Mesoamerican people perfected details of rubber processing more than 3,000 years ago: study

May 24 2010, by David L. Chandler

The Aztec god, Xiuhtecuhtli, as one of the nine Lords of the Night, offers up rubber balls in this drawing.

(PhysOrg.com) -- Spanish explorers encountering an advanced civilization in Mesoamerica in the 16th century had plenty of things to be astonished about, but one type of object in particular was unlike anything they had ever seen before: rubber balls. No such stretchy, bouncy material existed in the Old World, and they had to struggle to find words to describe it.

New research from MIT indicates that not only did these pre-Columbian peoples know how to process the sap of the local rubber trees along with juice from a vine to make rubber, but they had perfected a system of chemical processing that could fine-tune the properties of the rubber depending on its intended use. For the soles of their sandals, they made a strong, wear-resistant version. For the rubber balls used in the games that were a central part of their religious ceremonies, they processed it for maximum bounciness. And for rubber bands and adhesives used for ornamental wear and for attaching blades to shafts, they produced rubber optimized for resilience and strength.

All of these, according to the research by Professor Dorothy Hosler and Technical Instructor Michael Tarkanian of MIT's Department of Materials Science and Engineering, were most likely achieved by varying the proportions of the two basic ingredients, latex from rubber trees and juice from morning-glory vines, which were cooked together. A paper describing the findings will be published soon in the journal *Latin American Antiquity*.

The research builds on a paper that Hosler, Tarkanian and Sandra Burkett, then an assistant professor at MIT, published in Science in 1999 that showed for the first time that the Mesoamerican people could have used the combination of two ingredients to produce rubber. The new work, which draws on a combination of laboratory experiments, recovered artifacts and the descriptions left by early explorers, demonstrates how varying the formula could fine-tune the rubber's properties.

Although Hosler and Tarkanian's research demonstrates that the Mesoamericans had the raw materials and the basic knowledge to make these different formulations, proving that's what they actually did would require further evidence, either from contemporaneous accounts or from chemical analysis of samples used for different purposes.

Long before Goodyear

Charles Goodyear is credited with having invented vulcanization — a chemical process for converting rubber or related polymers into more durable materials — while experimenting with rubber and sulfur in the mid-19th century. But it has long been known that the Aztecs, Olmecs and Maya — the civilizations that, over a span of more than three millennia, dominated the region that is now Mexico and parts of Central America — were adept at making rubber, and that the material was used to produce the large, heavy balls used for the ceremonial games played on stone-walled ball courts. A few such balls have been found in archeological digs in the region — the oldest dating back to 1600 B.C., or more than 3,000 years before Goodyear's contributions — and though they have become hard and brittle with age, their nature is unmistakable. "They were really spectacular, really enormous," Hosler says of the Mesoamerican rubber balls, which ranged in size from a few inches to a foot across — the size of a beach ball.

An image of a ball court at Xochicalco, a pre-Columbian archaeological site in the western part of the Mexican state of Morelos.

Until the new research, nobody had shown that it was possible to obtain

the different properties needed for other uses of rubber, simply by varying the recipe's proportions. Unlike the rubber balls, Mesoamerican rubber-soled sandals have never been found. But they are described in the diaries of the Spanish explorers and missionaries, and their existence is clear from linguistic evidence: The Aztecs used a compound word that clearly blends the words for "rubber" and "sandals."

The ancient rubber material that has survived tends to be so degraded that it can't be tested for its mechanical properties. So Tarkanian and Hosler set up their own processing facility at MIT, using raw materials collected in field trips to Mexico. They made batches of rubber with varying proportions of the two plant substances, and then subjected the product to a suite of tests to measure wear resistance, elasticity, toughness and other properties.

Sure enough, varying the proportions produced different properties. A 50-50 blend of the latex and morning glory produced maximum elasticity, or bounciness, perfect for the rubber balls. Rubber used as an adhesive or for joining other materials (such as ceramic and wood) needs different properties — strength and damping ability — and for that, pure latex seems to work best. For sandals, where wear resistance is the most important quality, a three-to-one mix of latex to morning glory provides the most durable material.

The Mesoamericans had plenty of time to work out these properties through trial and error. By the time the Spanish arrived, Tarkanian says, "there was a large rubber industry" in the region, producing 16,000 rubber balls each year, and large numbers of rubber statues, sandals, bands and other products. Most of those were produced in villages in outlying areas, and were shipped to the capital city as a form of tax payment.

Hosler has also studied these ancient civilizations' advanced work in

metallurgy, and suggests that they were likely also accomplished practitioners of other kinds of materials processing that have yet to be studied, such as formulating mortars, plasters and paints.

Frances Berdan, professor of anthropology at California State University at San Bernardino, says Hosler and Tarkanian's latest work has implications well beyond rubber. "There are other areas of production where the pre-Hispanic peoples cleverly combined materials to achieve enhanced products. The Tarkanian-Hosler research on ancient rubber should have the effect of directing our attention to the methods used by these peoples, and recognizing that they developed sophisticated answers to their everyday (and also not-so everyday) problems."

John McCloy, a senior research scientist at Pacific Northwest National Laboratory, says that "Tarkanian and Hosler have compiled a compelling case that ancient Mesoamerican peoples were the first polymer scientists, exerting substantial control over the mechanical properties of rubber for various applications." He adds that "what remains to be done is to find archaeological evidence of rubber footwear in ancient Mesoamerica, and to study the production methods for Mesoamerican rubber as an adhesive and as footwear. It would also be interesting to do chemical analyses on rubber balls, adhesive rubbers, and sandals (if they are found) to see if quantification of morning-glory additives corroborates the laboratory study of the mechanical properties."

Provided by Massachusetts Institute of Technology