Application Note – N°. 898/2025

Process intensification with Pure Essential

Abstract: This study compares open column and flash chromatography in terms of efficiency, time, solvent use, and cost. Flash chromatography using different configurations of Pure Essential proved significantly faster, more efficient, and cost-effective over time, especially when using gradient elution and full system configurations.

1. Introduction

Chromatography is a fundamental technique in chemical laboratories for separating and purifying compounds from complex mixtures. Among the most commonly used preparative techniques are open column chromatography and flash chromatography. While both rely on similar principles of differential adsorption onto a stationary phase, their performance, efficiency, and cost vary significantly.

This study aims to systematically compare traditional gravity-driven open column chromatography with modern flash chromatography systems, focusing on separation efficiency, processing time, solvent consumption, and cost-effectiveness. Additionally, different elution strategies (isocratic vs. gradient) and modular configurations of the Pure Essential flash system are evaluated to determine their impact on operational efficiency and return on investment (ROI).

Through a series of standardized separation runs using identical dye samples, this investigation highlights the benefits of modern flash chromatography, offering insights into how labs can optimize their workflows and reduce operational costs.

2. Equipment

- Gravity column chromatography set-up consisting of glass column, filled with Silica and FC60 rack.
- Pure Pump C-900 with interface.
- Pure Fraction Collector C-106.
- Pure UV Detector C-107.
- Flash cartridges: FlashPure EcoFlex Silica 12 g (50 µm).

3. Chemicals and Materials

Chemicals:

- Sudan Yellow.
- Sudan Red G.
- Silica (50 µm).
- Heptane.
- Ethyl acetate (EtAc).
- Dichloromethane (DCM).

4. Procedure

Run 1

- Open glass column.
- 25 mg of both Sudan Yellow and Sudan Red G were dissolved in 50 mL dichloromethane (DCM).
- A slurry-mixture of 12 g silica and about 60 mL of DCM was filled into the glass column.
- Then 0.5 mL of the dye mixture was introduced, and solvent were added by hand.
- Fractions were collected by hand.

Run 2

- Pure pump C-900.
- 25 mg of both Sudan Yellow and Sudan Red G were dissolved in 50 mL dichloromethane (DCM).
- Flash cartridge: FlashPure EcoFlex Silica 12 g (50 µm).
- Equilibration for 3 min at a flow rate of 20 mL/min with 100% DCM. After conditioning, 1 mL of the dye solution was loaded on the cartridge and the elution procedure started with a flow rate of 20 mL/min.
- Fractions were collected by hand.

Run 3

- Pure pump C-900.
- 25 mg of Sudan Yellow and 25 mg of Sudan Red were dissolved in 50 mL of a mixture of 70% hexane and 30% ethyl acetate.
- Flash cartridge: FlashPure Ecoflex Silica 12 g (50 µm).
- Equilibration for 3 min at a flow rate of 20 mL/min with 30% Ethyl acetate and 70% Heptane. After conditioning, 1 mL of the dye solution was loaded on the cartridge and the elution procedure started with a flow rate of 20 mL/min.

0–2 min	70% Heptane, 30% Ethyl acetate
2–3 min	30%–40 % Ethyl acetate

- Fractions were collected by hand.

Run 4

- Pure pump C-900 + Fraction Collector C-106.
- 25 mg of Sudan Yellow and 25 mg of Sudan Red were dissolved in 50 mL of a mixture of 70% hexane and 30% ethyl acetate.
- Flash cartridge: FlashPure Ecoflex Silica 12 g (50 µm).
- Equilibration for 3 min at a flow rate of 20 mL/min with 30% Ethyl acetate and 70% Heptane. After conditioning, 1 mL of the dye solution was loaded on the cartridge and the elution procedure started with a flow rate of 20 mL/min.

0–2 min	70% Heptane, 30% Ethyl acetate
2–3 min	30%–40% Ethyl acetate

- Fractions were collector with the automated fraction collector.

Run 5

- Pure pump C-900 + Fraction Collector C-106 + UV Detector C-700 (Pure Essential).
- 25 mg of Sudan Yellow and 25 mg of Sudan Red were dissolved in 50 mL of a mixture of 70% hexane and 30% ethyl acetate.
- Flash cartridge: FlashPure Ecoflex Silica 12 g (50 µm).
- Equilibration for 3 min at a flow rate of 20 mL/min with 30% Ethyl acetate and 70% Heptane. After conditioning, 1 mL of the dye solution was loaded on the cartridge and the elution procedure started with a flow rate of 20 mL/min:

0–2 min	70% Heptane, 30% Ethyl acetate
2–3 min	30%–40% Ethyl acetate

- Fractions were collected by the fraction collector using the threshold of 0.02 AU of the UV signal.

5. Result

5.1 Comparison open column chromatography versus flash chromatography.

Separation runs of the same type of sample, mobile and stationary phase on an open column and a pre-packed flash cartridge using a flash instrument have been compared. In all tested conditions, the dye mixture was successfully separated into its red and yellow components.

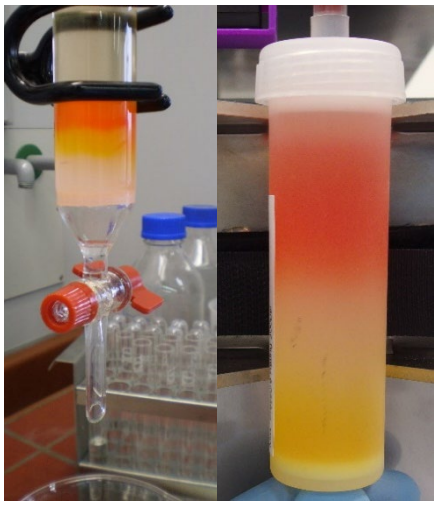


Figure 1: Separation of the dyes Sudan Yellow and Sudan Red G using silica. Left; gravity column chromatography and right; flash chromatography.

The prepacked flash cartridge outperformed the manually packed glass column, as shown by the cleaner and more distinct separation of colors in the collected fractions (Figure 2). The superior performance of the flash system can be attributed better packed stationary phase (silica) and optimized flow rate.

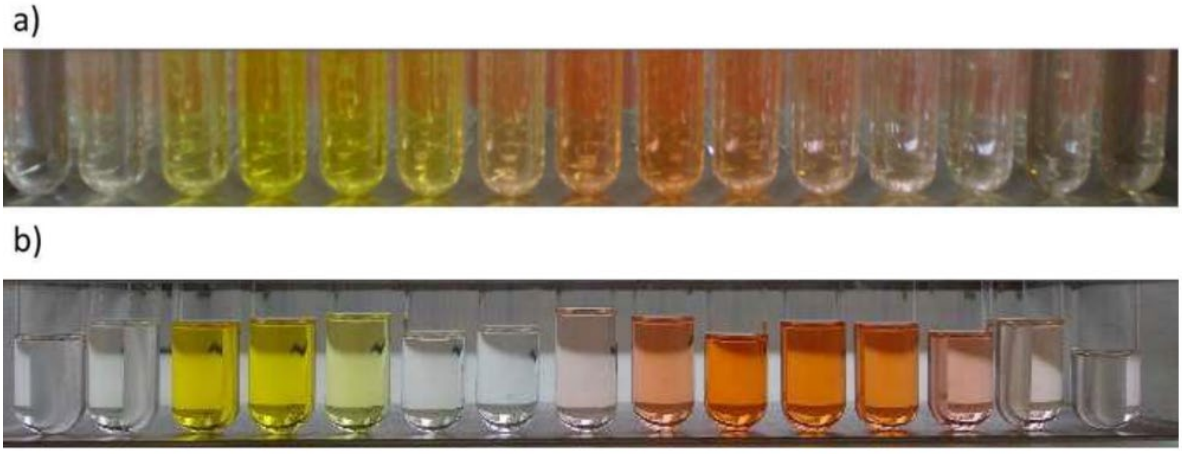


Figure 2: Separated and collected dyes. a): separation with gravity column chromatography. b): separation by flash chromatography using Pure Essential.

A detailed comparison of gravity (Run 1) and flash chromatography (Run 2) was conducted with respect to time and solvent usage (Table 1). The total time required for packing, equilibrating, running, and cleaning a flash cartridge was significantly lower than that for open glass column—approximately 85% less. Additionally, the flash system allowed for an increase in sample loading from 0.5 mL to 1 mL without compromising separation quality, resulting in a 30% reduction in solvent consumption.

Table 1: Time and solvent saving of Run 1 and 2.

	Run 1	Run 2
Equipment	Gravity flow system	Flash instrument Pure C-900 Pump
Consumable	Silica self-packed glass column (12 g)	Flash cartridge (FlashPure EcoFlex Silica 12 g)
Packing material	Silica, 50 µm	Silica, 50 µm
Sample amount	0.5 mL	1 mL
Column packing	10 min	-
Equilibration *	1 min	2 min
Sample injection	1 min	1 min
Separation	12 min	7 min
Cleaning	10 min	1 min
Total time	34 min	11 min
Total time per 1 mL sample	68 min	11 min
Time savings	-	85% or 6x faster
Mobile phase	DCM	DCM
Flow rate	Gravity	20 mL/min
Solvent consumption	160 mL	220 mL
Solvent consumption per 1 mL sample	320 mL	220 mL
Solvent savings	-	30%

** Equilibration of the glass column filled with a slurry is faster than the dry flash cartridge.*

5.2 Comparison of isocratic and linear gradient elution.

Flash chromatography using an isocratic elution with dichloromethane (DCM, polarity 0.42) (run 2) was compared to flash chromatography employing a gradient elution (run 3). In the gradient runs, a heptane (polarity 0) and ethyl acetate (polarity 0.58) mixture was used, offering not only additional time and solvent savings but also enhanced safety due to the lower toxicity and flammability of the solvents.
By using gradient elution, the separation time as well the solvent consumption for the separation part were both reduced by 57% compared to isocratic elution.

Table 2: Time and solvent saving of the separation part of Run 2 and 3.

	Run 2	**Run 3**
Equipment	Flash instrument Pure C-900 Pump	Flash instrument Pure C-900 Pump
Consumable	Flash cartridge (FlashPure EcoFlex Silica 12 g)	Flash cartridge (FlashPure EcoFlex Silica 12 g)
Packing material	Silica, 50 µm	Silica, 50 µm
Sample amount	1 mL	1 mL
Mobile phase	DCM	Heptane / EtAC
Gradient	Isocratic	Linear
Separation time	7 min	3 min
Time savings	-	57% or 2.5x faster
Flow rate	20 mL/min	20 mL/min
Solvent consumption separation	140 mL	60 mL
Solvent savings	-	57%

5.3 Comparison different Pure Essential configurations.

Pure Essential offers a modular design, centered around the C-900 pump, which enhances separation speed and improves reproducibility. To further boost efficiency, the system can be expanded at any time with the addition of the C-106 fraction collector and the C-107 UV detector.

To demonstrate the flexibility of this modular setup, three different configurations were evaluated based on operator hands-on time. Incorporating the fraction collector allows for unattended operation, while the UV detector eliminates the need for TLC analysis, saving even more time. Compared to using only the C-900 pump, these upgrades reduced hands-on time by 27% and 73%, respectively. Besides that, using a fraction collector allows to use the instrument outside of a fume hood.

Table 3: Hands-on time of Run 3, 4, and 5.



	Run 3	Run 4	Run 5
Equipment	Flash instrument: Pure C-900 pump	Flash instrument: Pure C-900 pump Fraction collector C-107	Flash instrument: Pure C-900 pump Fraction collector C-107 UV detector C-106
Consumable	Flash cartridge (FlashPure EcoFlex Silica 12 g)	Flash cartridge (FlashPure EcoFlex Silica 12 g)	Flash cartridge (Flash-Pure EcoFlex Silica 12 g)
Packing material	Silica, 50 µm	Silica, 50 µm	Silica, 50 µm
Mobile phases	Heptane / EtAC	Heptane / EtAC	Heptane / EtAC
Sample amount	1 mL	1 mL	1 mL
Method programming	1 min	1 min	1 min
Sample injection	1 min	1 min	1 min
Collection during separation	3 min	-	-
Cleaning and disposal	1 min	1 min	1 min
TLC analysis	5 min	5 min	
Total hands-on time	11 min	8 min	3 min
Hands-on time savings	-	27%	73%

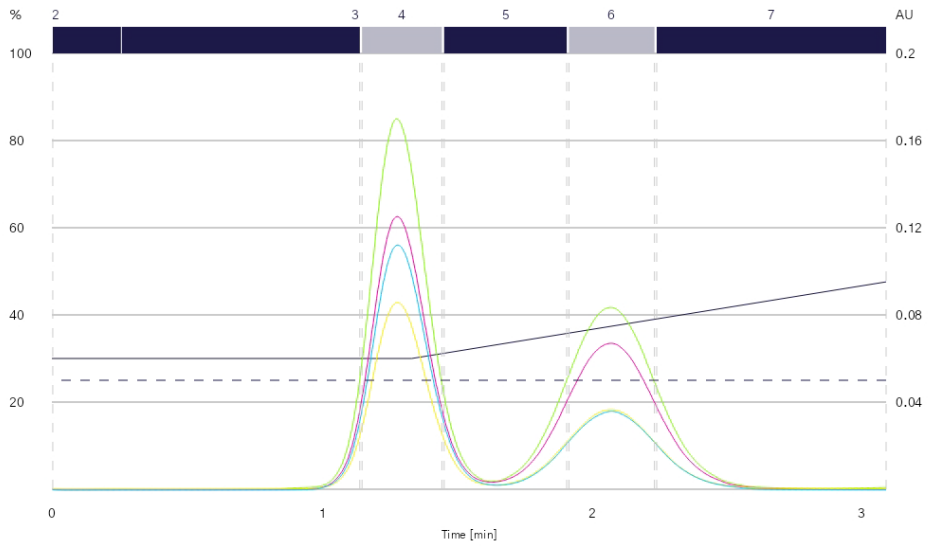


Figure 3: Chromatogram of the separated dyes using Pure Essential (pump, fraction collector and UV detector).

5.4 ROI of open column versus flash chromatography.

First, the initial setup costs (based on U.S. pricing) were calculated for open column chromatography and the three Pure configurations (see Table 2).

Table 3: Start-up cost for Run 1, 3, 4, and 5.




	Run 1	Run 3	Run 4	Run 5
Equipment	Gravity flow system Glass Column	Flash instrument: Pure C-900 pump	Flash instrument: Pure C-900 pump Fraction collector C-107	Flash instrument: Pure C-900 pump Fraction collector C-107 UV detector C-106
Included	Racks Silica Stand	Racks Flash cartridge	Racks Flash cartridge	Racks Flash cartridge
Start-up cost	$ 1,048	$ 7,267	$ 16,318	$ 19,772

Next, hands-on times were calculated for all four setups. This refers to the time the user spends directly operating the instrument or performing any related tasks when working with a similar amount of silica (12 g).

Next, operational costs were analyzed using U.S. market prices. Solvent prices were sourced from Fisher Scientific, and FlashPure cartridge prices from BUCHI Corporation at the time of publication. An operator wage of $ 23 per hour was assumed and included in the operational cost estimates. All data were normalized to show the cost and time required per 1.0 mL of sample. Open column chromatography was performed using isocratic elution, whereas linear gradient elution was used for the flash chromatography systems.

Table 4: Total costs of Run 1, 3, 4, and 5.

**68 min (see table 1) + 2x 5min for TLC analysis.*




	Run 1	Run 3	Run 4	Run 5
Equipment	Gravity flow system: Glass Column	Flash instrument: Pure C-900 pump	Flash instrument: Pure C-900 pump Fraction collector C-107	Flash instrument: Pure C-900 pump Fraction collector C-107 UV detector C-106
Hands-on Time (min/hour)	78*/ 1.3	11/ 0.18	8/ 0.13	3/ 0.05
Operational Cost (23 $ per hour)	$ 30	$ 4.14	$ 3	$ 1.15
Material Cost (Silica/Cartridge/ Solvent)	$ 37	$ 12	$ 12	$ 12
Total Costs per Run	$ 67	$ 16.14	$ 15	$ 13.15

While the initial cost of an open column setup is significantly lower than that of a flash chromatography system, the cost per run is considerably higher for open column users. This is primarily due to increased hands-on time, which results in higher operator costs. Additionally, material expenses—such as solvents, cartridges, and silica—further contribute to the higher cost per run.

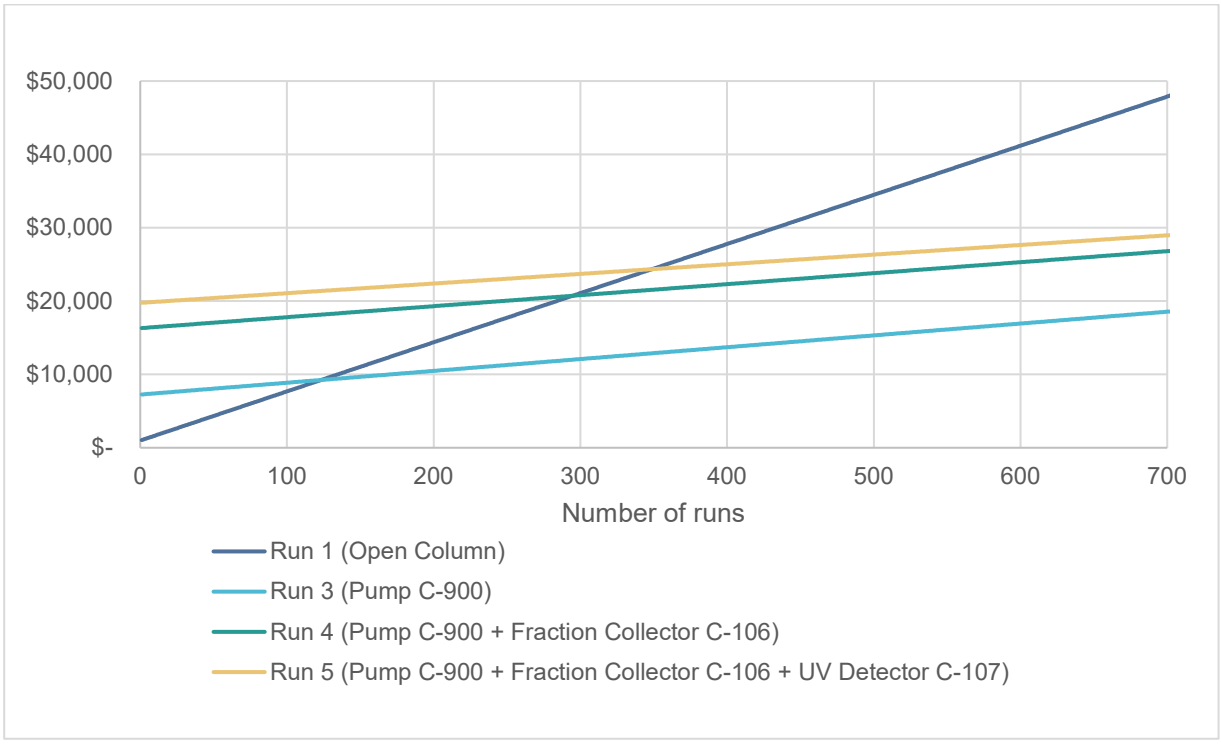


Figure 3: Graph of costs versus number of runs of Run 1, 3, 4, and 5.

The return on investment (ROI) was calculated for each Pure Essential setup based on operational and material costs per run. The results are as follows:

- Pump C-900: ROI achieved after 123 runs.
- Pump C-900 + Fraction Collector C-107: ROI achieved after 299 runs.
- Pump C-900 + Fraction Collector C-107 + UV Detector C-106: ROI achieved after 348 runs.

These values illustrate that each configuration can deliver a cost-effective return within a practical timeframe. For instance, the standalone Pure C-900 pump reaches its ROI after only 123 runs, equivalent to approximately one month of use at five runs per day. Even under a more conservative workload of just two runs per day, the fully automated Pure Essential system would still break even in less than nine months, making it a sound investment for labs with regular purification needs.

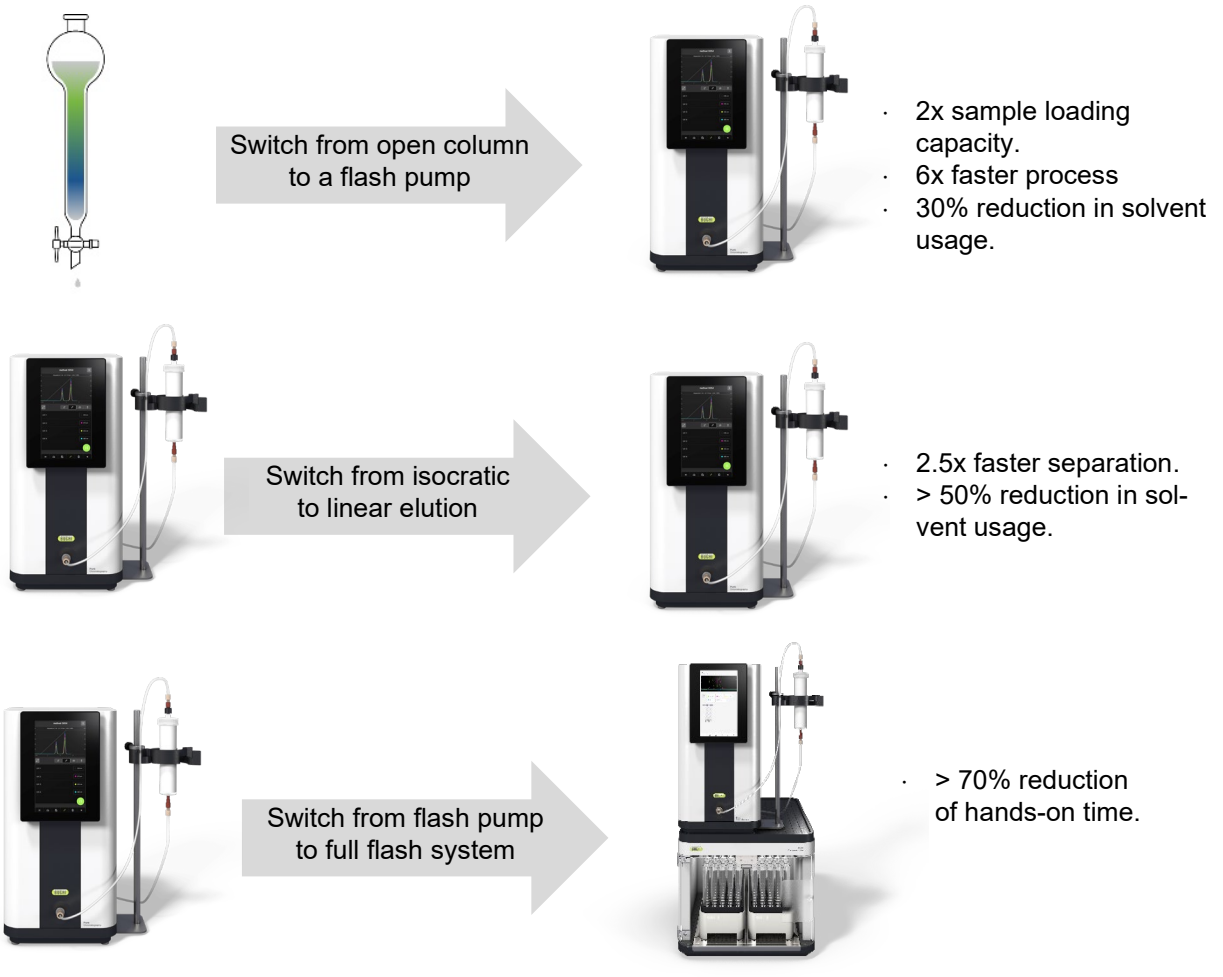
6. Conclusion

This report presents a detailed comparison between traditional open column chromatography and modern flash chromatography, highlighting their differences in performance, efficiency, and cost. Through standardized separation runs using the same sample flash chromatography was shown to consistently outperform gravity-based methods in all key areas.

The switch from open column chromatography to a Flash system including just a pump provided faster separation (up to 6 times quicker), cleaner fractionation, reduced solvent consumption (by 30%), and increased sample loading capacity, all contributing to higher throughput and better reproducibility.

The use of gradient elution further enhanced efficiency, cutting separation time and solvent usage by over 50% compared to isocratic methods.

Additionally, the modular design of the Pure Essential system demonstrated how automation, through a fraction collector and UV detector, can dramatically reduce hands-on time by > 70%.



- 2x sample loading capacity.
- 6x faster process
- 30% reduction in solvent usage.
- 2.5x faster separation.
- > 50% reduction in solvent usage.
- > 70% reduction of hands-on time.

From an economic perspective, while open column setups are less expensive to purchase initially, they incur significantly higher operating costs due to manual labor and greater solvent usage. In contrast, flash chromatography systems offer a faster return on investment, reaching break-even points within 123 to 348 runs, depending on system configuration.