A better way of lubricating human joints and implants

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Researchers at the University of Oxford have discovered that certain lubricants reduce friction much more effectively in water or water-based solutions than in machine oil or air, which may be how the process works in biological systems as well.

'Boundary lubrication is common in machines but is also thought to act between joints and other living organs in the form of phospholipid films,' said Professor Jacob Klein. 'This new mechanism could lead to better lubricated artificial implants, as well as to more effective treatments for joint problems like osteoarthritis.'

Professor Klein and his colleagues at the Physical and Theoretical Chemistry Laboratory at Oxford reported their discoveries in the 9 November issue of the journal *Nature*.

For more than fifty years, films or layers which are one molecule thick have been used in air or oil to lubricate surfaces which rub together, reducing friction and wear. These layers have usually belonged to the class of amphiphilic surfactants, whose head is water-loving, while their tail is water-repelling.

'Each of the rubbing surfaces is coated by a "boundary" layer of surfactant molecules, with charged heads that stick to the surface while their hydrocarbon tails dangle out,' explained Professor Klein. 'In classical boundary lubrication in air or oil, the rubbing occurs between these protective tails and greatly reduces friction and wear.'

The Oxford researchers studied the friction between mica surfaces in the different environments, with and without overlaying surfactants. They have shown that the friction stress between two sliding surface coated by surfactant monolayers can decrease much more in water than in air or oil, falling to one percent or less of its value for the latter environments.

‘We believe this happens because the charged head groups then become hydrated, that is, coated with water molecules,’ said Professor Klein. ‘This enables them to slide much more easily past the substrate than the hydrocarbon tails can slide past each other. As a result, the slip occurs at the substrate, rather than between the surfactant tails as in the classical mechanism.’

The researchers proved that the hydration of the anchors must be largely responsible for the reduction in friction by testing surfactants which were homologous to the original but could not be fully hydrated at the surface because of their structures, which resulted in greater friction. They also eliminated the possibility of this occurring due to the flipping of the surfactants’ anchors when they came into contact with water by performing the same experiments on surfaces which were brought into adhesive contact before being immersed, so that the anchors could not flip.

Citation: “Boundary lubrication under water’ by Wuge H Briscoe, Simon Titmuss, Fredrik Tiberg, Robert K Thomas, Duncan J McGillivray and Jacob Klein is published in *Nature* on 9 November 2006.

Source: University of Oxford