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Technical Report

Automated Gradient Optimization based on AI Algorithm for LC Method Development

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Abstract:

In the process of method development, gradient optimization doesn't only require creating a lot of analysis schedules but also require human intervention for exploring the optimal condition based on the analysis results. LabSolutions MD, a dedicated software for supporting method development, has a unique AI algorithm for automatic optimization of gradient conditions and by setting criteria of resolution, it automatically searches for the gradient condition that meets the criteria. In this article, a case study demonstrates the application of automatic optimization of gradient condition for the simultaneous analysis of catechins, theaflavins, and gallic acid (15 compounds).
Keywords: method development, gradient optimization, AI, automatic, LabSolutions MD

1. Background

In the typical LC method development, the process begins with "preparation" which includes mobile phase preparation, installing columns, and, creating analysis schedules, followed by running analysis. Then, the data is analyzed for the subsequent "preparation" and data acquisition. Method development is accomplished by repeating these processes over and over, but in addition to the massive amount of time required to repeatedly create analysis schedules, exploring the optimal condition based on the data analysis requires expertise in chromatography. In other words, typical method development requires "human intervention". Therefore, eliminating the involvement of human and automating such method development processes would be desirable to improve labor efficiency. LabSolutions MD has a unique AI algorithm to automatically optimize gradient conditions by repeating the process of "improvement gradient conditions by AI" and "correction analysis with improved condition". This enables anyone to explore the gradient conditions without "human intervention", leaving only the tasks of initial preparation of mobile phases and columns, and confirming the final result.

2. Automatic Optimization of Gradient Conditions by LabSolutions MD

Fig. 1 shows a comparison of the normal workflow of gradient optimization and automated workflow by AI algorithm of LabSolutions MD. The workflow of automatic optimization of gradient conditions consists of the following three phases.

1) Initial setting (① in Fig. 1)

2) Exploration of gradient conditions by AI (② in Fig. 1)

3) Determination of optimal condition (③ in Fig. 1)

In the "initial setting" phase, several gradient curves and the resolution criteria are set (Fig. 2 and 3). In the "exploration of gradient conditions by AI" phase, LabSolutions MD explores the gradient conditions to give better resolution based on the results from initial analysis (condition search and correction analysis in Fig. 1 ②). This process continues repeatedly until the resolution criteria is satisfied. In the "determination of optimal condition" phase, the gradient condition suggested by AI can be checked to sufficiently meet the criteria.

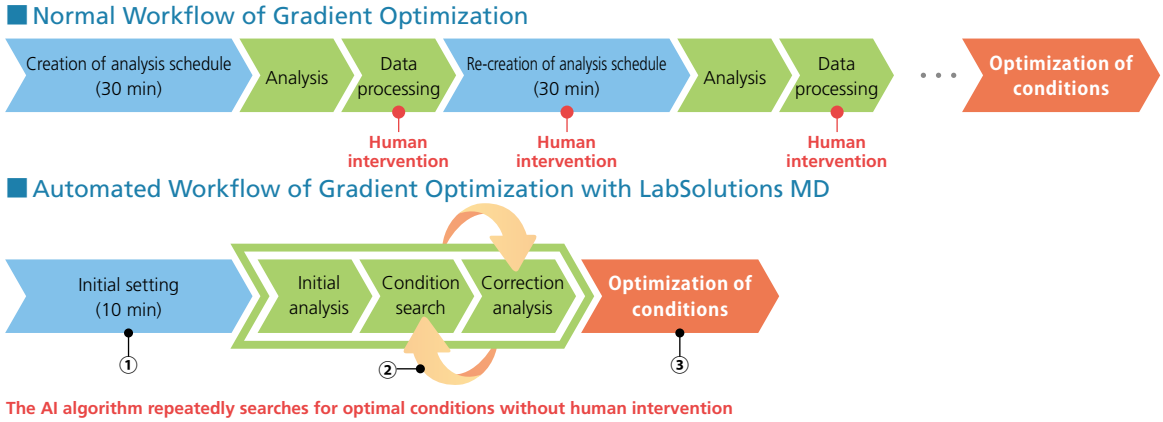

Fig. 1 Comparison of Normal Workflow and Automated Workflow with LabSolutions MD

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The advantages of using LabSolutions MD to automatically optimize gradient conditions are indicated below.

- Significant improvement of efficiency in the workflow of gradient optimization can be achieved without "human intervention".
- Anyone, regardless of experience in chromatography, can optimize gradient conditions by utilizing AI algorithm of LabSolutions MD.

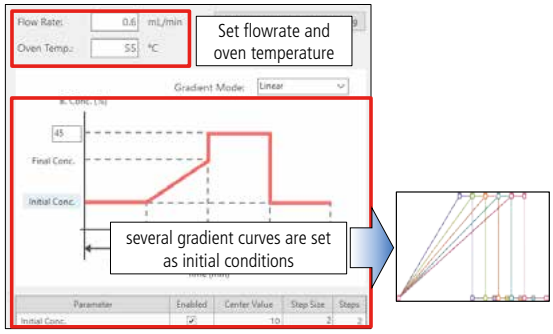

Fig. 2 Initial Setting for Gradient Optimization

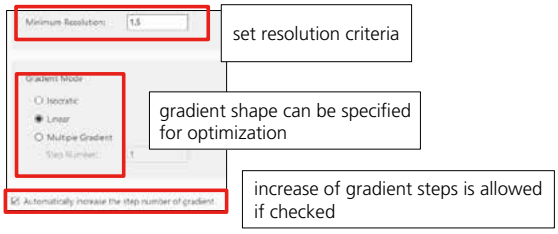

Fig. 3 Resolution Criteria Settings

3. Application to Functional Components in Foods

Fig. 4 shows an example of gradient optimization for simultaneous analysis of functional components in foods including catechins, theaflavins, and gallic acid (15 compounds). (Refer to Table 1 for analytical conditions.)

Table 1 Analytical Conditions

System : Nexera™ X3	
Sample : Catechin, Theaflavin and Gallic acid (15 compounds)	
C1) Gallocatechin	C8) Epicatechin gallate
C2) Epigallocatechin	C9) Catechin gallate
C3) Catechin	C10) Epicatechin 3-(3"-O-methyl) gallate
C4) Epicatechin	T1) Theaflavin
C5) Epigallocatechin gallate	T2) Theaflavin 3-gallate
C6) Gallocatechin gallate	T3) Theaflavin 3'-gallate
C7) Epigallocatechin 3-(3"-O-methyl)gallate	T4) Theaflavin 3,3'-digallate
	G1) Gallic acid
Mobile phase : Pump A : 0.2 % phosphoric acid in water Pump B : Acetonitrile	
Column : Shim-pack™ GISS C18 (100 mm × 3.0 mmI.D., 1.9 µm)*1 *1 227-30049-02 (Shimadzu GLC Part No.)	
Initial Settings :	
B Conc.	: 15 % (0 min) → 45 % (X min) → 15 % (X~X+5 min) *X = 6, 8, 10, 12, 14 (5 patterns)
Column Temp.	: 55 ℃
Flow rate	: 0.6 mL/min
Injection Vol.	: 5.0 µL
Detection	: Max plot 240-280 nm (SPD-M40, UHPLC cell)
Criteria of minimum resolution	: 1.5
Gradient shape for optimization	: Linear

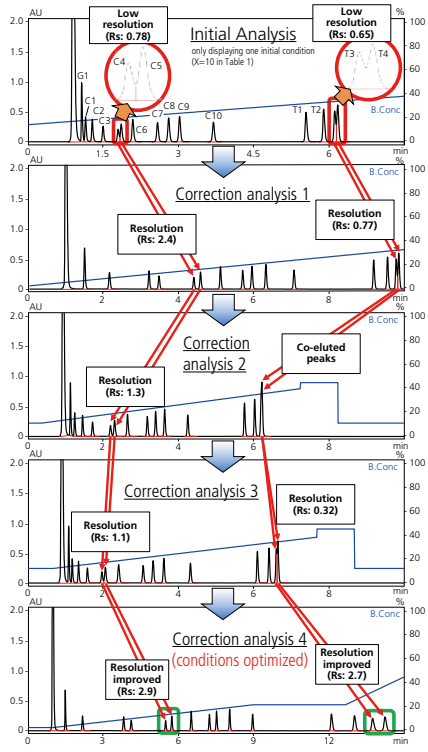

Fig. 4 Automatic Optimization of Gradient Conditions (blue lines show gradient curves)

The result of initial analysis shows the resolution between peaks C4 and C5 and between peaks T3 and T4 was not enough (shown in a red box at the top of Fig. 4). However, by using AI algorithm to repeatedly perform correction analyses, the gradient condition that satisfies the criterion (minimum resolution of 1.5) was finally discovered (shown in a green box at the bottom of Fig. 4). In this case, T3 and T4 were successfully separated by applying an isocratic elution after 9 minutes. Normally, exploring such gradient conditions requires human intervention for data analysis and knowledge about chromatography. In contrast, AI algorithm of LabSolutions MD enables anyone to easily find gradient conditions that satisfy specified criteria without relying on the intuition or experience.

4. Summary

When optimizing gradient conditions for method development, human intervention is normally required each time for creation of analysis schedules and data analysis. Therefore, automatic optimization of gradient conditions is in demand. LabSolutions MD, incorporated with unique AI algorithm, automatically explores gradient conditions that satisfy the resolution criteria, which can be expected to significantly improve the efficiency of method development.

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