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Trace element analysis of pegmatite lithium ores by GD-MS

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The lithium-ion battery (LIB) industry sources high purity lithium carbonate and lithium hydroxide from lithium-rich brines and "hard rock" lithium ore. Hard rock lithium is mainly found in spodumene and petalite – lithium-aluminum-silicates found in pegmatite deposits. As the world shifts to more sustainable and equitable mining, it is important to be able to differentiate among ore sources to ensure supply chain integrity. Different deposits have potentially unique ratios of trace element concentrations which can serve as "fingerprints" for source discrimination and traceability of lithium products. Furthermore, battery manufacturers are demanding increasingly stringent purity requirements for lithium carbonate and lithium hydroxide products manufactured from hard rock lithium. GDMS is positioned to expand the list of measurable trace impurities beyond the limited set traditionally measured by ICP-OES.

Typically, lithium ore is analyzed using one or more of the following approaches: ICP-OES, ICP-MS, and XRF. The major weakness of these techniques is sample preparation. It is time-consuming, has the potential to introduce contamination into the sample, and generates hazardous waste. XRF is widely used to analyze rocks and sediments but is unable to reach sub-ppm sensitivity.

Glow Discharge Mass Spectrometry (GDMS) is a solid-state sampling technique that is well-positioned to perform fast, reliable analysis of lithium ores and concentrates for trace element impurities. GDMS does not require sample prep and only uses a small amount (~10-20 mg) of material. It can analyze the full mass range – excluding H, C, N, O – and is able to reach sub-ppm sensitivity. While it is a semi-quantitative technique, we apply relative sensitivity factors (RSFs) to account for ion yields in the plasma, ensuring a more accurate concentration measurement. Semi-quantitative concentration data from techniques like XRF and LA-ICP-MS are widely used in geochemistry and archaeometry for source discrimination studies of geomaterials. GDMS is positioned to improve on this approach by utilizing oxide-specific RSF values to obtain more accurate concentrations.

We analyzed a suite of commercially available lithium ore standards from OREAS (OREAS 750, 751, 752, 753, 999) which were then processed into nanopowders by myStandards GmbH. We analyzed the powders using an Ametek Nu Instruments Astrum GDMS. Using an oxide RSF set developed in-house, we were able to obtain consistent results across multiple days of analysis. Out of 54 analyzed elements, including elements with indicative values, 10 were within 10% recovery, 19 were within 25% recovery, and 47 were within a factor of two of the certificates – the expected methodological precision range for GDMS. More importantly, the RSD of the measured elements across all 5 OREAS powders were generally better than 25%, with 45 of the 54 elements exhibiting less than 25% RSD variations between standard powders. This long-term consistency is vitally important when comparing element ratios for source discrimination and traceability.

GDMS is poised to provide a fast and reliable analytical solution to the increasing demand for traceability and purity requirements from LIB producers.