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Lab & Production Materials

Application Note

Redi-Dri™ Packaging for Consistent Free-Flow in Hygroscopic Salts

Introduction

Hygroscopic anhydrous inorganic salts are widely used in precision driven workflows, including pharmaceutical synthesis, semiconductor processing, and battery material preparation, where control of moisture during storage is relevant to material handling. Many inorganic salts readily absorb atmospheric moisture, leading to increased water content and, over time, clumping and reduced flowability. These changes can affect routine operations such as weighing, transfer, and dispensing under ambient storage conditions.

Maintaining controlled moisture levels during storage is essential to preserve the salts' free-flowing properties, chemical integrity, and purity. Redi-Dri™ packaging is designed to reduce moisture exposure during storage of hygroscopic salts used in moisture sensitive workflows.

Impact of Moisture on Hygroscopic Salt Flow

Moisture exposure can influence the handling and flow behaviour of hygroscopic anhydrous salts used in moisture sensitive workflows. Even trace levels of water may promote hydrolysis in catalytic reactions or compromise precursor integrity during Chemical Vapor Deposition (CVD) and Atomic Layer Deposition (ALD). In applications such as catalytic processes and semiconductor deposition workflows, unintended moisture uptake may also contribute to variability in precursor behaviour during handling prior to use.

Many commonly used inorganic salts, including magnesium chloride and lithium chloride, readily absorb moisture during storage. Continued moisture uptake can increase interparticle interactions, leading to agglomeration, reduced flowability, and variability during weighing, transfer, and dispensing under ambient storage conditions.

Redi-Dri™ packaging is designed to reduce moisture uptake in hygroscopic salts by providing controlled storage conditions within the container. Maintaining low moisture levels, as quantified by Karl Fischer titration, is associated with stable handling behavior during weighing, transfer, and dispensing under the evaluated conditions.

Time-Lapse Study: Moisture Absorption in Salts with Redi-Dri™ Packaging

To assess moisture uptake over time, a controlled time lapse storage study was conducted in which moisture content was measured at predefined intervals using Karl Fischer (KF) titration. Samples packaged with Redi-Dri™ sheets and samples in standard packaging were exposed to a controlled high humidity environment (>75 ±5% relative humidity) to simulate challenging storage conditions.

Moisture content was monitored through monthly KF titration and visual inspection over a 12 month period. Salts stored with Redi-Dri™ packaging maintained low moisture levels and remained free flowing throughout the study duration, while samples stored in standard packaging exhibited progressive moisture uptake accompanied by visible agglomeration within two months.

Anhydrous lithium sulfate (99.5% trace metals basis) was evaluated as a representative hygroscopic salt under these conditions. Identical sample quantities were stored in standard and Redi-Dri™ packaging and analysed at regular intervals, as shown in **Figure 1**.

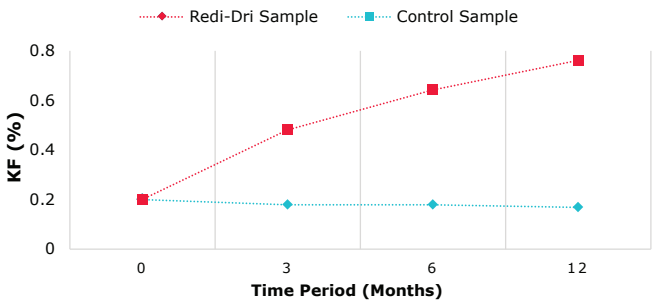

Figure 1. Karl Fischer moisture content (%) of anhydrous lithium sulfate (99.5% trace metals basis) during 12 month storage under high humidity conditions (>75 ±5% RH), comparing Redi-Dri™ and standard packaging.

The Redi-Dri™ sample maintains consistently low moisture content with minimal variation over time, while the control sample shows a steady increase in moisture content, consistent with progressive moisture uptake during storage.

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The time lapse storage study revealed distinct differences in moisture uptake between hygroscopic salts stored in Redi-Dri™ packaging and those stored in standard packaging. Over the 12 month study period, samples stored with Redi-Dri™ packaging maintained low moisture content and remained free flowing, with no observable agglomeration.

In contrast, samples stored in standard packaging showed progressive moisture uptake accompanied by agglomeration within two months, resulting in reduced flowability and increased variability during routine handling operations such as weighing, transfer, and dispensing.

Quantitative Results

- **Sample with Redi-Dri™ Packaging:** Moisture content decreased from 0.20% to 0.17% over 12 months, indicating controlled moisture levels under the tested storage conditions.
- **Sample without Redi-Dri™ packaging:** Moisture content increased from 0.20% to 0.76% over the same period, consistent with progressive moisture uptake in unprotected hygroscopic inorganic salts.

These results demonstrate that traditional packaging conditions using Redi-Dri™ support sustained low moisture content and stable handling properties for moisture sensitive inorganic salts used in energy storage and semiconductor related workflows.

ICP-MS/OES Verified Long-Term Trace Metals Purity

In applications involving hygroscopic inorganic salts, changes in trace metal impurity levels during storage may influence material consistency and reproducibility. Trace metal impurities are therefore monitored to ensure that storage conditions and packaging systems do not introduce contamination or alter impurity profiles over time. Analytical techniques such as Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) are commonly used for this purpose due to their sensitivity and multi element capability.

To evaluate trace metal impurity stability during storage, samples packaged with Redi-Dri™ sheets and samples stored in standard packaging were analysed at predefined intervals, including Day 0 (baseline), Day 90, Day 180, Day 270, and Day 365. Samples were stored under controlled conditions representative of typical storage environments.

Across the monitored storage period, ICP-MS analysis showed no increases in trace metal impurity levels consistent with leaching, adsorption, or other interactions between the packaging components and the stored material. As shown in **Figure 2**, ICP-MS analysis of anhydrous lithium sulfate (99.5% trace metals basis; Trace Metal Analysis <5000 ppm) was performed to monitor trace metal impurities during storage over a 12 month period.

The data compare samples stored with Redi-Dri™ packaging to control samples stored without the Redi-Dri™ sheet. Analysis of a 32 element panel showed less than 2% variation in measured impurity levels over time, indicating stable trace metal profiles throughout the study duration under the evaluated storage conditions.

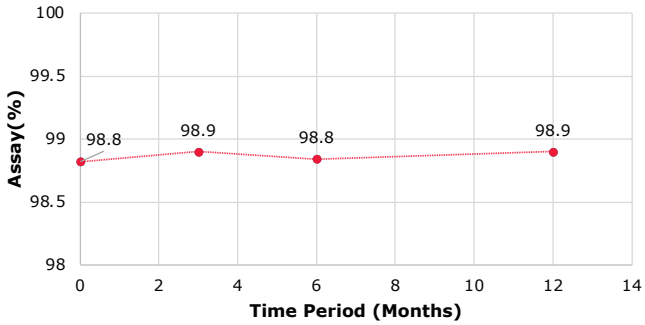

Figure 2. Trace metal impurity levels measured by ICP-MS for anhydrous lithium sulfate (99.5% trace metals basis; <5000 ppm) during 12 month storage, comparing Redi-Dri™ and standard packaging.

Assay Stability

Assay values were monitored over the storage period to evaluate whether prolonged moisture exposure and storage conditions led to measurable chemical degradation or impurity formation. Assay stability serves as an indicator of chemical integrity, particularly for hygroscopic inorganic salts that may be susceptible to moisture induced reactions during storage.

As shown in **Figure 3**, assay measurements for anhydrous lithium sulfate (99.5% trace metals basis) remained stable over the 12 month storage period for samples stored with Redi-Dri™ packaging. No systematic decrease in assay values was observed when compared to baseline measurements, indicating the absence of measurable degradation under the tested conditions.

These observations suggest that controlled storage conditions maintained using Redi-Dri™ packaging support preservation of chemical assay values during extended storage, consistent with maintained material integrity for hygroscopic inorganic salts.

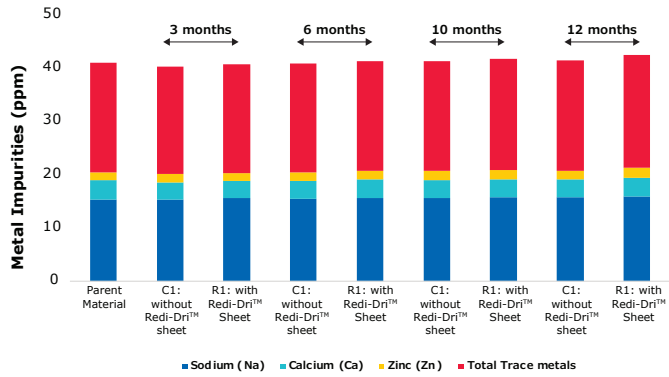

Figure 3. Assay values (%) of anhydrous lithium sulfate (99.5% trace metals basis) measured over 12 month storage, comparing Redi-Dri™ and standard packaging.

Conclusion

Hygroscopic anhydrous inorganic salts are susceptible to moisture uptake during storage, which can lead to changes in flow behavior, handling variability, and, in some cases, chemical or impurity related concerns. Over time, these effects may influence material consistency and reproducibility in applications such as pharmaceutical synthesis, semiconductor processing, and battery material preparation.

The findings below summarize the impact of controlled moisture conditions on the stability and handling behaviour of inorganic salts stored with Redi-Dri™ packaging.

Key Findings: using Redi-Dri™ packaging

- **Moisture control:** Karl Fischer titration performed under high humidity conditions (>75 ±5% RH) showed that salts stored with Redi-Dri™ packaging maintained low moisture content over the study period, with a measurable reduction in moisture content observed over time.
- **Assay stability:** Assay values remained stable over 12 months (**Figure 3**), with no measurable evidence of chemical degradation, hydrolysis, or impurity formation under the tested conditions.
- **Trace Metals Stability:** ICP-MS analysis across a 32 element panel showed less than 2% variation over 12 months, consistent with stable trace metal impurity profiles and no evidence of leaching or interaction between the packaging components and the stored material.
- **Visual Free-Flow Reliability:** Materials stored with Redi-Dri™ packaging remained free flowing and pourable throughout the 12 month storage period, with no visible agglomeration observed.

Overall, the observations indicate that controlled moisture conditions provided by Redi-Dri™ packaging support stable handling characteristics, preserved chemical integrity, and consistent trace metal impurity profiles in hygroscopic inorganic salts during storage. The combination of low moisture content, stable assay values, and unchanged trace metal levels corresponds to reduced clumping risk and maintained material quality over time, with relevance for moisture sensitive storage workflows used in pharmaceutical synthesis, semiconductor CVD/ALD precursor handling, and battery electrolyte preparation.

Related Products

Product No.	Product Name	Specification
944289	Magnesium chloride	Free-flowing, Redi-Dri™, ≥98%
944270	Lithium chloride	Anhydrous, free-flowing, Redi-Dri™, 99.95% trace metals basis
944246	Lithium chloride	Powder, free-flowing, Redi-Dri™, ≥99.98% trace metals basis
944262	Ammonium formate	Free-flowing, Redi-Dri™, ≥99.995% trace metals basis
946478	Lithium fluoride	Free-flowing, Redi-Dri™, ≥99.99% trace metals basis
946494	Lithium hydroxide	Free-flowing, Redi-Dri™, 99.9% trace metals basis
944378	Lithium sulfate	Anhydrous, free-flowing, Redi-Dri™, 99.5% trace metals basis
946435	Nickel (II) chloride	Free-flowing, Redi-Dri™, anhydrous, powder, 99.99% trace metals basis
944351	Cesium chloride	Free-flowing, Redi-Dri™, ≥99.999% trace metals basis
944335	Calcium fluoride	Anhydrous, powder, free-flowing, Redi-Dri™, 99.99% trace metals basis
946656	Iron (III) chloride	Free-flowing, Redi-Dri™, ≥99.9% trace metals basis
946664	Calcium chloride	Anhydrous, free-flowing, Redi-Dri™, 99.99% trace metals basis
947806*	Sodium carbonate	Anhydrous, free-flowing, Redi-Dri™, 99.999% trace metals basis

* Coming soon

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