Carbon footprint almost halved by new LION GLASS solution

Researchers at Penn State have developed LION GLASS, a more sustainable and stronger glass with significantly reduced energy consumption and improved crack resistance. LionGlass aims to cut the carbon footprint of glass manufacturing by half, and its potential applications are being evaluated through patent applications and chemical testing.

On a global scale glass manufacturing annually produces no less than 86 million tons of carbon dioxide. However, a new glass type could potentially reduce that carbon footprint by 50 percent. The groundbreaking innovation, denominated LionGlass, has been meticulously engineered by researchers at Penn State. LionGlass requires much less energy during production while exhibiting far greater damage resistance when compared to the standard soda lime silicate glass. In a significant stride towards market implementation, the research team recently completed the filing of a patent application.

IN IT FOR THE LONG HAUL

John Mauro, Dorothy Pate Enright Professor of Materials Science and Engineering at Penn State who is also lead project researcher, articulated the team's overarching objective thus: "Our goal is to make glass manufacturing sustainable for the long term." Elucidating further on the properties of LionGlass, he affirmed that "LionGlass eliminates the use of carbon-containing batch materials and significantly lowers the melting temperature of glass."

The common variety of glass known as soda lime silicate glass, which finds extensive use in an array of everyday items such as windows and glass tableware, is made by melting together three primary constituents, namely quartz sand, soda ash, and limestone. Notably, soda ash is constituted by sodium carbonate whereas limestone is made of calcium carbonate - both of which emit carbon dioxide (CO2) upon melting: a greenhouse gas that's responsible for heat retention. Says Mauro: "During the glass melting process, the carbonates decompose into oxides and produce carbon dioxide, which gets released into the atmosphere." Nonetheless, it's the energy-intensive heating of furnaces to the elevated tem-

peratures necessitated for glass melting that mostly contributes to the bulk of CO2 emissions. When using LionGlass, melting temperatures are appreciably reduced by approximately 300 to 400 degrees Celsius. This significant reduction, explained Mauro, equates to an estimated 30 percent decrease in energy consumption compared to the conventional soda lime glass.

AN ARRAY OF WINNING PROPERTIES

LionGlass not only exhibits a reduced environmental impact. It also outperforms conventional glass in terms of strength. Here the research team were delighted to discover that the new glass variant, aptly named after Penn State's iconic Nittany Lion mascot, manifests considerably greater crack resistance in comparison to its traditional counterpart. Certain glass compositions formulated by the team exhibited such remarkable crack resistance that they remained impervious to cracking even when subjected to a load of one kilogram-force exerted by a Vickers diamond indenter. LionGlass, being at least ten times more resistant to cracking in comparison to standard soda lime glass, which succumbs to cracking under a load of approximately 0.1 kilograms force, defies any definitive limits. Here the researchers clarified that the full extent of LionGlass' crack resistance capabilities has not yet been ascertained as they encountered the maximum load capacity of the indentation equipment during their investigations.

"We kept increasing the weight on LionGlass until we reached the maximum load the equipment will allow," said Nick Clark, a postdoctoral fellow at Mauro's lab. "It simply wouldn't crack." Mauro underscored the significance of crack resistance as a crucial quality in evaluating glass, emphasizing that it determines the eventual failure of the material. Over time, glass develops microcracks on its surface, which serve as vulnerable points. Breaking glass is attributed to weaknesses caused by pre-existing microcracks. Mauro emphasized the value of glass that resists the formation of microcracks, noting how it is particularly advantageous.

NEW FRONTIERS FOR RESILIENCE

"Damage resistance is a particularly important property for glass," affirmed Mauro. "Think about all the ways we rely on the strength of glass in the automotive industry and electronics industry, architecture and communication technology like fiber optic cables. Even in health care, vaccines are stored in strong, chemically-resistant glass packaging." Mauro expressed his hope that the enhanced strength of LionGlass would enable the creation of lighter-weight products. Given that LionGlass exhibits ten times greater damage resistance than existing glass, it could be substantially thinner - even while maintaining the same level of damage resistance. Mauro commented, "We should be able to reduce the thickness and still get the same level of damage resistance. If we have a lighter-weight product, that is even better for the environment, because we use less raw materials and need less energy to produce it. Even downstream, for transportation, that reduces the energy required to transport the glass, so it's a winning situation for everyone."

Penn State University

Mauro emphasized that the research team is currently assessing the potential of LionGlass. It has submitted a patent application that covers the full glass composition range within the LionGlass family, each one possessing its distinct properties and potential applications. As such the team is currently subjecting various LionGlass compositions to diverse chemical environments to analyze their reactions. The results will provide valuable insights into the versatile utilization of LionGlass worldwide. "Humans learned how to manufacture glass more than 5,000 years ago. Since then it has been critical in bringing modern civilization to where it is today," said Mauro. "Now, we're at a point in time when we need it to help shape the future as we face global challenges such as environmental issues, renewable energy, energy efficiency, health care and urban development. Glass can play a vital role in solving these issues, and we are ready to contribute."

ABOUT JOHN MAURO

Dr John Mauro, an esteemed expert in glass science, is a graduate of Alfred University. Having gained extensive experience at Corning Inc, he is also known for his contributions to glass compositions, including Gorilla® Glass. At Penn State, he focuses on glass transition and relaxation as well as predictive design of new glassy materials. Mauro's research covers various areas, including high-strength glasses, nucleation/crystallization and glass melting/processing. With over 340 publications and 72 US patents behind him, he is now an influential figure in the field and serves as Editor-in-Chief of the Journal of the American Ceramic Society.