2LabsToGo system with breakthrough analytical strategy

Paradigm shift in analytical methodology

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The compact 2LabsToGo system includes all relevant steps normally performed in a chemistry and biology laboratory [1–3]. It enables rapid and low-cost planar separations in liquid chromatography and a breakthrough analytical strategy for prioritizing important compounds in complex samples.

Thanks to the detection of the biological effect of compounds in the complex samples, it points to important compounds. In contrast, the prevailing trend in separation science is to separate everything and get lost in the many thousands of unknown signals with unknown activity (no toxicity data) [4,5]. This disruptive strategy resolves pressing questions regarding hazards or benefits of samples and is extremely powerful, as demonstrated by the recent discovery of genotoxic compounds in more than 30 oils used in a healthy diet [6].

The small-scale 2LabsToGo system (ca. 7 kg, 31 cm x 26 cm x 34 cm) is portable and powered on-site by solar cells in the latest model. Samples are applied automatically on the planar adsorbent surface as raw or original as possible, which allows for a high sample integrity and almost no sample preparation. After their simultaneous separation, the capability for orthogonal multiple detections widens the range of detectable compounds in the UV/Vis/FLD via simple LEDs and chemical derivatization reactions. Most importantly, however, is the non-targeted biological detection of compounds by applying and incubating cells on the same separation adsorbent. In this way, information is obtained on any beneficial or hazardous compounds present in the complex samples.

The instrumental functions as well as data and results obtained have been shown to be comparable to those of conventional instruments filling two laboratories. Since it has been developed as an open-source instrumentation, the entire system can be customized and optimized to your own needs. It is suitable for everyone! Its functionality has been proven by various application examples, such as screening lactose in lactose-free dairy products or saccharides in food (Fig. 1) [2], ergot alkaloids in rye, and estrogen-like substances in wine and beer. The obtained quantitative results based on the biological response, as shown for EC50 values, are very comparable (Fig. 2). Advantageously, the latest model costs only around € 2000 and is cheaper by a factor of 100 than respective state-of-the-art systems. This affordability contributes to the widespread adoption of this effective and powerful strategy. Very important is also the fact that the lean all-in-one miniaturized instrumentation and its methods are comparatively very sustainable, supporting method greenness and eco-friendliness.

In analytical chemistry, the viral aspect of open source developments is flexibility, i.e. to give to the community innovative tools to be included in laboratories and to enable small teams to generate progress in tailored research areas or in cutting-edge science, in which commercial mainstream solutions are of no use. Open source developments are freely available, the hardware blueprint as well as the source code of software and firmware are open, and changes to the device are possible at any time. During self-assembly, the user gains valuable troubleshooting and customization skills. Open source developments are similar to radical chain reactions, exponential in progress and highly dynamic in its result. It is highly interesting to contribute and pursue completely unusual new ideas. Sample application, chromatographic separation, multi-imaging and effect-directed detection is combined on the same adsorbent surface, providing an image worth a thousand words and based on real effects. By mapping and comparing patterns or profiles, results are globally understood across languages. Artificial intelligence [7,8] may assist image evaluation in the future.

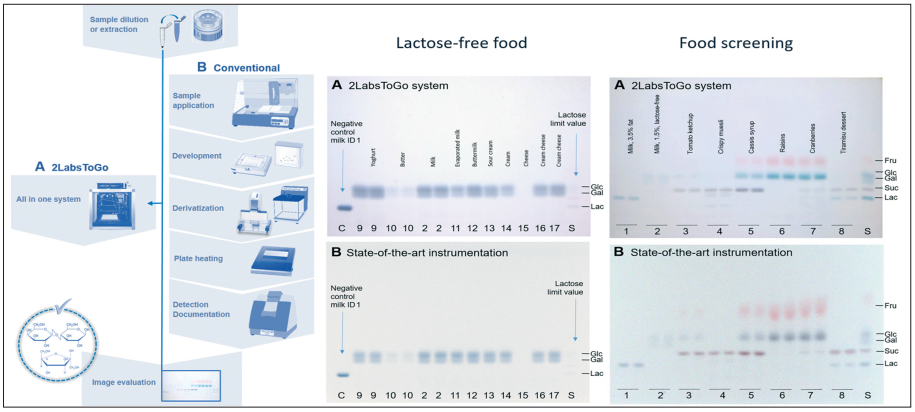

Fig. 1. Screening of lactose-free food for lactose and complex food samples for saccharides via the 2LabsToGo system (A) in comparison to the state-of-the-art instrumentation (B); permission obtained from Elsevier, Amsterdam [2]

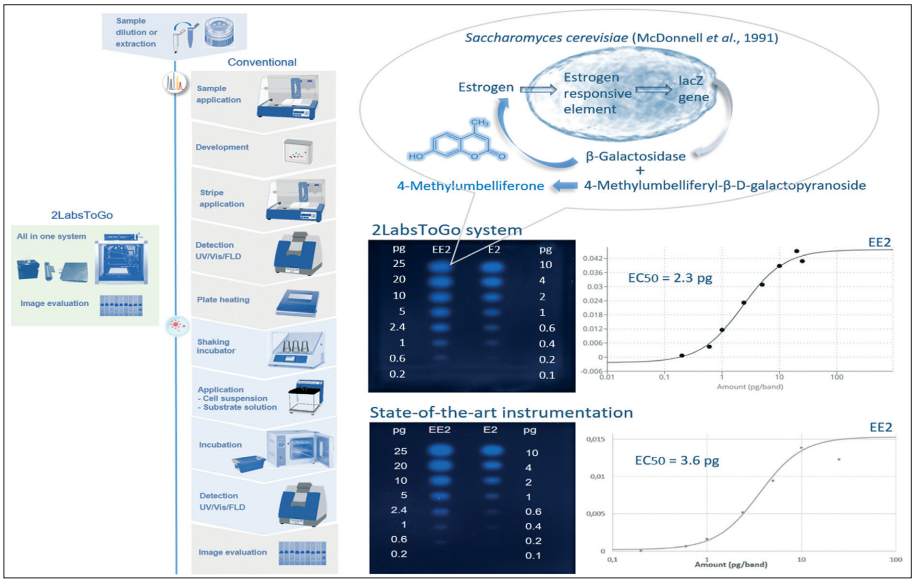

Fig. 2. Quantitative comparison of EC50 values for estradiol (E2) and ethinylestradiol (EE2) using the 2LabsToGo system versus state-of-the-art instrumentation for performance of the planar yeast estrogen screen (pYES) bioassay

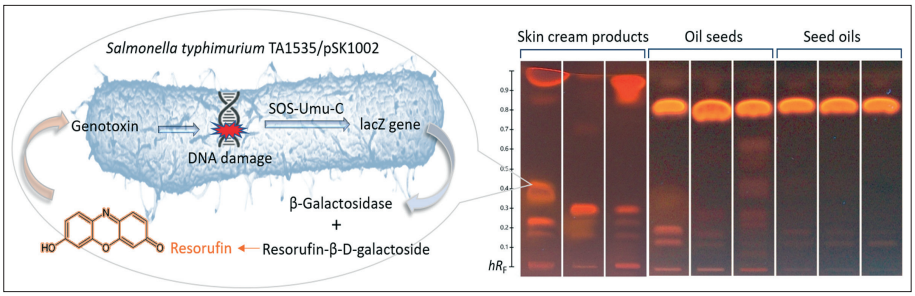

Fig. 3. Screening of food products and cosmetics with the planar genotoxicity bioassay (HPTLC–FLD–SOS-Umu-C), which detects genotoxins as orange fluorescent compound zones, which were, for example, preliminarily assigned to epoxidized unsaturated fatty acids

Currently, in vitro microtiter plate assays are blind to opposing signal responses in complex samples, providing a sum value but no effect differentiation. Although non-target approaches such as spectral fingerprinting and sophisticated chromatography–mass spectrometry techniques open new vistas, they are not able to prioritize the important active compounds based on real biological effect data. Evaluation constructs and decision making are increasingly based on algorithms. Moreover, in target analysis, even multi-methods covering several hundred analytes can never be comprehensive [4,5]. So how can we quickly find important beneficial or hazardous compounds, including the ones that have not previously been a focus? A shift toward effect-directed planar assay screening provides better overall safety (Fig. 3). The validity of the technique has been proven and is ready for use [9]. Depending on the selected assay, planar assay screenings take only 5 to 20 min per sample and have consumption costs of € 0.50–1.00 per sample. Beneficial or hazardous compound zones detected in a complex sample, which cannot be assigned to known sus-pected compounds, can be subjected directly from the bioautogram to high-resolution mass spectrometry [10–12]. This optional super-hyphenation (10D or 12D hyphenations) makes the planar assay screening strategy highly efficient. Only important compounds (not background/matrix) are transferred to the expensive machines. This keeps data evaluation and storage useful and lean.

Interested parties can get a first impression on the topic of multi-component mixtures at the respective initiative (www.vielstoffgemische.de) [13]. Expertise in planar effect-related assays in combination with planar chromatography will be taught annually, and the next course will be held at the end of February/March 2024 as a hybrid module (www.uni-giessen.de/food).

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