Controlled, Pressure-driven, Sequential Actuation of Fluids for a Food Quality Monitoring System

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Numerous dispensing and dosing solutions for a broad range of applications such as life sciences are available, all with their individual advantages. However, when working with aggressive solvents, most of these solutions are not suitable due to material incompatibility of tubing or inline sensors. Some of these solutions also fail for mobile applications due to their weight and size. For a mobile food quality monitoring system, we have implemented our controlled pressure driven dispensing system which precisely and contact-less measures the volume dispensed out of a bottle. It only requires one valve located in fluid communication, which is available for high chemical resistance. One lightweight control unit can be used to dispense from multiple bottles filled with different solvents. Further the system offers the capability to dispense gases with the same precision as for liquids. In our specific application, water, acetonitrile, and air are dispensed in volumes of 100 µl up to 10 ml with accuracies of about 3%. The resulting continuous and pulsation-free flow is advantageous for many microfluidic applications.

Based on the fundamental principles of the ideal gas law, a low-cost, small outline control unit has been developed which enables the precise dispensing of critical liquids such as acetonitrile, hexane and other solvents as much as gases (air) and water from containments that can be pressurized. While pressurizing the containment, the pressure trend is evaluated and the encapsulated gas volume is calculated. For known containment volumes this gives direct feedback of its fill-level and enables automatic refilling or messaging to the user to request refilling where appropriated. Once the gas volume is detected this information is used for calculating target pressure points when dispensing (see Figure 1). For more details refer to Graf, *et al.* [1]

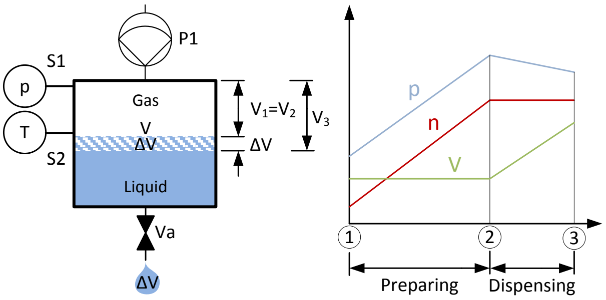

Figure 1: (left) Schematics of the device; (right) Gas parameter change during containment compression and liquid dosing.

This dispensing method combines the benefits of time pressure dispensing (TPD) with additional direct sensing of the dispensed amount of liquid. Hence differences in viscosity of the medium or flow resistance of the system (filter, SPE, etc.) are not important. Due to the working principle compressing the gas volume needs a few seconds, so that first dosing cannot be performed instantaneously. After performing this initial procedure, fast dispensing is possible.

As the system operates only with a pressure sensor - in fluid communication with the gas volume - one control unit can be used to sequentially dispense from a multitude of containments. This can be done by actively selecting the containment to be dispensed from, without recompressing the containment [2]. By that system outline and weight are reduced, when compared to getting the same functionality with multiple syringe pumps even drastically. Additionally various types of containments can be used within one system setup. The system for food quality monitoring uses standard 80 ml and 150 ml laboratory bottles. Compared to syringe pumps this allows the dispensing of high amounts of liquids without additional effort of refilling the syringe for dispensing.

Figure 2: Food quality monitoring system integrating a controlled, pressure driven dispensing subsystem (all five bottles are controlled).

The control automatically detects clogging of the downstream fluidic system as well as leakage of the gas volumes and enables therefore an advanced system monitoring when incorporated in automated systems.

Two versions of the system (bottle cap and multi-bottle actuation Figure 2) have been tested for volumes between a few ml and 100 µl. However, due to the underlying physical principles the system is scalable, both, to higher and smaller volumes and one can expect comparable dispensing deviations.

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[1] S. F. Graf, J. Goldowsky, H. F. Knapp, "Compact, Pressure-based Flow System for Sequential Actuation of Fluids with Integrated Flow Monitoring", CSEM Scientific and Technical Report (2014), 114.

[2] S. F. Graf, J. Goldowsky, T. Volden, H. F. Knapp, "Automation of Traditional Sample Preparation for Oil, Milk, and Nuts", CSEM Scientific and Technical Report (2015), 50.