Ensuring bottled beverage shelf-life

Oxygen transmission rate testing

by Michelle Stevens, technical expert in the barrier packaging industry, Systech Illinois, brand of Industrial Physics

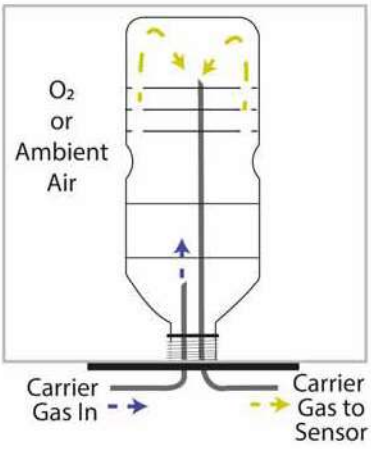
As the beverage industry experiences increased focus on health and wellness products, demand for oxygen transmission rate measurement of bottles has compounded. Many of the new products are diverging from traditional carbonated soft drink recipes to include fruit juices, vitamins, minerals, and other oxygen sensitive ingredients.

Traditional methods for determining a bottle's shelf-life are no longer adequate, if even relevant. O_2 ingress resulting in ingredient deficiency, rancidity and/or off-flavours is quickly becoming the limiting factor in beverage bottle shelf-life. Oxygen transmission rate (OTR) testing of the entire bottle as well as the components is now required in both research and development and quality assurance / quality control scenarios.

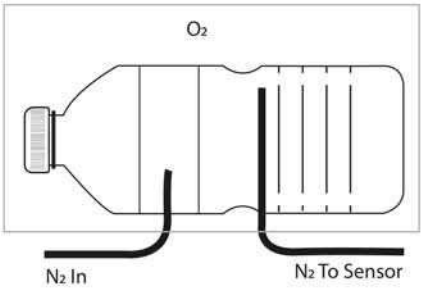
Oxygen transmission greatly influences the shelf-life of a beverage as the ingress of oxygen can rob the product of flavour, colour, taste, and nutrition. Oxygen can also cause adverse reactions in oxygen-sensitive ingredients found in many health and wellness beverages. By measuring the rate at which O_2 transmits through the package material, one can begin to determine the shelf-life or amount of time the unopened package will still provide 'good' product.

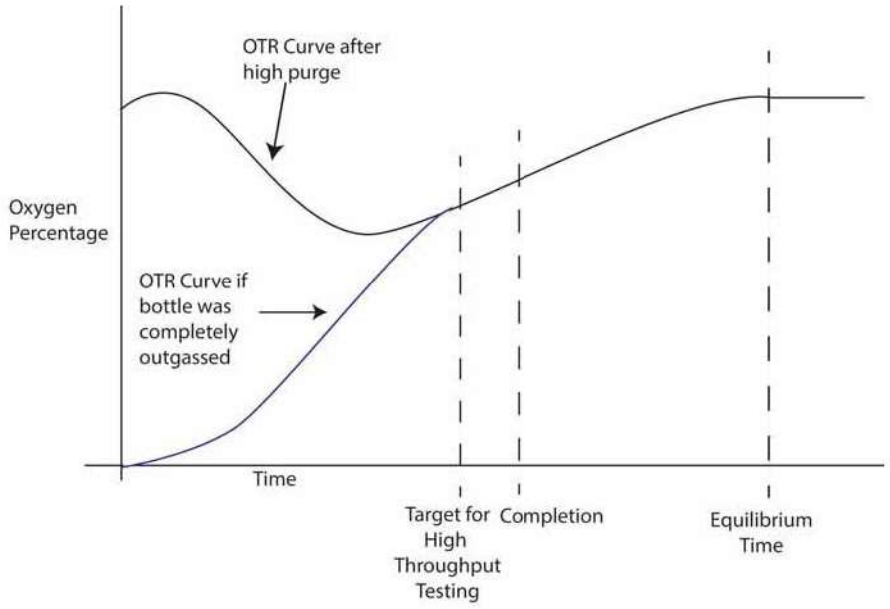
Oxygen transmission rate testing for R&D and component testing

Oxygen transmission rate testing is crucial in both the bottle design/R&D phase as well as QA/QC phase. Bottles are tested for OTR by challenging the outside of the bottle with oxygen (typically either 21% [room air] or 100%) and sweeping the inside with a nitrogen carrier gas. Molecules of O_2 that permeate the bottle are picked up by the N_2 carrier gas and analysed at a detector. The concentration of O_2 at the sensor is translated to an OTR with typical units of cc/day, which corresponds to the amount of oxygen entering the entire bottle in one day.



From bottle design to QA/QC, a variety of OTR testing variations may be used. In the development phase, materials are tested as flat films. Based on OTR performance and a host of other factors, top-ranking candidate materials are formed into bottles. It is crucial to test the OTR of each candidate again as a bottle because processing conditions, thickness variations and other factors can alter the predicted OTR value of the finished product. Because oxygen ingress is not limited to just the bottle, the closure system must also be evaluated for OTR. Finally, the entire bottle and closure system can be tested as a complete, finished package.





High throughput OTR testing

High throughput is always a dominant consideration when testing permeation, especially in the QA/QC environment. However, OTR testing of bottles presents some unique challenges. Due to the intricacy of the sensors in the testing instrument, room air and any residual oxygen must be swept out of the bottle before testing can begin. This process can be lengthy without a proper high-flow purge phase. Additionally, traditional permeation measurement devices typically have only two test cells. Based on other testing in the beverage industry, a much larger sample size is required for QA/QC processes. Finally, depending on the barrier level of the bottle, OTR tests can take several days to a week to reach equilibrium.

Fortunately, instruments are available that offer high-flow purge with eleven bottle stations. Unfortunately, the time to equilibrium of any type of OTR test can only be reduced by increasing the temperature. While this may be an option in R&D applications, it isn't an accepted alternative in QA/QC processes. It is possible however, to reduce the test time and, in conjunction with a high-flow purge and 11-cell instrument, significantly increase throughput.

While it is impossible to accelerate equilibrium time, with a proper protocol development the time bottles are in test may be shortened. During a batch quality OTR analysis, most bottle outliers should manifest in the beginning to middle of the test. However, in order to determine the appropriate amount of time required and to better understand the bottle behaviour, a protocol development study should be conducted. This type of study should involve a variety of bottles tests including but not limited to: standard test with high purge (to evacuate residual O_2 from the inside the bottle), modified test with extended purge on inside and outside (to evacuate all oxygen from both inside the bottle and within the materials), and standard test with high purge on bottle with known defects. Data from this development study can be used to determine optimal test time for a quality system protocol, insuring confidence in the accuracy of the desired bottle parameters.

As beverage products continue to diversify, the capacity to measure oxygen ingress, rather than carbon dioxide levels, will become increasingly important as an indication of shelf life. Rigorous and accurate testing, along with careful protocol development, will ensure products maintain their quality without jeopardising plant productivity.

Systech Illinois offers an 11-cell, high-purge OTR testing system, the 8700 Oxygen Permeation Analyser. The 8700 can measure 11 samples simultaneously - individually started, stopped or delayed. Fixed platens and Turbopurge technology allow for rapid OTR testing of multiple bottles. Systech Illinois' scientists can aid in developing an 8700 test protocol to create an industry-leading, high-throughput OTR analysis system for QA/QC of beverage bottles.

www.industrialphysics.com

Authored by Michelle Stevens, a 24-year veteran and globally recognised technical expert in the barrier packaging industry. Michelle has spent her career working for and consulting with many major companies and trade and testing organisations throughout the industry. For the last three years she has lent her expertise exclusively to the technical and sales teams at Systech Illinois. Systech Illinois is an Industrial Physics brand.