Hottot et al. compared five different types of sensors for the detection of the sublimation endpoint in syringe configuration [6]. Results showed that the Lyotrack and Pirani sensors provided similar results, with clear and precise sublimation endpoint determination. The Lyotrack sensor gave better signal-to-noise ratio than the Pirani gauge, which is possibly due to the signal disruption to Pirani caused by air injection for pressure regulation.

De Beer et al. simultaneously implemented four newly introduced PAT tools to monitor freeze-drying processes [2]. It was found that a combination of Raman and Lyotrack allows the monitoring of nearly all critical process aspects. Raman spectroscopy can give insight into the product behavior during freezing stage and also the bound water removal dynamics during secondary drying, whereas plasma emission spectroscopy gives information about the drying process.

The Lyotrack is simple to integrate into a lyophilizer via a tri-clamp flange due to its portable nature. Also, it is steam-sterilizable thanks to its durable construction. However, it also has some limitations. The humidity signal from the Lyotrack ranges between 0 (no water vapor) and 1 (saturated with water vapor), and it is difficult to transform this qualitative value into a measure of water quantity. In addition, Lyotrack involves ionization of the gas present in the chamber and the formation of free radical, and there is a potential risk to the stability of the freeze-dried product. In a recent study, oxidation of human growth hormone (HGH) was found to be significantly increased (about 12%) upon using Lyotrack in the drying chamber to freeze-dry HGH and HGH/sucrose formulations [20]. Thus, this technology could compromise the product quality of a molecule which is sensitive to oxidation. Moreover, Lyotrack is relatively expensive as compared to a Pirani gauge, and both sensors give very similar gas composition profiles, therefore, there is no strong advantage of using Lyotrack instead of the Pirani gauge for the primary drying endpoint determination.

Near-Infrared Spectroscopy

NIR is an effective tool for the understanding of the lyophilization process and evaluation of lyophilized pharmaceuticals. The NIR spectrum has a frequency range from 4000 to 12,500 cm^{-1} (800–2500 nm), and is highly sensitive to vibrational motions of the hydrogen atom in different molecular environments. Due to its ability to penetrate glass and plastic containers, NIR spectroscopy can also be used as a fast and noninvasive method to monitor the lyophilized product [1]. NIR has been not only used to determine the residual moisture in lyophilized samples but also evaluated for in-line process monitoring during freezing and drying stages. In addition, it offers many unique advantages such as the monitoring of protein conformational change and excipient morphology conversion during the drying process. NIR can therefore be a valuable tool for speeding the development of formulations and lyophilization process.