Title: FLC Notable Technology Award Oleo-Furan Surfactant

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1. Please explain your technology, the problem it solves and its benefits. *[50 points/1,000 words]*

It's a well-kept secret that laundry detergents are harmful to the environment. The important chemical in laundry detergent, called a surfactant. Surfactants are the workhorses of laundry detergent and soaps, and they're attracted to things like grease on your hands and dirt in your clothes to wash them away. Surfactants are used in everything from shampoo, hand soap, laundry detergent, and cosmetics. Many current surfactants are made from petroleum feedstock. These petroleum-derived building blocks come with a big carbon footprint. As the need for greener feedstock alternatives for synthesizing surfactants became obvious, manufacturers turned to natural oils, such as palm kernel and coconut oil. However, these oils are costly, particularly in areas where they are not domestically produced, and using them for surfactant synthesis competes with the food supply chain.

Surfactants deactivate and do not work in hard water. Hard water is common—85% of the U.S. water supply is considered hard because of the presence of small metal ions. These metal ions cover the surfactants making them useless. To solve this problem, many manufacturers add chemicals called chelators to bind the metal ions and make the water less hard, enhancing the effectiveness of the laundry detergent. However, this solution leads to more problems, including increased cost of detergent production and a large output of environmentally harmful chemicals.

There remains a strong need for effective laundry detergents that do not negatively impact the environment and are available to consumers at an affordable cost. The American Cleaning Institute (ACI), a surfactant manufacturer organizing body, is emphasizing commitment to developing bio-renewable alternatives to current surfactants in laundry detergents. That's why chemists at SIRONIX Renewables partnered with Los Alamos National Laboratory to further develop Oleo-furan surfactants (OFS).

OFS are a new class of non-toxic, non-irritating surfactants for laundry detergent. It is the only surfactant that performs effectively in cold and hard water without chelators to bind the metal ions in hard water. OFS can be produced readily from sustainable, bio-derived molecules. They are multi-functional molecules—performing the role of a surfactant and a chelator in one—and are completely bio-degradable. OFS does not rely on petroleum feedstock and is synthesized from non-food, bio-renewable cellulosic feedstock. OFS solves each of the pertinent problems facing detergents and our environment today.

Benefits of OFS:

- Hard water tolerance is over 200x greater compared to conventional detergents
- No toxic chelators
- No fossil fuel feedstock
- Reduces production costs

- Reduces energy use by cleaning clothes in cold and hard water

2. Who/what are or will be the markets or consumer of this technology? *[40 points/650 words]*

The global market for laundry detergent is currently $12.8 billion and growing.

Trends toward improved product safety, environmental stewardship, and product performance have created an urgent need for new surfactant ingredients in home and personal care products. As existing ingredients face increased scrutiny and regulatory action over product safety, the list of acceptable surfactants for formulators of eco-friendly detergents has been reduced to only a handful, none of which provide the cleaning strength that consumers demand.

Despite their best efforts existing, well-known brands, such as Tide PurClean, come up short in product safety. The recent regulatory action in New York that essentially bans 1,4-dioxane, a carcinogenic byproduct of the main ingredient in Tide Original and Tide PurClean, has left the industry scrambling for solutions.

Competitors such as Seventh Generation and Method are considered green in some regards, but when a summation is made over all factors, they negatively impact the environment.

Additionally, hard water is a major challenge in countries with high levels of hard water but limited capacity to pre-treat, or soften water. These countries, including India, China, and Brazil, have large emerging cleaning products markets, amounting to a $9.2B worldwide market for hard water surfactants. As a result, the improved performance and environmental profile of OFS has the potential to have a major impact.

Other products that use surfactants include paints, inks and coatings, oil field chemicals, agriculture and agrochemicals, and personal care and cosmetics.

3. What partnerships, if any, formed to help develop and potentially transfer the technology? *[5 points/450 words]*

The Department of Energy, Energy Efficiency and Renewable Energy, Bioenergy Technologies Office (BETO) funded the work at Los Alamos, and SIRONIX contributed cost share. SIRONIX and Los Alamos engaged in a Cooperative Research and Development Agreement (CRADA) in April of 2018 to develop an improved technology process and demonstrate continuous production at pilot scale.

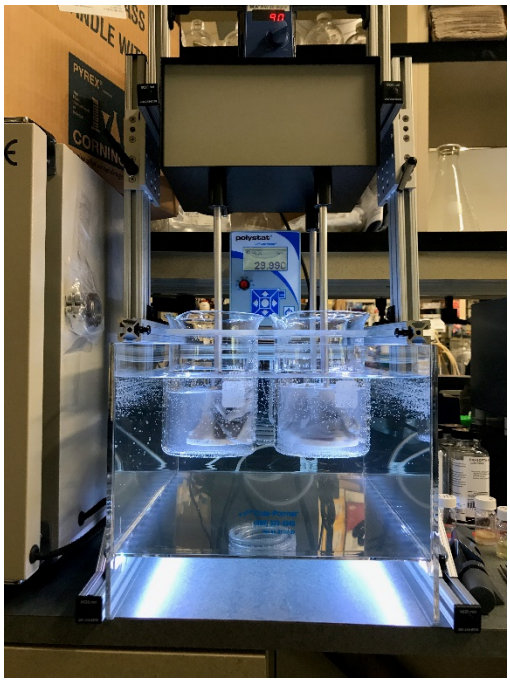
SIRONIX has partnered with the State of Washington to comply with environmental and regulatory steps toward commercialization. SIRONIX also partners with detergent and personal care product brands to test the ingredients in their existing formulations, then offers these existing brands the OFS based formulas to incorporate into their current formulations. These partnerships provide useful feedback for continued improvements in order to help change the way the world cleans.

4. What patents were filed or planned to be filed? *[5 points/450 words]*

The chemistry required to develop OFS is nontrivial, the foundational science was established by SIRONIX founder Christoph Krumm and recently advanced through the collaboration with Los Alamos National Laboratory to include a provisional patent for non-toxic catalysts.

The process to make OFS comprises three steps. Each step has been honed toward smart, clean chemistry. The process is patented: Synthesis of Fuels and Feedstocks, U.S. Pat. No. 9,783,477 issued October 10, 2017. SIRONIX and Los Alamos are working together under a CRADA to develop bio-based surfactants for use in cleaning products. Intellectual property developed during this CRADA project will be evaluated for patent filing and licensing.

The OFS final liquid product as sent to leading cleaning product brands that formulate eco-friendly detergents. Ongoing partnerships with product brands help provide performance feedback for OFS in real-world conditions.



A miniaturized laundry testing apparatus is used to test new surfactant molecules in real-life laundry wash conditions. Each glass beaker is filled with a small amount of water, detergent, and pre-stained fabrics. Backlighting allows for researchers to see issues during the wash cycle, such as cloudiness that is a result of incompatibility with hard water.

Video Link: https://youtu.be/Y_3eNFNg1EQ

Potential publications:

"Tunable Oleo-Furan Surfactants by Acylation of Renewable Furans," ACS Central Science

ICS Innovation Awards 2019: Best Innovation by a Small or Medium-Sized Enterprise: SIRONIX Renewables

October 2019 ICIS Innovation Award Supplement