technology today

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SLIPS—The Slipperiest Engineered Coating in the World

In our natural world, you will find many living organisms that have amazing characteristics that scientists and engineers want to copy. At the Harvard University Wyss Institute for Biologically Inspired Engineering, scientists and engineers were able to create an ultra-slippery self-healing coating by duplicating the properties of the Nepenthes Pitcher plant (Photo 1). Their research has now reached the point of creating viable products through a spinoff company first named SLIPS Technologies Inc., and very recently rebranded as Adaptive Surface Technologies (AST).

Wong Laboratory for Nature Inspired Engineering, Penn State

Photo 1—The carnivorous pitcher plant gets its name from its distinctive shape. It catches bugs that crawl on its moist top rim that is so slippery they fall in.

Photo 2—Two balls in oil, one uncoated (left) and one SLIPS coated (right)

Wong Laboratory for Nature Inspired Engineering, Penn State

The pitcher plant is carnivorous, but visually it appears to have no way to catch and trap the crawling bugs that it needs to eat. It traps its prey by having a surface that is ultra-slippery. When moist, bugs that crawl on its top surface can't keep their footing and therefore slide into the pitcher of the plant to become dinner.

The coating that the Wyss scientists, engineers, and their students created is named "SLIPS," which stands for Slippery Liquid Infused Porous Surfaces. Besides being very slippery, it is also transparent, self healing, durable, and basically repels everything that falls on it (Photo 2). It is more slippery than Teflon and like Teflon it can handle very high temperatures without losing its slippery properties.

Dr. Tak-Sing Wong invented SLIPS while he was working at the Wyss Institute under the leadership of Dr. Joanna Aizenberg. He is now an Assistant Professor of Mechanical Engineering at Penn State University and continues, working with his students, to research new technologies that are inspired by biological organisms.

To fabricate SLIPS into what the Wyss scientists called a "superglass," the team assembled micro-sized polystyrene hollow beads into a tightly packed layer on top of a piece of glass. The tightly corralled beads were entombed in a second layer of liquefied glass, then the beads were burned away, leaving a micro-sized honeycomb structure that was created because the beads were hollow.

Wong Laboratory for Nature Inspired Engineering, Penn State

Photo 3—If you look carefully you can actually see the liquid hit the surface and bounce back into the air.

This second layer of glass was intentionally thin so it would leave micro-sized openings into the honeycomb layer that once contained the beads. Into the honeycomb layer they infused their SLIPS formulation. (Photo 4). Since SLIPS doesn't evaporate or dissolve in water or oil, the backup reservoir, in the honeycomb, is for self healing of the surface layer.

To add SLIPS to any material one needs to create a hybrid micro sized honeycomb outer coating that can be infused with SLIPS (Fig. 1). Laboratory experimentation indicates it should be possible for AST to create coatings that can be applied to many different types of materials including glass, metals, and ceramics. The Wyss news releases indicate that SLIPS could even be used as a coating on medical instruments, but the

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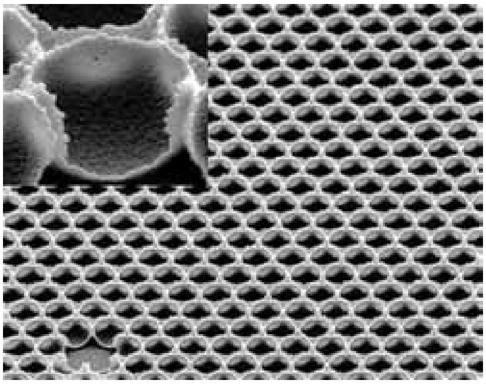


Wyss Institute at Harvard University

Photo 4—To create the self-cleaning superglass, the Wyss Institute scientists needed to create a sheet of glass with a middle layer that contained a honeycomb of micro-sized wells into which they infused SLIPS. To see these opening you would need to view the glass under an electron microscope.

spinoff company was not given the rights to develop SLIPS infused medical products at this time.

Now that SLIPS has moved from the laboratory to manufacturing, what makes it so special is it can be clear or opaque, colored or colorless, and coat almost any type of surface. It doesn't have to be infused into a glass substrate unless you want to create superglass self cleaning windows, scratch proof optical lenses, or self-cleaning solar panels.

Used as a metal coating on ships, it would prevent barnacles from forming. Used on steel, it could prevent corrosion. On medical equipment it could prevent the growth of bacteria and viruses. The list of uses is endless; it is only a matter of time before you might be able to purchase products with a SLIPS outer coating. This YouTube video visually shows SLIPS slipperiness: youtube.com/watch?v=-b8SAZMqg0s

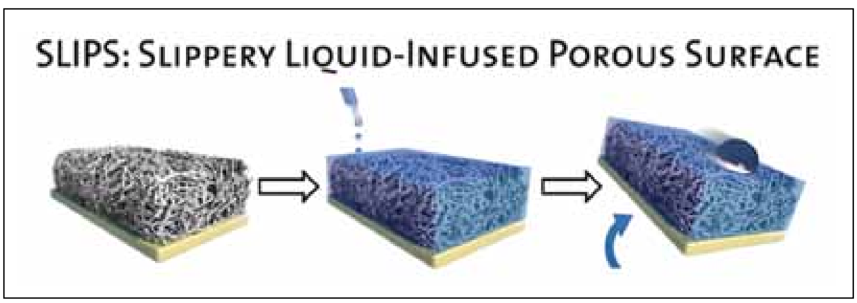
Taking It a Step Further

1. Stickiness is the opposite of slipperiness. There are many glues being sold with the tag line "our adhesive creates a stronger bond than any other glue." Select different commercial glues and develop a testing procedure to determine which one gives the strongest bond. Each of the glues must be applied following the manufacturer's application and curing directions.

Instructor note: This testing phase should be supervised to prevent students from getting injured if the testing procedure does not provide adequate protection from falling or flying material when glue joints fail.

2. Creating medicine from parts of plants and animals existed in ancient civilizations. Working in teams of 3-5 students, see which group can find the most examples of:

- Ancient uses of plants and other living organisms for their curative abilities.
- Modern uses of plants and other living organisms to create medical breakthroughs. td



Wyss Institute at Harvard University

Fig. 1—The figures show openings that would be invisible unless you were looking at the object under an electron microscope. To infuse SLIPS, the outer layer of a metal or ceramic material would need to have micro-sized openings that serve as SLIPS wells to self-heal the outer coating if it is damaged.

More than Fun Answers

But It Just Doesn't Add Up!

There are at least two possible answers:

25 + 4 – 3 = 26 and 4 – 3 + 52 = 26

5 (2 × 3) – 4 = 26 could also be acceptable since it doesn't use the same multiplication symbol twice.

Merrily We Roll Along . . .

The average speed is 13.333 mph.

Let the distance up the hill be 20 miles. Then it took 2 hours to go up and 1 hour to come back down.

So, the average speed is found by dividing total distance (40 miles) by total time (3 hours).

Road Trip!

165.749 or 166 mpg.

To find mpg, you must divide total miles by the total gallons.

Let x = the mpg for the second part of the trip. Set up the following table to help you:

	mpg	Gallons	Miles
1st Part	39	21 / 13	63
2nd Part	x	28 / x	28
Whole Trip	51	91 / 51	91

The number of gallons used on the first part of the trip plus the number of gallons used on the second part must equal the total number of gallons used for the trip, so this gives us our equation:

$21 / 13 + 28 / x = 91 / 51$

$1.65153 + 28 / x = 1.784$

Then $28 / x = 0.1689291105$, so $x = 165.74999$ or 166 mpg.

Tech Inventors

1—D Bowie knife
2—G Braille alphabet "M"
3—C Bunsen burner
4—J Ferris wheel
5—B Foucault pendulum
6—H Fresnel lighthouse lens
7—E Klieg carbon arc spotlight
8—A Morse code "M"
9—I Petri dish for bacterial cultures
10—F Wheatstone bridge

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