Application Note

Avoiding Discolored Plastic

with In-line Oxygen Measurement

Background

Polyethylene terephthalate (PET) is one of the most abundantly used polymers making up 18 % of the world's polymer production. Its versatile nature allows for an extensive range of bulk applications as well as niche products. Common uses include fibers, beverage bottles and building materials.

The key to its versatility comes from its repeating molecular makeup: its long chains of ethylene terephthalate. This accounts for its chemical inertness and ability to be crystalized or made into an amorphous glass-like material, depending on the chosen polymerization process. Further modifications can be made through strict control of the polymer chain length, degree of cross-linking between the chains, addition of modifying agents, and heat treatments. Thus strict reaction and process control is required to produce the specific characterizations for the desired application.

Process

The two chief routes for PET production are through transesterification and direct esterification. In transesterification, dimethyl terephthalate (DMT) and a catalyst are heated to a reaction temperature of 125–220 °C in a closed vessel. Since water is a by-product and the reaction is reversible, constant removal of the water is required and can be accomplished by vacuum, inert gas or inert solvent. For direct esterification, raw material for PET is chiefly terephthalic acid synthesized from crude oil-based paraxylene, along with ethylene glycol. The reaction is performed under a pressure of 2.7–5.5 bar at 220–260 °C without the need

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for a catalyst. This reaction also requires continuous removal of water due to the equilibrium shift. After the reaction is completed to the desired molecular weight, the remaining solvents and precursors are removed in a drying step. The resulting polymer can be spun into fiber or pelleted into small solids.

In both methods, and throughout production steps, the materials must be under oxygen-free, inert conditions. Oxidations, which can occur throughout production, will interrupt the polymerization as well as produce undesired color changes. Yellowing, which can occur at higher temperatures, is a serious problem as it will render the product unacceptable for white or clear applications. Further, in spinning, pelleting and hopper storage, yellowing can still occur, so it is important to keep all headspaces oxygen free.

InPro 6950i G amperometric gas sensor
- Trace gas measurement ability down to 5 ppm
- Long lasting and easy to maintain membranes
- ISM predictive diagnostics

M400 2-wire transmitter
- Loop powered multi-parameter transmitter
- Full ISM compatibility
- cFMus / ATEX / NEPSI Ex-approved for hazardous areas

InTrac 781 retractable housing with flushing chamber
- Intelligent sensor locking system
- Pneumatic or manual operation
- Available in stainless steel, Hastelloy™, PP, PVDF and PEEK

Analysis of oxygen levels in production and storage vessels are therefore required, and this is best achieved with in-line measurement systems giving continuous measurements. These provide real-time values of oxygen in the vessels and do not require sampling systems. The in-line sensors must be able to provide precise and accurate readings at very low levels of oxygen.

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The InPro® 6950i G is an amperometric-type trace oxygen probe which has the ability to detect down to 5 ppm oxygen in the vessels and process pipes of PET production. With a real-time response even small increases in oxygen can be detected quickly, allowing rapid remedial action. A METTLER TOLEDO M400 2-wire transmitter completes the measurement loop for integration into any control environment.

Diagnostics of sensor health are available from the InPro 6950i G's Intelligent Sensor Management (ISM®) technology. ISM probes feature a Dynamic Lifetime Indicator (DLI) to show the sensor's remaining lifetime. The DLI changes according to the measurement conditions and displays on the connected transmitter a value in days before sensor replacement will be required. Further, the Time To Maintenance tool and Active Calibration Timer show how many days until servicing will be needed.

For ease of cleaning, an InTrac® 781 retractable housing is used. It includes a flushing chamber for rinsing any potential fouling build-up on the sensor. This ensures consistent performance without process interruption.

For more information, visit:
- **www.mt.com/InPro6950**
- **www.mt.com/M400**
- **www.mt.com/InTrac781**

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