Ozone Processing to Enhance Starch Performance

Researchers from University of São Paulo Investigate Ozone Processing to Enhance the Performance of Different Starch Sources, Creating New Ingredients for Different Industries

Edited from a write-up provided by Pedro E. D. Augusto, University of São Paulo.

The Problem: Starch is a natural biopolymer synthetized and stored in vegetables as an energy source. It is also a versatile industrial ingredient that is widely used in various sectors such as: food, feed, chemicals, petrochemicals, adhesives, paints, paper, textiles, and pharmaceuticals. Although many different properties of starch are demanded by industry, the available sources of starch are limited by nature. Consequently, different starch modification processes are being developed to achieve new properties and applications to enhance starch performance. Currently the modification technologies that are most frequently applied involve chemical substances such as hypochlorite, acetates, phosphates, and acids. These techniques generate a large volume of effluents, which causes concerns for both the consumer and the environment. As a consequence, there is a rising demand for starch modification alternatives using environmentally friendly technologies.

The Solution: The Process Engineering Research Group (Ge²P) of University of São Paulo has been studying ozone technology as an alternative to starch modification for 6 years. Different starch sources have been studied such as: maize, cassava, potato, wheat and arracacha. The combination of ozone processing to modify starch with other technologies has also been studied, particularly ozone combined with ultrasound and dry heating treatments.

Ozone is produced by the coronal-discharge method from industrial oxygen and can reach concentrations of 40-50 mg O_3 L^{-1} in the gas stream. The starch is suspended in water and the reaction occurs at room temperature, where the gas stream is bubbled in the starch suspension in a glass reactor. The system is multiphase with three different phases and physical states: gas (O_2 + O_3), liquid (water), and solid (starch granules). The concentration of ozone is continuously monitored in both the reactor inlet and outlet using an ozone monitor (2B Technologies, Model 106-H, Boulder, USA) to evaluate the reaction. Different ozone concentrations, gas flows and reaction times were evaluated.

The native and modified starches were evaluated in relation to their structure (both molecular and granule), properties, and functionalities.

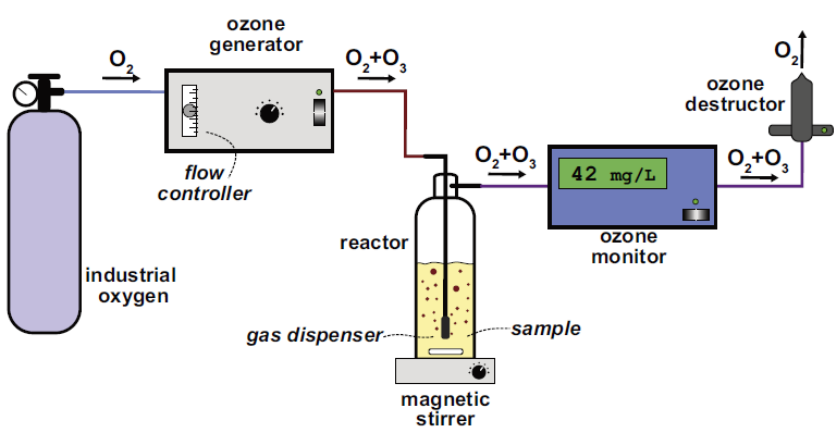

Figure 1. The ozone processing system used in the starch modification studies.

Results: The ozone process is highly efficient to promote starch modifications, however its effectiveness varies depending on the starch source. Even when the same ozone system and processing conditions are applied, different properties can be observed depending on the starch source that is being evaluated. This indicates the starch structure plays an important role in the final results.

Figure 2. Pictures representing the starch gel strength.

Figure 3. Pictures representing a better 3D printing

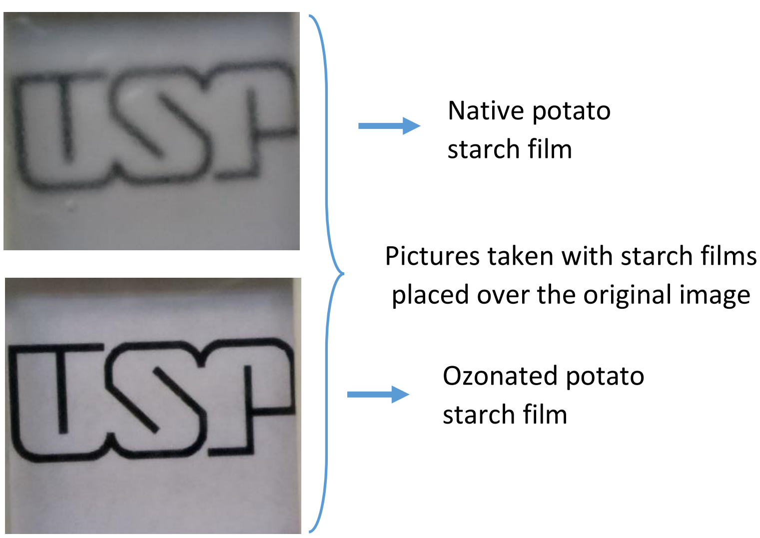

Figure 4. Pictures representing the starch film transparency.

Despite the different sources, the main modifications in relation to starches' structure are the increase of carbonyl and carboxyl groups content (as a consequence of oxidation of hydroxyl groups) and partial depolymerization (decreasing of the molecular chain length) of both amylose and amylopectin molecules. These structural changes result in different molecular interactions that affect the starch properties and possible applications.

For example, hydrogels are 250-300% stronger than those produced from native starch. The hydrogels were also resistant to acidic conditions. Additionally weaker gels can also be obtained by changing the process conditions. Gel formation is the most important property of starch for different industrial applications. The stronger hydrogels improve 3D printing performance, an emerging technology in food processing.

The different molecular interactions of ozonated starches resulted in better oven expansion. This allowed for the production of gluten-free doughs and biodegradable plastics with enhanced properties such as stronger and more transparent films.

The research has shown that the combination of technologies also improved starch modifications. Pre-treatment with ultrasound affected the subsequent ozone processing, while the order of combination of ozone + dry heating treatment influenced the final properties.

Click here to view the full paper:
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The Model 106-H High Concentration Ozone Monitor

The 2B Tech Instrument's Role: The Model 106-H was used to measure the ozone concentration in the multiple gas streams at the reactor's inlet and outlet to aid in evaluating the reactions occurring in starch modification experiments. The flow-through nature of the Model 106-H allowed the instrument to measure the ozone gas at both of these locations without affecting the treatment of the starch. The instrument's measurement range of ~0 – 275 mg/L (0-20 wt %) made it possible to measure the 42 mg/L used to treat the starch during the experiment. The highly portable nature of the Model 106-H made for easy deployment of an ozone monitor in the context of this application.

The Bottom Line: If you are planning to use an ozone monitor to control the output of a high-concentration ozone generator or to measure wt% levels of ozone, then look no further than the Model 106-H. With low power consumption and high portability, the instrument can be deployed for a wide variety of industrial applications involving high ozone. The instrument is designed as a flow-through ozone monitor and is meant to be operated under pressure. It can withstand pressures up to 50 psig with resulting flow rates between 0.5-55 L/min. The Model 106-H is available in three different configurations (see photo below): a standard benchtop configuration, an industrial/NEMA wall-mount configuration, or an OEM configuration to aid in integration into your ozone system. The instrument is equipped with two 2-level relays which can be used to control the output of an ozone generator or alarms (our Tech Note 45 describes some of these applications of the relays). Please contact us to discuss using the Model 106-H for your application.