

Simplifying Air Analysis Using an Ambient Ion Monitoring System

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Executive Summary

Studying the chemical composition and size distributions of particulate matter can help us understand the dynamics of air pollution, and ultimately lead to developing more effective methods for improving air quality. The Ambient Ion Monitor (AIM) system simultaneously measures the ionic composition of both particulate matter and gases. The AIM system is now controlled by a single software package: Thermo Scientific™ Dionex™ Chromeleon™ 7.2 Chromatography Data System (CDS) software. Users can easily interface instruments and review/process data via many of Chromeleon 7.2 CDS's powerful features, including ePanels, eWorkflows™, Report Designer, and Remote Management.

Keywords

Air Pollution, Particulate Matter, Ambient Ion Monitor, Chromeleon 7.2 CDS, ICS-1100, ICS-2100, URG-9000, Anions, Cations

The Importance of Air Analysis— The Ambient Ion Monitoring System

For several decades, the emission of particulate matter (PM) and gaseous pollutants has continuously increased due to growing populations, industrialization, and other human activities. Particulate matter is a complex mixture of tiny particles found in the air. Some particles are emitted directly, while others are formed in the atmosphere when pollutants react with each other. Particles vary in size, but are typically categorized into two groups. Those less than 10 μm in diameter are designated as PM 10, and are

considered “coarse” particles. They are small enough to enter the lungs unnoticed, potentially causing respiratory ailments such as lung cancer, aggravated asthma, and decreased lung function. Particles less than 2.5 μm in diameter are designated PM 2.5, PM 1, and PM 0.1, and are referred to as “fine” (PM 2.5, PM 1) and “ultrafine” (PM 0.1) particles. The smaller particle sizes are the focus of recent studies, and presently, neither PM 1, nor PM 0.1 is regulated. All three of these particle sizes have similar effects to PM 10, but are also likely to be responsible for an increase in cardiovascular diseases. The primary sources of fine particles include any type of combustion, including motor vehicles, power plants, residential wood burning, forest fires, agricultural burning, and industrial processes.



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This type of pollution must also be managed to help prevent unnecessary environmental damage. It can have dire effects on sensitive ecosystems, causing acidification of lakes and streams, which shifts the nutrient balance in coastal waters and river basins. This will, in turn, adversely affect wild flora and fauna, drinking water, crops, and food sources. Finally, there are the detrimental effects on the Earth's atmosphere, as particulate matter can scatter solar radiation and reduce visibility through the formation of haze and smog, and even affect precipitation.

Specifically designed to better facilitate this type of research, the AIM system simultaneously measures the ionic composition of particulate matter and gases, delivering time-resolved, direct measurements of numerous analytes, including nitrate, sulfate, nitrite, phosphate, chloride, and many other detrimental anionic and cationic species. The system itself consists of one URG-9000 series air sampler and one or two Thermo Scientific Dionex Ion Chromatography instruments, depending on the system model.

Used by a wide range of governmental agencies, universities, and other research groups, including the EPA, Florida's Department of Environmental Protection, and the Universities of Michigan and Wisconsin, the AIM system is a powerful tool for multi-ionic air pollutant monitoring and research of the health and environmental impacts of PM 1, 2.5, and 10.

Simplifying Air Analysis—Chromeleon 7.2 Chromatography Data System

To simplify air analysis using the AIM system, instrument control, data acquisition, and data analysis have now been consolidated into a single software package: Chromeleon 7.2 CDS software.

The four primary features found in Chromeleon 7.2 CDS software that enable much greater flexibility and automation of the air analysis workflow are:

- *ePanels* give real-time instrument and run status, last-injection and trending results, and allow direct control of connected instruments
- *eWorkflows* allow operators to start their runs with just a few mouse clicks
- *Report Designer* exports/prints all air analysis results and data trending, and allows operators to customize report templates according to their specific needs
- *Remote Monitoring* allows operators to view/analyze runs and the resulting data from anywhere in the world

Real-Time Instrument Control and Monitoring—ePanels

ePanels are the operator's direct interface with any instrument that is connected to Chromeleon 7.2 CDS software. They are designed to clearly present real-time readings and data, as well as provide full control of all connected instruments.

For the AIM system, there are two types of ePanels with which an operator will interface:

The first is the *URG-9000 Home ePanel* (Figure 1), which includes all controls and readings for the URG-9000, as well as the most frequently used controls and readings for each ion chromatography (IC) unit is a part of the configured AIM system. In addition, last-injection results or data trending are prominently displayed in the center of the screen, along with a real-time chromatogram display for each IC system.

The second is the *IC Device ePanel* (Figure 2), which displays all controls and readings for each individual IC instrument that is a part of the configured AIM system. This ePanel also includes the chromatogram that is generated for that instrument, as well as the audit trail for easy review of any changes made during the run. Depending on the AIM model, Chromeleon 7.2 CDS software will automatically display either one or two of these panels to correspond with the connected IC instruments.

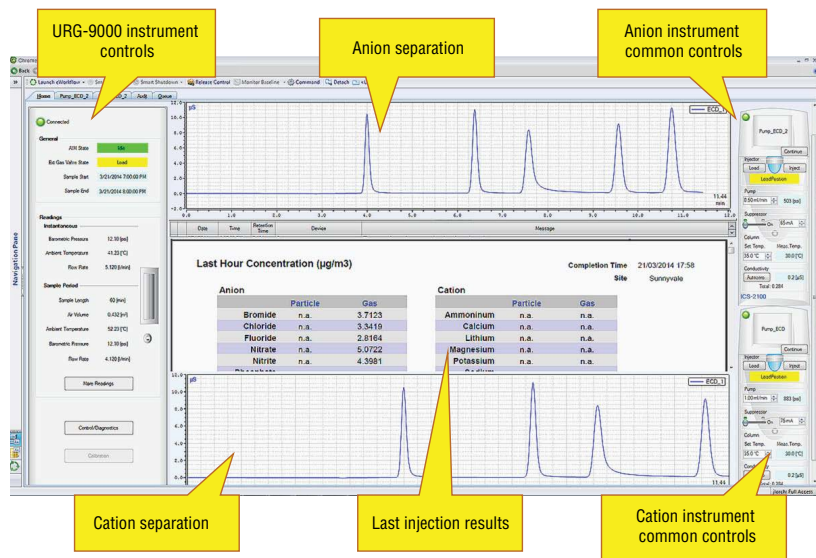


Figure 1. Home ePanel for the URG-9000D.

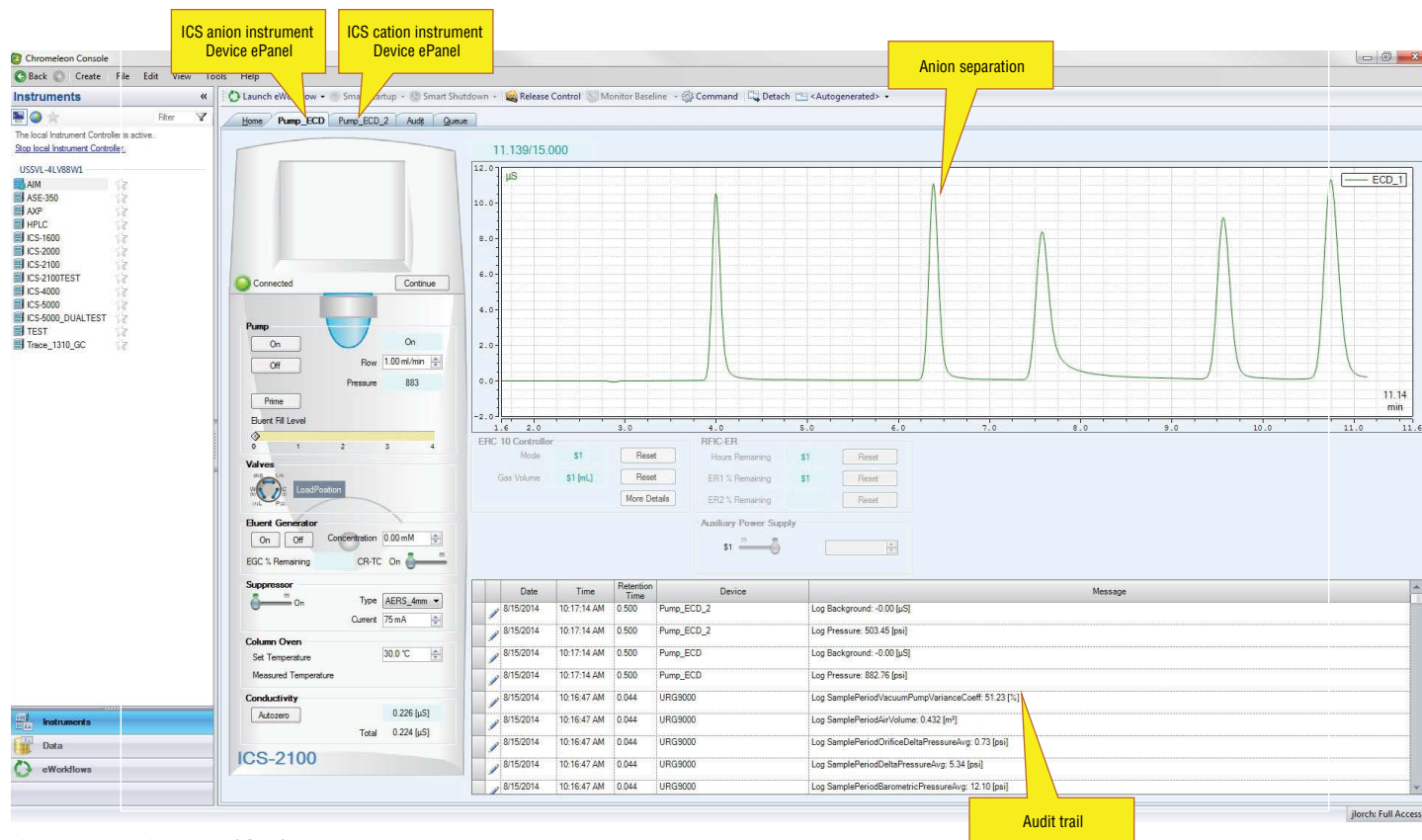


Figure 2. IC Device ePanel for the URG-9000D.

Automated Routine Analysis—eWorkflows

Chromeleon 7 CDS software provides a large step towards full automation of analytical runs via *eWorkflows*. Each acts as a template to create a complete sequence with predefined files and a well-defined structure. *eWorkflows* minimize the amount of training required to use Chromeleon 7 CDS software and help reduce the amount of work and time that operators must spend on routine air analysis. *eWorkflows* allow a user to start a two-week run with just a few mouse clicks: Select the *eWorkflow* and instrument, click Launch, and enter the number of samples to run (Figure 3).

As shown in Figure 4, the resulting sequence contains preconfigured instrument methods, processing methods, and report templates that all are specifically tailored to the configured AIM model. In addition, the sequence structure (e.g., alternating Gas and Particle injections) and properly assigned methods are automatically generated, requiring no input from the user beyond the number of samples to be analyzed. *eWorkflows* can be easily customized according to the specific needs of operators, applications and regulatory requirements.

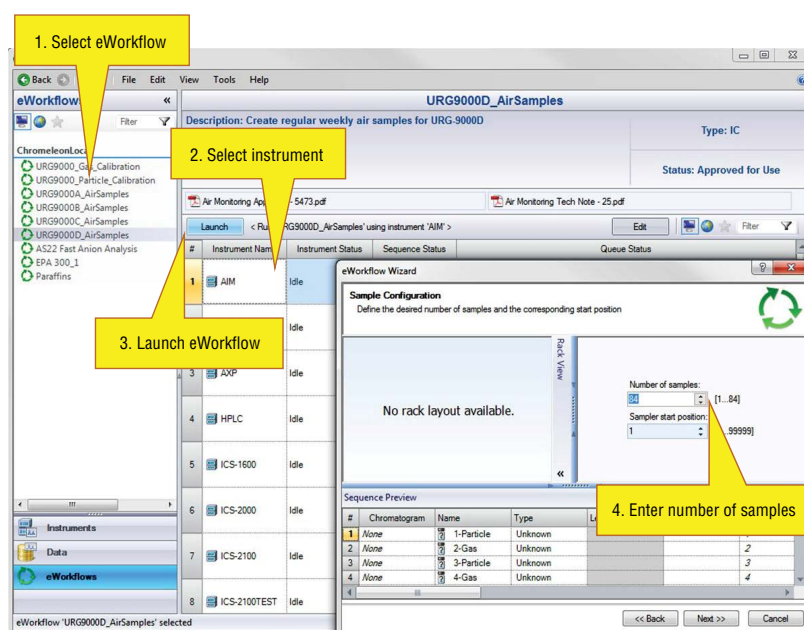


Figure 3. The URG-9000D *eWorkflow*.

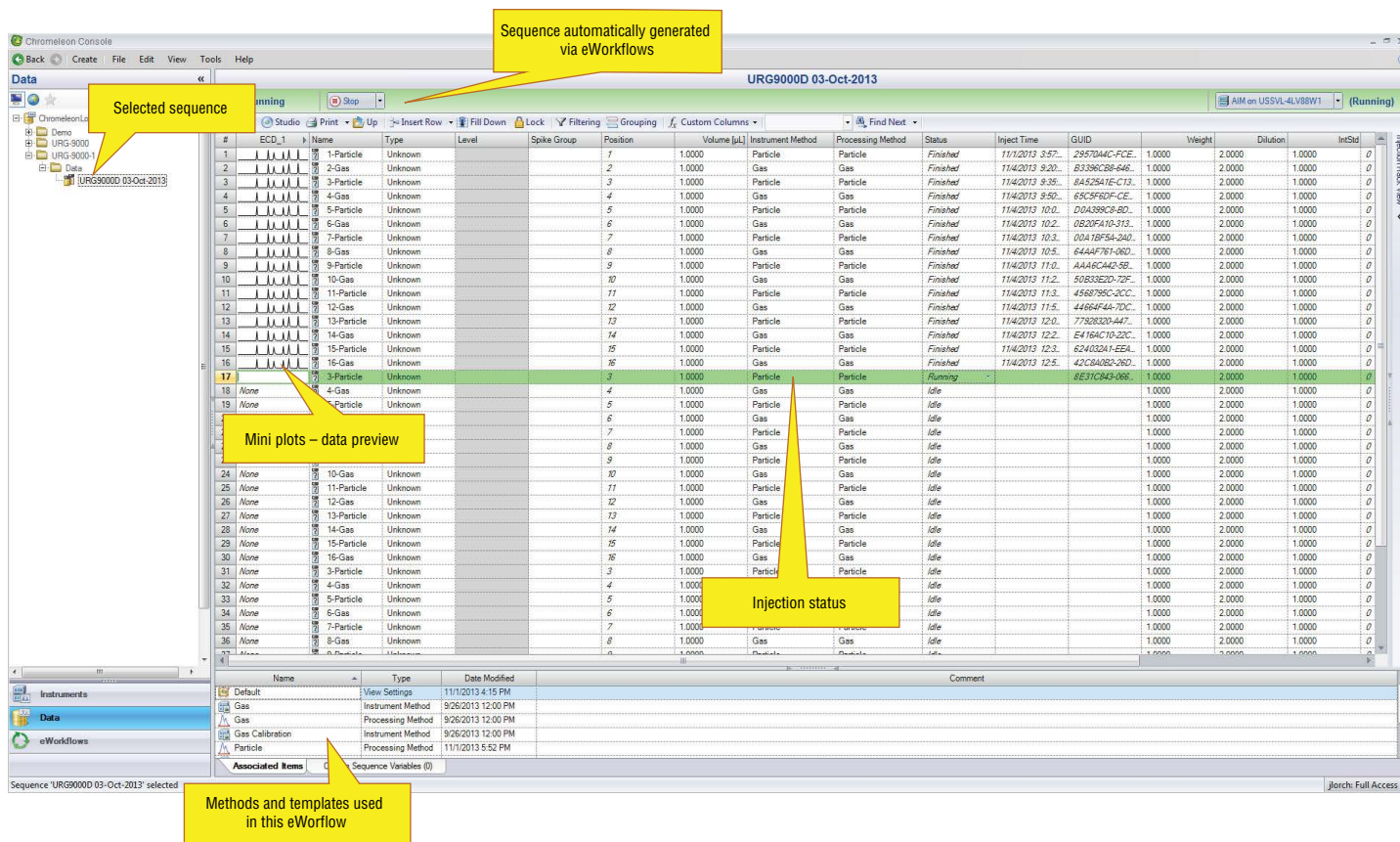


Figure 4. The URG-9000 eWorkflow automatically generates a sequence that is ready to be run.

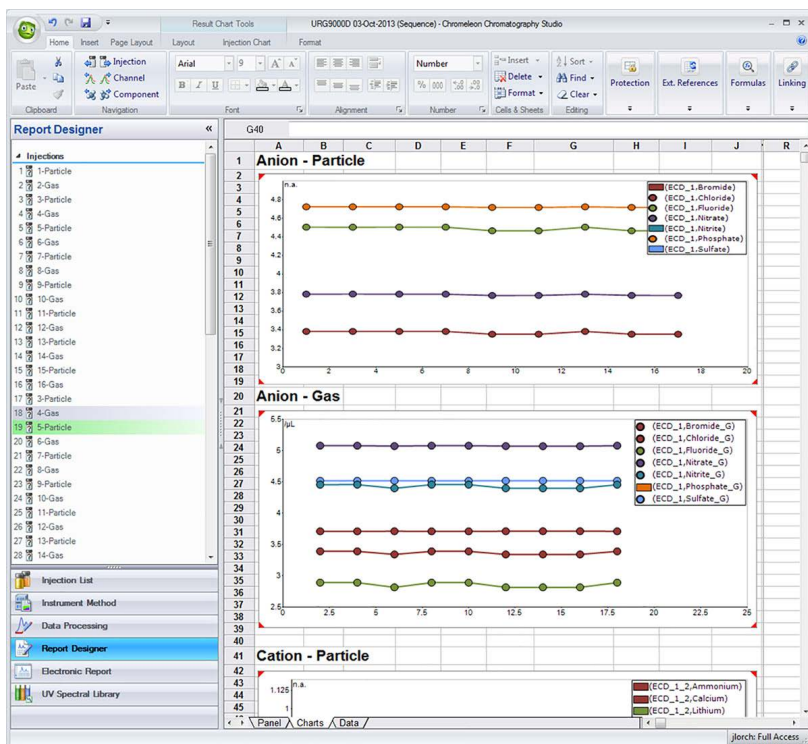


Figure 5. Report Designer automatically plots injection data trend lines.

Automated Report Generation—Report Designer Pro
Report templates, created in Report Designer, enable operators to display, export, and print data with minimal manual entry. Comprehensive data reports can be automatically retrieved after the completion of each sequence in both print and electronic formats.

The pre-loaded URG-9000 report templates are designed to display the data that most AIM customers require and, like eWorkflows, can easily be customized according to the operator's needs.

During the run, the reports show last-injection data in easy-to-read tables and automatically plot trend lines to help quickly reveal any changes in the concentration of ionic air pollutants over time, as shown in Figure 5.

Remote Management

To make collection and analysis of data from the AIM system even more convenient, Chromeleon 7 CDS software can remotely connect to any instrument in the field to directly control and monitor the status of one or more runs from a single location.

In addition, all data acquired at a remote site can also be collected to a centralized database, e.g., on a server at a company's main site, for immediate or future analysis. Given the data redundancies and power backup typically built into such systems, this adds another level of data security and eliminates the need to physically visit the remote site to retrieve the data.

Chromeleon 7 CDS software's unique Network Failure Protection feature also ensures that any issues with the network will not affect an ongoing run, even when started remotely, nor will it prevent a new local run from being started while the network is down. Once the network is restored, all data is automatically synchronized between the local installation and the main server.

Conclusion

With the significant increase of particulate and gaseous pollutants over the past decades, air analysis becomes ever more important. Because of this, tools, both hardware and software related, are required to help make the air analysis workflow easier and more efficient. Given the vast amounts of data collected, and the complexity of acquiring and reviewing such data, Chromeleon 7.2 CDS software and the AIM system offer unique features that help to streamline the entire workflow and simplify data analysis for faster, more accurate results.

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