

Chromatography

Autonomous Science – How developments in the automotive industry can predict the future of chromatography applications

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You are driving along a busy highway, yet you are calm and are listening to your favorite music. But what defines driving these days? The key never left your pocket, yet the car opened when you approached it, the engine started at the push of a button, the headlights came on automatically, the climate control created a comfortable environment and the wipers started automatically and took care of that light drizzle halfway down the road. The car reminds you now and then of the upcoming service in half a year, gentle vibrations in the steering remind you to use the indicators when changing lanes and emergency brake assistants can jump in at the last second to protect you and the people outside from harm.

How did we get here? In the years after 1885, following the invention of the car, the driver needed to understand the difference between diesel and petrol engines, needed to monitor temperatures and liquid levels of coolants and oils, gauge the lifetime of driving belts based on the odometer and match the engine speeds when changing gears. Leaps in sensor technology, safety and automation have made driving second nature to us, limiting the technical interaction with our cars to scheduling a service. The car checks itself and the owners can trust the car to do the job they expect of it: getting you there, in some cases even autonomously.



Repeating history

A similar trend is revolutionising chromatography applications. Smarter systems, machine learning and ever-increasing amounts of data are creating new possibilities to automate, reduce unplanned downtime and predict maintenance schedules, thus widening the customer base to include a wider spectrum of professionals, not just specifically trained scientists. As with cars, these developments are in part fuelled by leaps in sensor technology that, for example, allow online liquid flow rate measurements down to single nanolitres per minute.

Artisan science

Early iterations of chromatography systems required their operators - typically a highly trained scientist in a high-tech research facility - to manually prepare each sample for the next experiment. While an analytical procedure or process can be as short as minutes or even seconds, typical sample preparation steps take hours to complete. This sample preparation depends on the specific compounds of interest and may include weighing, filtering, evaporation, liquid-liquid extraction and homogenisation.

But the manual work was not yet done. Each of the painstakingly prepared samples then had to be loaded into the system, one by one, at just the right time. This required the operator to be dedicated to the system during the entire process.

Even after the experiments were finished, the work continued in the form of number crunching of the experimental results. The potential for optimisation and automation was huge.

A new state of the art

Current systems are automated to much higher degrees and offer full workflow integrations ranging from sample preparation to data analysis and visualisation. Automation systems can differ in their design and range from systems to replicate and emulate manual methods to closed systems that do part of the sample preparation, for example in a bench top system. Whereas the latter automates specific processes to an optimal degree, the former can be more flexible. Robotic systems that mimic a typical manual process can be adapted to perform different steps to complete another process in a similar automated fashion. One key driver of increased automation is, of course, to reduce costs and manual workload. However, due to advances in sensor technology, workflows can be monitored online and thus optimised to increase not only their speed and reproducibility, but also their stability and safety.

Versatile impact

This is, however, only the beginning. The high value of the test results of chromatography workflows and analytical instruments in general will cause their success to do nothing but increase. Current fields of interest include the food and beverage industry, where the results give insights into the safety of our nutrition. Given the ever-increasing demand for highly optimised and high-yield food production processes, every production batch will reach an ever-increasing number of consumers. Their health and safety thus depend on the safety and stability of the production processes.

Pharmaceutical products aim to help and heal the sick population, a group whose immune system is in many cases already compromised. For these patients in particular, the safety, security and reliability of controlled production processes is key. Analytical instruments and workflows are already used to control for these safety aspects and, with newer and more complex treatments becoming available, the demand for such workflows to be efficiently and seamlessly integrated into the production processes will increase further.

Already at the development stage of vaccines, for example, chromatography systems help identify the specific antibodies involved in fighting different diseases and thus enable fast production of specific compounds to combat the spread of potentially life-threatening epidemics.

In forensic science, chromatography and analytical systems are used to yield information to solve criminal cases. The analysis can cover natural and synthetic drugs and toxicological samples, but also the analysis of the debris of fires and explosions. Additional applications analyse paints and pigment molecules to link individuals to places or identify tell-tale signs of food fraud, counterfeit alcohol and adulterated fragrances.

Hidden champions

With the prevalence of such analytical systems only increasing in industry and research, the demand for and development of automated and stable processes for completing the workflows around the actual analysis will also increase.

A large portion of these developments are enabled through smart sensor solutions, where Sensirion is a valued partner for life science, diagnostic and analytical applications. Sensirion's sensor solutions enable dispense validation, process control and optimisation, and failure mode detection in myriad applications. Whether an application requires the monitoring of environmental factors, such as humidity and temperature, CO₂ concentration or particulate matter, or the precise measurement and control of liquid and gas flows, Sensirion's fully calibrated and digital sensor technologies offer a great and reliable basis for process and workflow automation and control.



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