Application Note AN-PAN-1051

Inline process monitoring of the moisture content in propylene oxide

Propylene oxide (C_3H_6O, PO) is a major industrial product with a global production of more than 11 million tons [1]. PO is mostly produced to make polyether polyols, propylene glycol, propylene glycol ether solvents, and other products.

There are several production processes available, however the majority of PO is still co-produced along with styrene monomer (approximately one-third of PO production worldwide). Other PO production routes include the chlorohydrin process, epoxidation of propylene with hydrogen peroxide, epoxidation of propylene with organic peroxides, and even epoxidation using molten salts.

This Process Application Note presents a method to closely monitor in «real time» low levels of moisture in PO safely, reliably, and optimally. Due to the hazardous and hygroscopic nature of PO, a single explosion-proof inline process analyzer is the preferred solution to reduce chemical treatment, improve product quality, and increase profits.

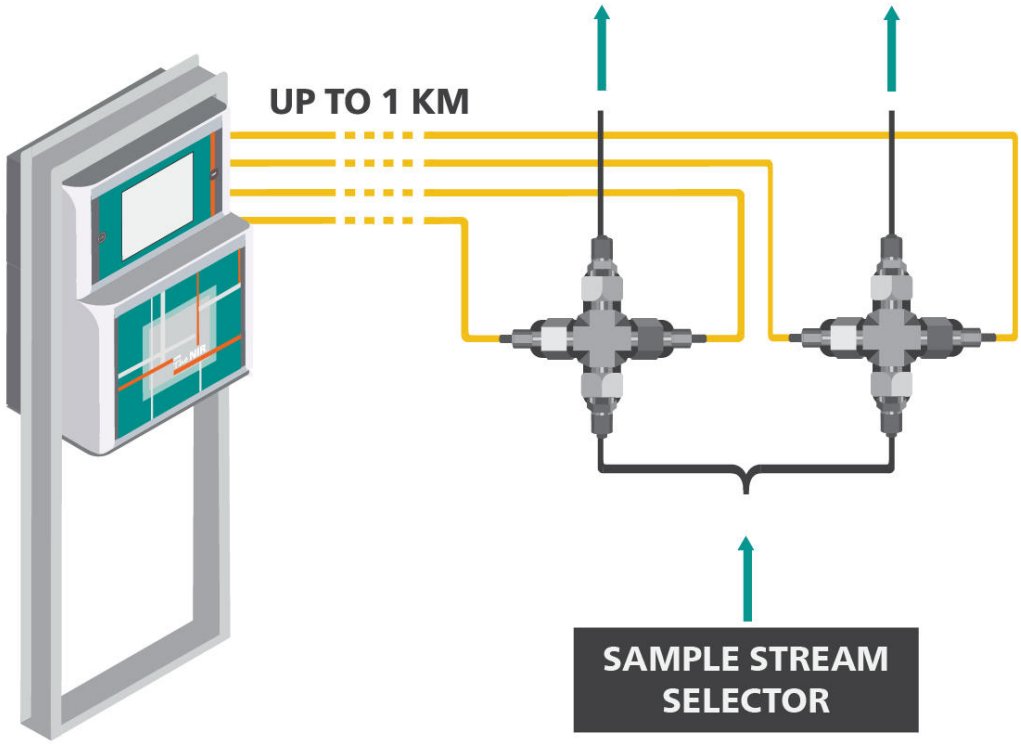
INTRODUCTION

PO is a highly hazardous, flammable, and hygroscopic substance, and therefore needs to be handled with extreme caution. Tight control over moisture and other impurities in the final product (as well as along the manufacturing process at critical points) is necessary to overcome unwanted side reactions or poor yields.

Manual laboratory methods can be quite cumbersome and can introduce bias depending on the analyst. Additionally, the hygroscopic nature of PO necessitates inline or online analysis of water content for the most precise results. «Real-time» analysis is a requisite for high throughput PO production because this gives short response times in case of process changes or increased water content in the final product.

Safe analysis of low moisture content in PO is possible with reagent-free techniques such as near-infrared spectroscopy (NIRS). Suitable NIRS process analyzers are available for use in hazardous environments with robust stainless steel flow cells (Figure 1a). Metrohm NIRS process analyzers enable comparison of «real-time» spectral data from the process to the primary method (titration) to create a simple, yet indispensable model for the PO production process.

a)



b)

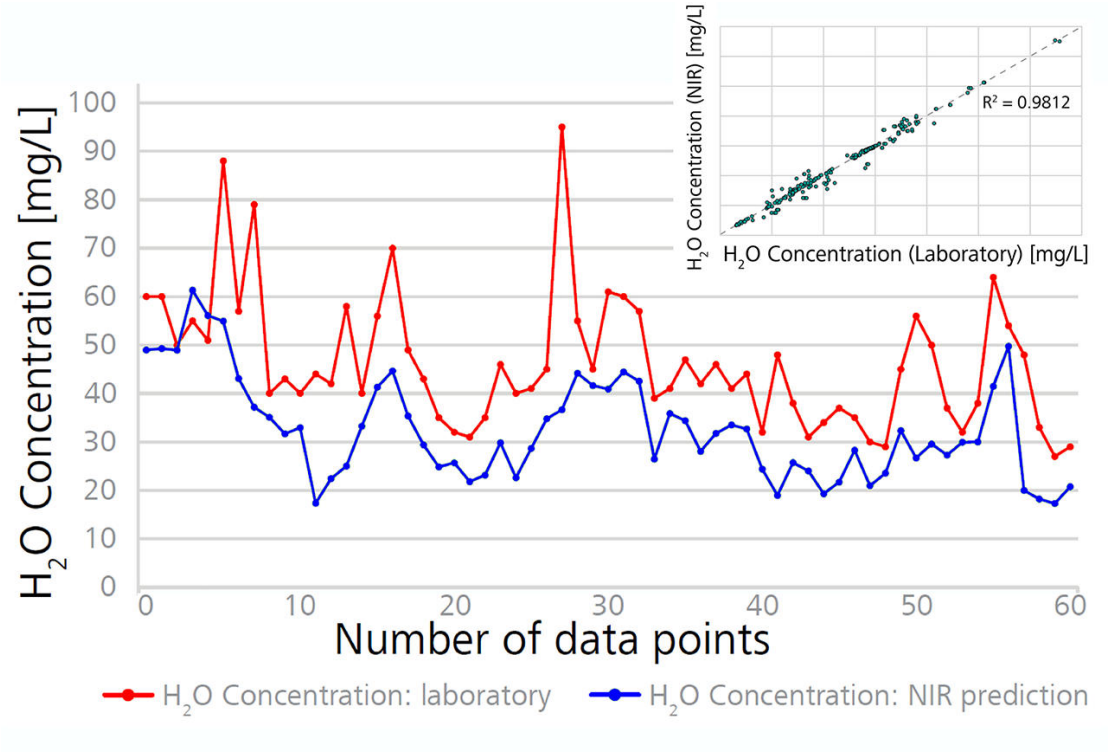


Figure 1. (a) NIRS system configuration for online analysis of water content in PO streams. (b) Validation of the NIR process data by laboratory Karl Fischer (KF) titration; inset shows enclosed NIR calibration model for predicting water concentration in propylene oxide process streams. All figures were adapted from GIT Labor-Fachzeitschrift article [2].

APPLICATION

Wavelength range used: 1850–1950 nm. Stainless steel flow cells were used for online measurements. Explosion-proof process analyzers are recommended for hazardous areas such as these.

Table 1. Typical water concentration range in PO according to ASTM guidelines

Component	Range (mg/L)
Water	20–30

REMARKS

A reference method (i.e., Karl Fischer titration) (Figure 1b) is mandatory to build the NIRS prediction models. Measurements performed in the laboratory showed higher water content values than those predicted via online NIRS. By the time the KF titration was performed in the lab, the PO samples had absorbed atmospheric moisture and were no longer completely representative of the actual process conditions. Therefore, online KF titration was used to build more accurate prediction models.

Table 2. Dedicated NIRS sampling solutions offered by Metrohm Process Analytics.

	Specification	Measurement principle	Fiber type	Connection	Process measurement
Flow cell	Fixed pathlength 2 mm SS316	Transmission	Single	Swagelok	Online
	Variable pathlength 0.5–12 mm	Transmission	Single	Swagelok	Online
	PTFE Flow-through cell	Transmission	Single	Swagelok	Online

CONCLUSION

The utilization of a single, explosion-proof online process analyzer for moisture analysis in propylene oxide enables the reduction of chemical treatment, improves product quality, and increases profits. Gain more control over propylene oxide production with a Metrohm Process Analytics 2060 *The* NIR Analyzer system configured for applications in hazardous areas. These analyzers can monitor up to five process points per NIR cabinet with the multiplexer option, facilitating increased sampling points and enabling the measurement of additional parameters like hydroxyl number.

RELATED PROCESS APPLICATION NOTES

AN-PAN-1007 Online analysis of peroxide in the HP-PO process

AN-PAN-1047 Inline monitoring of water content in naphtha fractions by NIRS

OTHER RELATED DOCUMENTS

WP-023 Karl Fischer titration and near-infrared spectroscopy in perfect synergy

8.000.5325 Water Content Analysis

BENEFITS FOR NIRS IN THE PO PROCESS

- **Optimize product quality** and increase profit with faster response time to process deviations
- Greater and faster **return on investment (ROI)**
- **No manual sampling needed**, thus less exposure of personnel to dangerous chemicals

REFERENCES

1. *Propylene Oxide Market Size, Growth, Share & Forecast, 2032*. https://www.chemanalyst.com/industry-report/propylene-oxide-po-market-755 (accessed 2023-09-28).
2. Kleimeier. Nahinfrarotspektroskopie Produktionsprozesse Unter Der Lupe. *GIT Labor-Fachzeitschrift* **2018**, 36–38.

CONTACT

Metrohm Portugal
R. Frei Luis de Granada 14G
1500-680 Lisboa
vendas@metrohm.pt