Direct Reaction Cell ICP-MS vs. XRF: Which is the Superior Technique for the Analysis of Water-Soluble and Total Elements in Fine Particulate Matter?

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Summary

State Implementation Plans (SIPs) will be developed to control fine particulate matter in consideration of the relative the contribution of a specific source or class of sources. It is likely that control strategies will not only be based on total concentration but that a significant amount of consideration will be placed on the composition of fine particulate matter and its relationship to adverse health affects. The White House Office of Management & Budget advised EPA to refocus its fine particulate research on health effects. OMB released the following statement, "If research can identify those particles most responsible for health risks, it may be possible to design controls that do more for public health and cost the economy less than would occur through policies that assume all particles are equally toxic." [1]

To meet these objectives, it is critical to select analytical techniques that can accurately determine and quantify the composition of fine particulate matter. The elemental composition of fine particulate matter is important. Historically, elemental analyses have been used to develop a profile or a fingerprint of a source(s). In addition, some of the transition metals have been the focus of much of the public health debate surrounding fine particulate matter. Determining elemental composition of fine particulate matter is complicated because the Federal Reference Method (FRM) used for sampling collects only microgram quantities of fine particulate matter. Therefore, it is absolutely essential that an elemental analysis technique with part-per-billion detection limits and excellent precision and accuracy be used.

X-ray fluorescence (XRF) is often used to determine the elemental composition of fine particulate matter because it is non-destructive, requires no sample preparation and provides excellent precision for higher concentration elements. However, the elemental sensitivity limitations of XRF are not compatible with the microgram quantities of fine particulate matter collected with the FRM. As a result, XRF can accurately determine only seven or eight of the more concentrated elements.

By contrast, Direct Reaction Cell (DRC) Inductively Coupled Plasma Mass Spectroscopy (ICP-MS) is a more suitable technique to accurately determine the elemental composition of fine particulate matter collected by FRM. Although it is a destructive technique, DRC ICP-MS provides much more elemental information about fine particulate matter than XRF. For example, the DRC ICP-MS sensitivity is sufficient to determine 21 elements with adequate precision and accuracy. In addition, the DRC ICP-MS offers more utility than XRF. It is not limited, like XRF, to analyzing only dry fine particulate matter filters and it can be used to accurately determine elements from a water-soluble leach of the fine particulate matter. This makes the DRC ICP-MS attractive for exposure and health-effects studies.

Results will be provided demonstrating the ability to analyze certified reference materials (e.g. NIST Standard Reference Materials) by DRC ICP-MS. In addition, the DRC ICP-MS and XRF results will be compared to results provided by a High Resolution ICP-MS.

[1] Graham, J.D., as quoted in Chemical & Engineering News, Government & Policy Concentrates, December 24, 2001, p.22.