Roundtable Session – Table 3 – Modernizing CE Workflows: Automation and Throughput

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Abstract:

Capillary electrophoresis (CE) continues to play a critical role across biopharmaceutical development, characterization, and quality-focused laboratory environments. However, many laboratories are experiencing increasing pressure to process more samples, shorten turnaround times, improve data traceability, and maximize utilization of skilled scientific staff. At the same time, advancements in laboratory automation, software platforms, instrument connectivity, and data management are creating new opportunities to modernize CE workflows.

This roundtable will explore how laboratories are approaching workflow modernization and where automation can deliver meaningful value. Topics will include automated sample handling, integration between analytical instruments and laboratory automation systems, digital workflow management, centralized data and user administration, and the evolving role of software in supporting scalable laboratory operations. Participants will be encouraged to share real-world experiences, challenges, and lessons learned from implementing automation initiatives across development, characterization, and quality-focused environments.

The discussion will focus on practical considerations rather than technology alone, including organizational readiness, return on investment, workflow bottlenecks, change management, regulatory expectations, and strategies for balancing flexibility with standardization. Attendees will leave with a broader understanding of how the industry is approaching modernization and what the next generation of CE workflows may look like.

Discussion Questions:

1. Where are the biggest bottlenecks in your CE workflows today, and what challenges have you encountered when attempting to automate them?

Is it sample preparation, instrument utilization, data review, reporting, scheduling, training, or something else? Why has that bottleneck been difficult to address?

2. When evaluating automation projects, what defines success in your organization?

Is success measured by throughput, analyst time savings, method consistency, data integrity, staffing efficiency, cost reduction, or other metrics? Where has automation delivered the least value in your workflow, and why?

3. What laboratory activities have you successfully automated, either within CE workflows or elsewhere in the laboratory? Looking ahead, what would you want to automate next if budget and technical constraints were removed?

What prevents that capability from being implemented today? Are the primary challenges related to sample preparation, reagent preparation, sample transfer, instrument integration, acquisition orchestration, data analysis, digital workflow management, software interoperability, validation requirements, or something else?

4. How flexible should automated CE workflows be?

Should automation solutions be designed around a limited set of standardized, high-throughput methods, or should they provide extensive customization to support diverse assays and evolving laboratory needs? How do laboratories balance flexibility with the robustness, scalability, and maintainability required for successful automation?

5. What will a highly modernized CE laboratory look like five years from now, and what role should vendors and technology partners play in enabling that future?

Will scientists primarily interact with instruments, software platforms, automation systems, AI-assisted workflows, or an integrated laboratory ecosystem? What capabilities, standards, integrations, or services do you expect vendors and third-party providers to deliver to accelerate laboratory modernization?

Notes:

The discussion focused on practical opportunities and barriers associated with modernizing capillary electrophoresis (CE) workflows on automation and throughput. Participants emphasized that successful automation requires more than instrument capability: workflows must also be standardized, supportable, connected across software platforms, and appropriate for the sample volume and assay complexity. The summary

below reflects the themes discussed and does not identify individual participants or their organizations.

1. Primary workflow needs and bottlenecks

• Sample preparation and reagent preparation were consistently identified as high-value targets for automation, including gel-based electrophoresis and CE-SDS workflows.

• Buffer exchange and sample concentration were discussed as examples of operations that could be automated either independently or as part of an integrated preparation workflow. One example involved processing multiple samples preparation at different settings in parallel for downstream CE-SDS analysis.

• Participants distinguished between full automation and semi-automation. The preferred level depends on assay demand, workflow maturity, sample volume, and the need for analyst intervention.

• Complex preparations remain difficult to automate when a single method requires multiple settings, variable liquid classes, viscosity-dependent handling, or assay-specific conditions.

• Inconsistent sample-submission containers and vial formats create avoidable challenges. Standardizing vial types and plate formats could simplify method development, transfer, and routine operation.

• For some low-throughput or highly variable workflows, automated preparation may take longer than manual pipetting. The benefit may instead come from freeing analysts to perform other work while the automated process runs.

2. Training, usability, and troubleshooting

• Ease of training is essential for adoption. Intuitive, guided preparation workflows may allow new users to become productive more quickly, but method setup and optimization still require specialized knowledge from trained personnel.

• Training must cover not only operation of liquid handlers and small-scale preparation systems, but also liquid behavior, viscosity, transfer accuracy, deck layout, and assay-specific exceptions.

• Troubleshooting remains a major barrier. Participants discussed the value of cameras, run monitoring, clear error messages, and traceable event logs to help identify failed transfers or other preparation issues.

• A dedicated automation configuration for a stable, routine assay may be easier to maintain than a single highly customized platform that changes frequently between methods.

3. Where automation is most likely to succeed

• Well-defined, repetitive, and standardized preparations were viewed as the strongest candidates for automation. Routine CE-SDS preparation was cited as an example.

• Automation is more difficult when stressed samples or changing modalities produce highly variable peak profiles that require different integration approaches.

• Successful implementation depends on understanding the complete workflow, including sample receipt, preparation, instrument loading, acquisition, processing, review, approval, reporting, and archival.

• A future-state concept discussed was end-to-end sample preparation in which source samples are prepared and then distributed into assay-specific plates for loading onto multiple analytical workflows.

• A successful non-CE example involving automated UV analysis illustrated that automation principles may be transferable across analytical technologies when workflows are sufficiently standardized.

4. Defining value and success

• Shorter turnaround time, reduced hands-on analyst time, improved consistency, and reliable automated data processing were identified as meaningful success measures.

• Throughput should be interpreted in the context of sample number demand. It varies based on how many samples are tested, whether and how the leadership support in individual organizations.

• Automation can still provide value when the automated step is not faster than manual execution, provided it creates unattended time, improves traceability and ergonomics, and/or reduces repetitive work.

• Return on investment should account for implementation effort, validation, maintenance, software updates, training, troubleshooting, consumables, and business continuity.

• Participants noted that organizations may be reluctant to fund comprehensive automation where there is limited redundancy, uncertain utilization, or no practical backup plan.

• The broader operating context includes pressure to reduce unnecessary testing and costs while maintaining compliance and delivering more with limited resources.

5. Data flow, software connectivity, and compliance

• The desired future state is an integrated data path from the instrument through processing, review, verification, reporting, and transfer to the laboratory data repository or information-management system.

• Current workflows may still require manual movement of CE data or results into electronic laboratory notebooks or other repositories, creating additional verification work and opportunities for error.

• Interoperability between automation platforms, analytical instruments, chromatography or electrophoresis data systems, laboratory information-management systems, and electronic notebooks remains inconsistent.

• Participants encouraged vendors to provide stable, well-documented interfaces and drivers that allow instruments and software from different suppliers to communicate reliably.

• Regulated environments require attention to GMP expectations, data integrity, validation, access controls, audit trails, and verification of automatically processed results.

6. Flexibility versus standardization

• Participants did not identify one ideal level of flexibility. Some workflows favor standardized, assay-specific systems, while others require configurable platforms that can support evolving methods.

• A practical implementation path may begin with a stable manual workflow, followed by selective automation after critical variables and failure modes are understood.

• Excessive customization can create maintenance and training burdens. Modularity, reusable methods, standardized labware, and controlled configuration changes may provide a better balance between flexibility and robustness.

• Custom fixtures and rapidly produced components, including 3D-printed parts where appropriate, were discussed as possible ways to address fit, positioning, or labware-handling gaps. Suitability and control would need to be evaluated for the intended environment.

• Laboratory automation layout, navigation, and ergonomics should be considered so that automation can be incorporated without unnecessary disruption between assays.

7. Artificial intelligence and advanced analytics

• AI-assisted tools may help scientists develop or troubleshoot automation scripts and could reduce the coding barrier for workflow configuration.

• Participants expressed interest in vendor-supported AI capabilities for data acquisition, peak integration, data analysis, and report generation across the full analytical workflow.

• AI-based analysis must accommodate modality-dependent changes in peak profiles, even when certain peak-shape characteristics remain similar.

• Key concerns include rapid model evolution, implementation cost, model training, lifecycle management, validation, change control, explainability, and continuity of support across technology generations.

• Human review remains important, particularly for atypical samples, changing peak patterns, and verification of automatically generated results.

8. Desired future state and vendor role

• The envisioned modern CE laboratory is an integrated ecosystem rather than a collection of isolated instruments. Sample preparation, scheduling, acquisition, processing, review, reporting, and data storage would be connected through coordinated digital workflows.

• Scientists would interact with both instruments and software, with routine operations increasingly orchestrated by automation while analysts focus on method understanding, exception handling, interpretation, and decision-making.

• Vendors and technology partners can accelerate modernization by prioritizing interoperability, open or well-supported interfaces, reliable drivers, standardized data exchange, long-term software support, and practical integration services.

• Participants also encouraged vendors to engage users early to understand whether customers need full automation, targeted semi-automation, or modular options that can expand as demand grows.