Waters™

Note d'application

Automate Standard Preparations for Food Analyses – A Real-World Evaluation

Kai Liu, Ben Pointer, Jinchuan Yang, Nigel Skinner, Scott Toerber, Dennis Karote

Eurofins Nutrition Analysis Center, Waters Corporation

This is an Application Brief and does not contain a detailed Experimental section.

Abstract

Andrew+ and the cloud-native OneLab Software platform have been evaluated in our food analysis lab for routine liquid handling methods involving mixing and serial dilutions for sample preparation and standards. We found its performance is consistent with rigorous requirements in accuracy and precision in sample preparation. The accuracy of automated robot operation ranged from -2.8% to 3.0%, as compared to -5.0% to 4.2% by a human operator, enabling technical staff to be freed for higher level tasks, whilst ensuring full traceability and

reducing risk of repetitive strain injury and error.

Benefits

- Accuracy and precision of the Andrew+ Robot for solution preparation is equal or better than manual preparation
- Analysts were liberated from repetitive time-consuming operations, which leads to increased productivity and quality of analytical work
- Andrew+ and OneLab Software is easy to set up

Introduction

Sample preparation is often time consuming and tedious but is a critical step in many chemical analyses. It often comprises multiple steps, such as homogenization, dissolution, digestion, derivatization, extraction, concentration, dilution, or reconstitution, depending on the complexity of sample matrix and the target analytes' properties. Any error in this process will affect the results, and it is costly. Automation of these steps in sample preparation can reduce human error and improve the accuracy and precision of the analyses. Automation of the entire sample preparation workflow is challenging. However, part of the sample preparation process, such as the preparation of calibration standard solutions from standard stock solution, is relatively simple and relatively easy to automate.

There are several lab automation products on the market. Many of them are complicated, difficult to learn and use, and are space consuming. The Andrew+ Robot and cloud-native OneLab Software is a liquid-handling automation platform that is easy to set up and does not occupy much lab space. This application brief presents our extensive evaluation results of the Andrew+ Robot and OneLab Software for the preparation of standards and samples in a real-world situation. First-hand experience with this Andrew+ and OneLab Software for food testing will also be discussed.

Results and Discussion

The evaluation was focused on the automation of the simple operation in sample preparation, the serial dilution and mixing for the standard and sample solution preparation. The scope of the evaluation was designed to test with a wide range of assays for different analytes, involving different techniques and solvents. The analytes included salt or ion (sodium chloride), vitamins (retinol, vitamin D, folic acids), sugar (galactose), amino acids, and another nutrient (carnitine and choline). The analytical techniques that were involved included chromatography based techniques, such as ion chromatography-conductivity detection (IC-CD), liquid chromatography-fluorescence detection (LC-FLR), liquid chromatography-ultraviolet/visible spectrometry (LC-UV/Vis), liquid chromatography-tandem mass spectrometry (LC-MS/MS), and non-chromatography based techniques, such as electrochemical detection and microbiological-turbidity detection. The solvents included those common to food analytical labs, such as water, methanol, acetonitrile, and hexane. Hexane is a volatile solvent and is difficult to pipette.

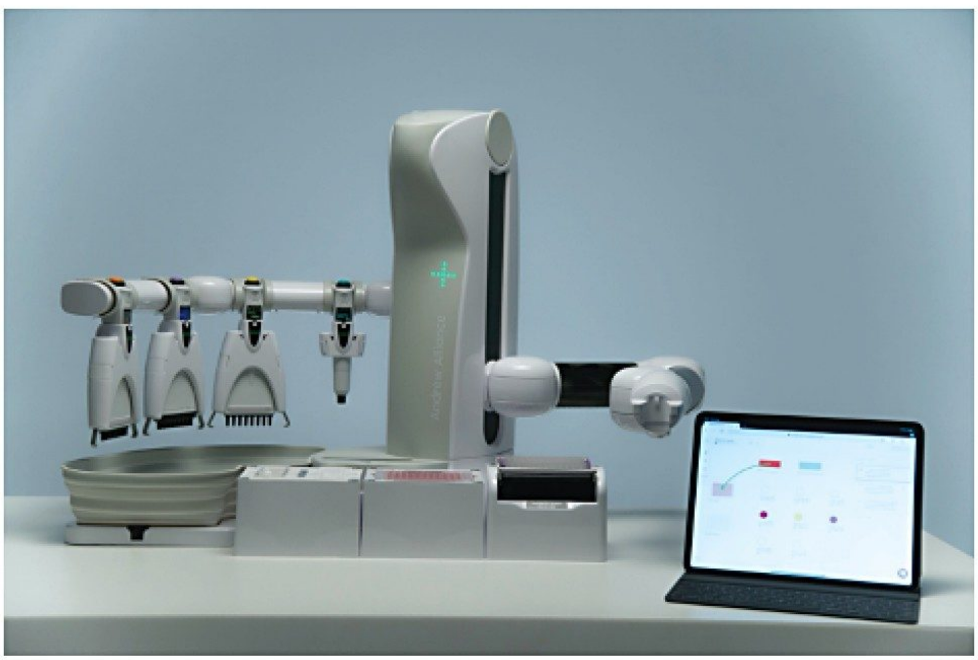

Figure 1. Andrew+ Pipetting Robot and the cloud-native OneLab Software.

The evaluation was carried out in two main steps. The first step was to evaluate the performance of the Andrew+ Robot in standard solution preparation only. The detector response ratios from the robot prepared standard solutions were compared against the standard operation procedure (SOP) dilution ratios to assess the accuracy in serial dilution and mixing. The results are summarized in Table 1. The second step was to evaluate the robot in real-world food analyses. The Andrew+ Robot was implemented in the sample preparation procedure, i.e., the standard solution serial dilution and the sample solution final dilution. The food analysis results using robot prepared standard and sample solutions were compared with those from manual preparation. The results are summarized in Table 2.

	Analyte	Technique	Diluent	Operations	Total dilution ratio	Accuracy (dilution ratio)	
						Andrew+	Manual
1	Sodium	IC-CD	Water	Serial dilution: 5 mL standard solutions mix with 5 mL water and mixing	1:64	-0.5% to 3.0%	N/A
2	Retinol	LC-FLR	Hexane	Serial dilution of 1 - 10 mL standard solutions with hexane and mixing	1:250	-2.8% to 2.9%	-5.0% to 4.2%
3	Vitamin D3	LC-UV/Vis	Methanol	Serial dilution of 0.4 - 10 mL various standard with diluent and mixing	1:250	0.2% to 1.7%	-0.3% to 3.5%
4	Galactose	Electrochemical detection	Water/Methanol	Serial dilution of 1 - 3 mL standard solutions with diluent and mixing	1:500	-0.63% to 0.65%	N/A

Table 1. Accuracy of automated serial dilution and mixing of standard solutions in different assays.

Table 1 shows that the robot delivered a slightly better accuracy in diluting solutions than human operation. The accuracy by robot operation ranged from -2.8% to 3.0%, as compared to -5.0% to 4.2% by human. In the real-world analysis evaluation (Table 2), the robot operation results were comparable to the human operation results. For the LC-based analytical methods, the relative difference from robot operation were -1.2% to 2.5% as compared to the results from human operation, except one result (carnitine) had a 6.7% relative difference from the human operation result. For the non-LC-based method, such as the microbiological-turbidity method, the relative difference was from -3.8% to 5.7%. These results demonstrate that there is no bias introduced in the food analysis by implementing Andrew+ in the sample preparation procedure. The precision of the robot dilution and mixing was also investigated (see Table 3). Relative standard deviation (RSD) of 2.0% was obtained for the dilution and mixing of a 10 μL sample solution with 490 μL water, and less than 0.7% RSDs were obtained for the dilution and mixing of 100, 250, and 2500 μL with various volumes of water.

	Analyte	Technique	Diluent	Operations	Total dilution ratio	Number of samples	Difference % (compared to manual results)
1	Folic acid	Microbiological turbidity	Water	Serial dilution of 0.4–10 mL standard solutions with diluent and mixing	1:125	5	-3.8% to 5.7%
2	Cysteine and methionine	LC-FLR	Water	Single dilution from 10 μL to 500 μL and mixing	1:50	3	Cysteine: -0.5% to 1.5%; Methionine: -0.7% to 2.3%
3	Amino acids	LC-UV/Vis	Water	Single dilution from 100 μL to 500 μL and mixing	1:5	4	Within -1.2% to 2.5% for 14 amino acids in four samples
4	Carnitine	LC-MS/MS	ACN/Water	Single dilution from 150 μL to 1500 μL and mixing	1:10	4	Within -1.1% to 0.4% for three samples and 6.7% in one sample.

Table 2. Relative difference in food analysis results between robot and human operations in standard solution preparation.

Analyte	Technique	Operations*	Precision (RSD)
Choline	IC-CD	10 μL sample mixed with 490 μL water	2.0%
		250 μL sample mixed with 250 μL water	0.3%
		100 μL sample mixed with 4900 μL water	0.7%
		2500 μL sample mixed with 2500 μL water	0.6%

*Picus pipette with volume range 10–300 μL was used for the 10, 100, and 250 μL liquid transfer, and Picus pipette with volume range 100–5000 μL was used for the 490, 2500, and 4900 μL liquid transfer.

Table 3. Precision of automated dilution and mixing of sample solutions in water (n=8).

During the evaluation, we found the OneLab software user interface was highly intuitive, enabling rapid creation of methods for different protocols. Most of the methods were created within 10 minutes. The automation platform provided an additional benefit of sample preparation traceability. Since the operation steps were in the scripts, we could check exactly how the standards and samples were prepared in case troubleshooting should be required. The robot operation time was about the same as the human operation, but the use of the robot liberated analysts' time and labor from repetitive dilution and mixing, which improved productivity and avoided possible human error and muscle fatigue or injury. As a result of the accurate metering of the liquid volume, we were able to scale down the solvent volume in some preparation protocols, which saved solvent consumption and waste disposal.

Conclusion

After our extensive evaluation of Andrew+ and OneLab platform in the routine food analysis lab, we found its performance meets the requirements in accuracy and precision in sample preparation. It can improve the analytical productivity, lab safety, traceability, and reduction of human error. It is easy to use and can be incorporated as part of the sample preparation for a wide range of analyses.

Acknowledgements

Kai Liu, Ben Pointer (Eurofins Nutrition Analysis Center, Des Moines, IA); Jinchuan Yang, Nigel Skinner, Scott Toerber, Dennis Karote (Waters Corporation, Milford, MA).

Featured Products

Automated Liquid Handling for LC & LC-MS Sample Preparation Workflows <https://www.waters.com/waters/nav.htm?cid=135070059>

720007126, January 2021