1021/jacs.2c03961)

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