Automation of Traditional Sample Preparation for Oil, Milk, and Nuts

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Food analysis for insecticides, antibiotics or mycotoxin residues always have a foregoing sample preparation step to transform the food sample into form which can be processed by the respective sensor. This can include concentrating the analytes, filtering the sample to remove solids, transfer analytes from solid materials to solvents, remove fatty sample part etc. In many cases problematic solvents as e.g. Acetonitrile or Hexane are required, hence food analysis is currently performed in dedicated laboratories. Having an on-site analysis system with integrated automated sample preparation could minimize food waste by not contaminating perfectly fine food with contaminated food.

On-site food sample preparation is difficult because of its complexity and the use of problematic solvents. Evaporators, centrifuges and shakers are often required for these processes. This project's goal is to move sample preparation from the laboratory to sites like farms where milk is collected for further processing at a production site. If contaminants are present in the milk, it would simply not be added to the already collected clean milk and thus not contaminate the whole load. In a first step of this project the preparation processes for oil, milk and nuts were modified to work with solid phase extraction (SPE) which is more suitable for automation. In SPE, analytes in the sample bind to a solid phase matrix because of their specific affinity. The analytes can then be eluted from the solid phase matrix using appropriate solvents. In a second step of the project, the common process steps for the three completely different food types were selected as shown in Figure 2, i.e. preparation of the SPE; binding the analytes in the SPE, washing the SPE and finally eluting the analytes and transporting them to the detection unit. For the time being, the preceding divergent process steps (Figure 1) of the different food types i.e. grinding, adding solvents, shaking and extracting, will be done manually.

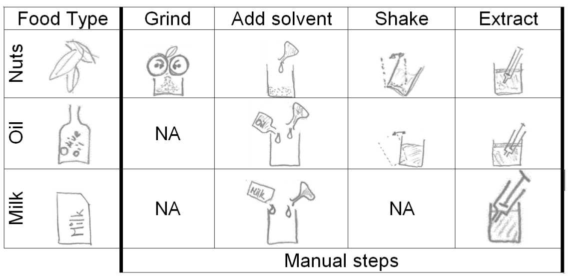

Figure 1: Preceding sample preparation steps for nuts, oil and milk.

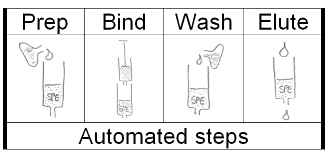

Figure 2: Common automated preparation steps using SPE.

Standard laboratory systems for SPE concentration and filters use vacuum to drive the liquid. Because of this the process is slow, as only less than 1 bar pressure difference can be applied. Our system is equipped with an independent pressure driven dispensing module [1] (patent pending) which can create a pressure difference of up to 1.5 bar (higher pressures in development) and precisely dose volumes from 100 µl up to several milliliters. After the sample is introduced via a pipette, the system takes over, preconditions the SPE, and pushes the sample through the SPE into waste. The SPE is then automatically washed and the analytes eluted with a defined volume and then guided towards the detection unit. A bread-board prototype based on the schematics in Figure 3 was tested and then miniaturized into a cartridge (Figure 4).

The pretreatment unit will be combined with the sensor unit based on an optical biosensor functionalized with aptamers to sense smallest contaminations in milk, oils or nuts. The combined system will be a portable setup which allows performing measurements on-site. At a later stage, this system will be customized for each food type to also automate the current manual steps.

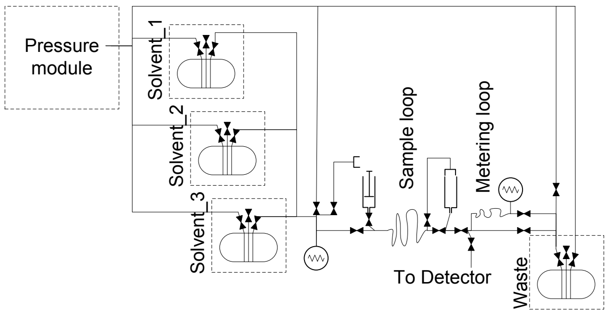

Figure 3: Schematics of the pretreatment system.

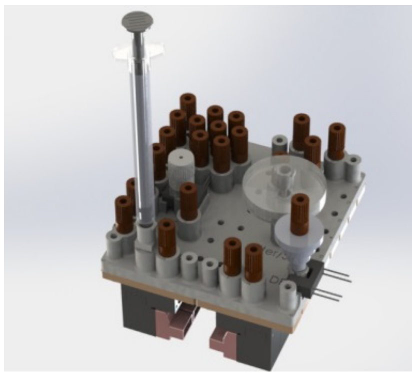

Figure 4: Drawing of the microfluidic cartridge for the sample preparation unit. H 76 mm x W 75 mm x D 80 mm. Not included in the figure are the electronics, tubing and liquid bottles for solvents and waste which are required for the complete system.

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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