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Issue 58

In This Issue

Biomimetics – Material Structure in Nature

The natural world is full of inspiration for the materials scientist. Many researchers are working in the field of biomimetics trying to develop synthetic materials that equal or even outperform materials found in nature. Many of these synthetic materials, while attaining similar specifications to the natural material, sadly fall short in performance comparisons. However, scientists are discovering that nature's high performance is not due just to the basic material properties, but to the structure and form of the materials. Two cases in points are the scales of the Arapaima fish and the exoskeletal cuticle of insects.

Arapaima

The Brazilian Arapaima is a huge fish weighing up to 300 lb. It lives in lakes alongside the better-known Piranha. So how come it doesn't become Piranha food?

This was the question that intrigued researchers at the Jacob's School of Engineering at UC San Diego. They found that, as much as the Piranha would have enjoyed snacking on the Arapaima, their needle-sharp teeth were unable to penetrate the scales of this massive fish.

Investigation of fish scale's structure showed that they are composed of an outer layer of a hard, mineralized biomaterial with an inner layer of softer collagen fibers. In other words, the fish is "case-hardened", offering a hard outer surface with a flexible inner core. The researchers carried out hardness testing on the scales using an indenter that held an actual Piranha tooth at its tip. The tooth was able to penetrate partway through the scale, but it fractured before it would have damaged the underlying muscle of the fish. Further, the outer layer of the scales is corrugated giving the hard scale the ability to bend with the movement of the swimming fish.

Insect Cuticle

Researchers at the Wyss Institute for Biologically Inspired Engineering at Harvard University have been investigating the properties and the structure of insect cuticle.

Insect cuticle is a composite material comprising layers of chitin (a polysaccharide polymer) and fibroin (a protein). These materials are arranged in layers, similar to plywood. Mechanical and chemical interactions between these layers and the different materials give the cuticle unique mechanical and chemical properties. The researchers have developed a thin, clear film from similar materials and with a similar layered structure as insect cuticle. The material is composed of fibroin protein from silk and from chitin extracted from discarded shrimp shells. It is thin, clear, and flexible, and the researchers claim it is as strong as aluminum at half the weight. They have called the new material Shrilk.

One of the biggest advantages of this new, low-cost synthetic material is its biodegradability. Shrilk could one day replace plastic for degradable consumer products, such as trash bags, packaging, and diapers, and be used safely in a variety of medical applications, such as sutures or scaffold for tissue regeneration.

Nature has always been an inspiration for materials scientists. Early man used natural materials, such as wood, bone, sinew, and leather to manufacture tools, clothing, and structures. Synthetic materials have improved on the properties of many of these basic materials, but for some of them the limits of their performance have been reached. Research into how nature constructs natural materials, as well as into their basic chemistry, offers the promise of attaining even higher performing synthetic materials in the future.

Images:
Arapaima image courtesy of George Chernilevsky in the public domain.
Grasshopper image courtesy of Gilles San Martin under a creative commons license.

Sources:
Piranha Vs. Arapaima: Engineers Find Inspiration for New Materials in Piranha-Proof Armor. Science Daily, Feb 8, 2012
Arapaima fish scales inspire new materials. robaid.com, Feb 9, 2012
Inspired by Insect Cuticle, Wyss Researchers Develop Low-Cost Material with Exceptional Strength and Toughness. Wyss Institute for Biologically Inspired Engineering at Harvard University, December 12 2011
As Strong As An Insect's Shell. Harvard Gazette, Alvin Powell, February 2, 2012

Advantages of a Twin-Bore Capillary Rheometer

Capillary rheometers allow users to better understand the processability of a thermoplastic prior to extruding or injection molding. This improves yields and reduces recycling/regrinding. Also, the rheometer enables users to perform process optimization to improve productivity by better understanding a thermoplastic's rheological behavior under specific test conditions.

These rheometers are available in single- and twin-bore configurations. The twin-bore systems offer some important advantages:

- First, the ability to perform two simultaneous and independent rheological tests at once increases testing throughput, which is invaluable in quality control testing.
- Second, it allows for the direct comparison of the behavior of two lots of the same material, or two different materials, which is of benefit to both the quality control tester and the researcher.

Q. What is GR&R?

A. Gauge Repeatability and Reproducibility (GR&R) is the determination of the accuracy of a measurement by ascertaining its repeatability - the consistency of measurements taken by the same operator - and reproducibility - the consistency of measurements taken by different operators.

There are five major elements of a measurement system that contribute to errors in a measurement process: the standard, the part being measured, the instrument, the operator, and the environment. All of these elements affect the measurement reading obtained. Overall measurement errors are minimized if the errors contributed by each of these elements are minimized.

There are various ways by which the GR&R of a measuring system may be assessed. A common method is to first measure variations due to the measuring equipment. Variations are calculated from measurement data obtained by the same operator taking measurements using the same equipment under the same conditions. Subsequently variations are calculated from different operators taking measurements using the same equipment under the same conditions. Variations may also be calculated from measurement data obtained from several different parts. An overall GR&R value, called the %R&R, is calculated from these combined variations.

The measuring system is considered satisfactory if the %R&R is less than 10%. A %R&R between 10% and 30% may also be acceptable, depending on what it would take to improve the system variability. A %R&R of more than 30%, however, should prompt an investigation into how the R&R of the measuring system could be further improved.

Instron Worldwide Headquarters
825 University Ave
Norwood, MA 02062
www.instron.com