AlteTube™

Technical Note: Use of AlteTubes in Cryogenic Storage

Introduction

This technical note provides guidance on the recommended use of AlteTubes in cryopreservation workflows.

Since the 1950s, liquid nitrogen (LN2) has been the gold standard for the long-term preservation of biological materials. Early cryogenic practices often relied on direct immersion in liquid-phase nitrogen. However, advances in cryogenic freezer technology now enable uniform storage under vapor-phase conditions above the liquid.

AlteTubes are specifically designed and validated for use in vapor-phase LN2 storage systems. This document outlines the scientific rationale for this recommendation and highlights the risks associated with liquid-phase storage.

Cryogenic Storage and the Glass Transition Temperature (Tg)

The long-term stability of biological materials depends on storing them below the glass transition temperature (Tg) of water, approximately –132 °C.

- Above Tg (e.g., –80 °C freezers): Metabolic activity is slowed but not eliminated, and ice formation may still occur, leading to structural and chemical damage to cells.

- Below Tg (e.g., vapor-phase liquid nitrogen at –150 °C to –196 °C): All metabolic activity ceases, ice crystal growth is prevented, and a safe, stable preservation environment is maintained.

Liquid nitrogen, with a boiling point of –196 °C, provides a ~64 °C safety margin below Tg, ensuring reliable long-term sample integrity.

Material Suitability of AlteTubes

AlteTubes (manufactured from virgin polypropylene) are validated for use across a temperature range of –196 °C to +100 °C. In practice, they are routinely employed in cryogenic applications under vapor-phase LN2 conditions (–150 °C to –196 °C, depending on freezer design and the tube's position relative to the liquid reservoir).

Risks Associated with Direct Immersion in Liquid-Phase LN2

While liquid-phase LN2 provides ultra-low temperatures, several risks are inherent to direct sample immersion:

1. Flooding and Leakage

- LN2 can infiltrate tubes if caps are not perfectly sealed.
- Upon warming to room temperature, trapped LN2 expands rapidly, creating a serious tube explosion hazard.

2. Cross-Contamination

- Published studies have shown that viruses and other biological contaminants can remain infectious in LN2.
- If LN2 enters tubes, the likelihood of cross-contamination between samples increases significantly.

3. No Absolute Seal Guarantee

- No tube manufacturer can guarantee complete exclusion of LN2 under immersion conditions.
- The risk of LN2ingress, and its associated hazards, can therefore never be fully eliminated.

Recommendation

For safety, reliability, and optimal sample integrity, AlteTubes should be stored exclusively in vapor-phase liquid nitrogen (LN2) freezers. Vapor-phase LN2 maintains temperatures well below the glass transition threshold of water (–132 °C), ensuring long-term biological stability, while eliminating the explosion and contamination risks associated with direct liquid-phase storage.

References

Kapoore, R.V., Huete-Ortega, M., Day, J.G. et al. (2019). Effects of cryopreservation on viability and functional stability of an industrially relevant alga. Scientific Reports, 9:2093. https://doi.org/10.1038/s41598-019-38588-6.