Study finds more effective way to dry ethanol, reduce costs

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(PhysOrg.com) -- Purdue University researchers have found an alternative environmentally friendly and energy-efficient way to dry corn ethanol, and their proof is in the pudding.

Michael Ladisch, a distinguished professor of agricultural and biological engineering; Youngmi Kim, a Purdue research scientist; and Ahmad Hilaly, director of process research at Archer Daniels Midland, found that the shape and structure of tapioca pearls are ideal for removing water from ethanol. Their findings were reported in the July issue of the journal *Industrial & Engineering Chemistry Research*.

After fermentation, ethanol contains between 6 percent and 12 percent water, which must be removed to make it fuel-grade. Many ethanol plants use corn grits, which absorb water, or molecular sieves, silica-based particles with tiny pores that only retain water molecules. Ladisch and Kim found that tapioca pearls work better than the conventional corn grit adsorbents.

"Any starch will absorb water. That's how you cook rice or pasta," Kim said. "The tapioca pearl is made of aggregated cassava starch granules that can adsorb more water."

Ladisch said tests found tapioca collected about 34 percent more water than corn. Molecular sieves, while effective, eventually wear out and create waste that must be disposed of. The tapioca can be dried and reused, and when they wear out, they can be used to make more ethanol.

"Tapioca is very efficient, and it's all-natural," Ladisch said. "There are no disposal issues. It's much more environmentally friendly."

Tapioca pearls, essentially spherical, are structured differently than corn grits, Ladisch said. While corn grits are solid, irregularly shaped particles, tapioca pearls contain a gelatin starch core upon which dry starch granules are aggregated, significantly increasing surface area.

While tapioca pearls are 100 percent starch, corn grits also contain fiber, protein and other substances that are not efficient for absorbing water.

Starch-based adsorbents like tapioca pearls also take up the heat created during drying, allowing that heat to be reused to evaporate water during regeneration of the drying bed.

"This combines fundamental biochemistry, biology and engineering with thermodynamics to obtain an efficient separation system," Ladisch said.

After trying several options to maximize water absorption, including corncobs and wood chips, inspiration struck Ladisch while watching his mother-in-law fix Thanksgiving dinner. As she started mixing up homemade tapioca pudding, Ladisch noticed that the tapioca pearls looked similar to the beads used in molecular sieves.

"I started thinking, 'It's a starch. Might this work?'" Ladisch said.

Ladisch said tapioca pearls may be used effectively in U.S. ethanol facilities, but he believes they could be more significant in facilities in South America and Africa where the plant used to create tapioca - cassava - is grown.

Ladisch and Kim said they would continue to test uses for tapioca pearls, including drying other alcohols. They also plan to create synthetic, starch-based adsorbents from other cheaper materials to lower the cost.

Ladisch is chief technology officer at Mascoma, a renewable fuels company based in New Hampshire. He received no funding from the company for this research. Archer Daniels Midland funded the work.

More information: ABSTRACT

Cassava Starch Pearls as a Desiccant for Drying Ethanol

Youngmi Kim, Rick Hendrickson, Nathan Mosier, Ahmad Hilaly, and Michael R. Ladisch

The fuel ethanol industry uses corn grits packed in fixed bed adsorption towers to dry hydrous ethanol vapors in an energy efficient manner. Spherical micropearl cassava starch exhibit a higher adsorption capacity than corn grits of the same size and may be a viable replacement for ground corn. Adsorption equilibrium curves, BET surface area measurements, and SEM images provide an explanation for the enhanced performance of cassava micropearls based on particle architecture and the surface area available to water molecules. The SEM images show that the micropearls form a core–shell structure with pregel starch acting as the scaffold that holds starch granules in an outer layer. This layer determines the BET surface area and the measured equilibrium adsorption capacity. The core–shell microstructure results in a shortened diffusion path-length and enhanced adsorption rates. These microstructural and operational characteristics provide a template for microfabrication of enhanced capacity starch based spherical adsorbents that could replace ground corn for the drying of ethanol.

Provided by Purdue University