Monitoring methanol during distillation with a hand-held device

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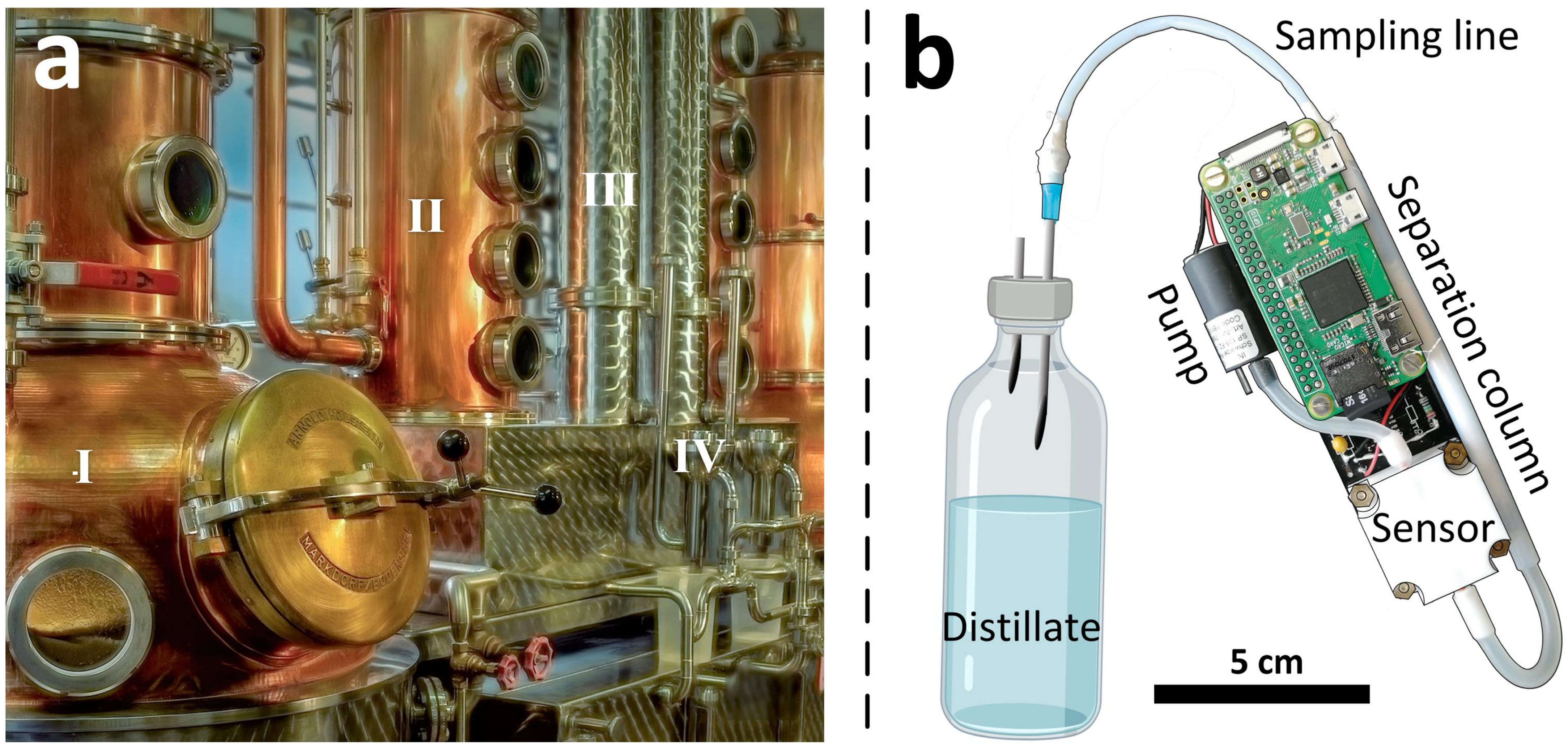
Motivation

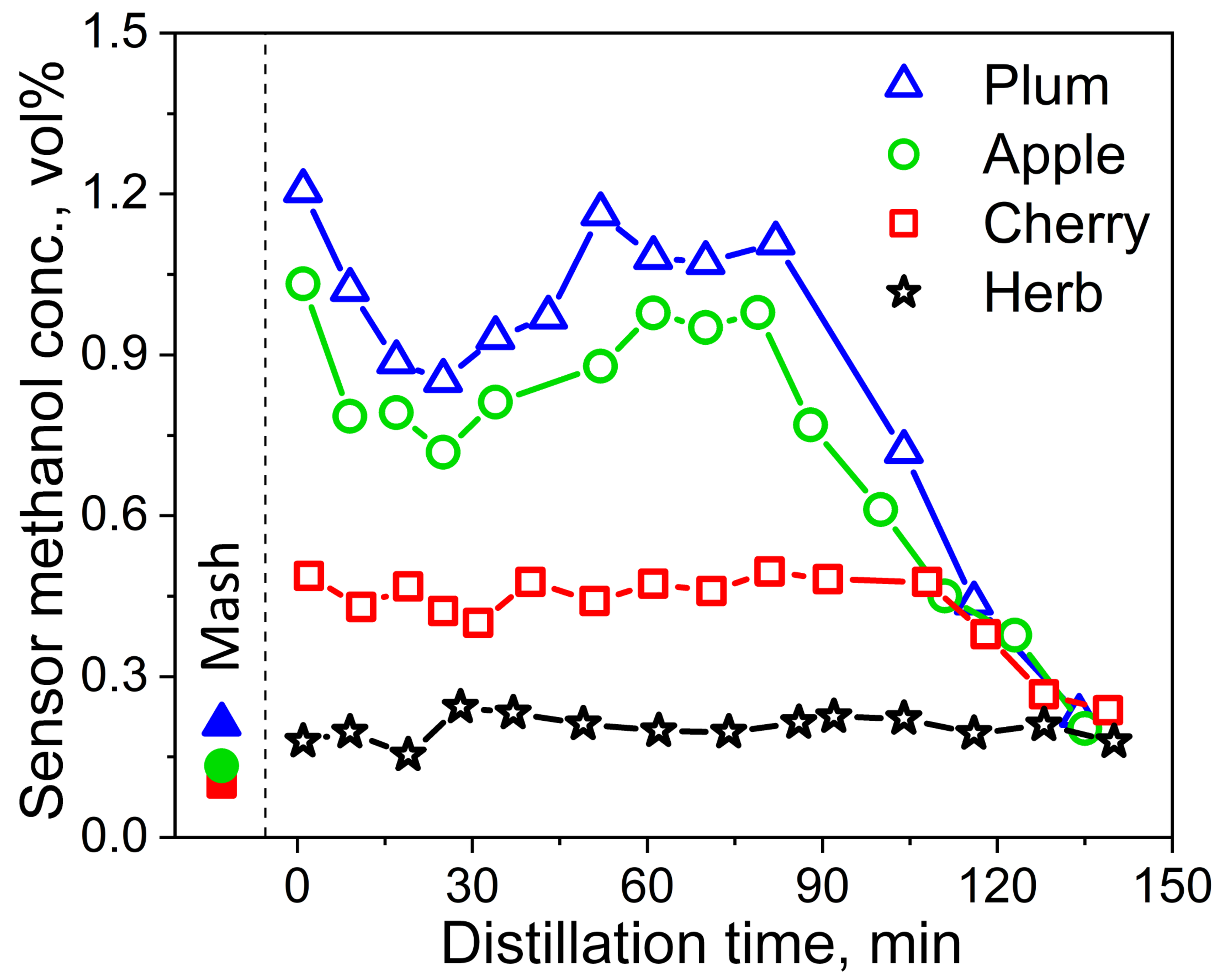
Toxic methanol occurs naturally in most alcoholic distillates. Yet, suitable detectors to check liquor adherence to legal limits (e.g., 1200 g methanol per hL ethanol for apple and plum spirit and 1000 g/hL for cherry spirit in the EU)[1] and most importantly, monitor *in situ* methanol content during distillation are not available. Usually, distillers rely on error-prone human olfaction while "gold standard" liquid or gas chromatography (GC) are rarely used being off-line, time-consuming and expensive. Here, we explore monitoring the methanol concentration during industrial distillation of cherry, apple, plum and herb liquor (196 samples) with a low-cost and handheld detector interfaced with a smartphone.

Methanol sampling in an industrial distillery



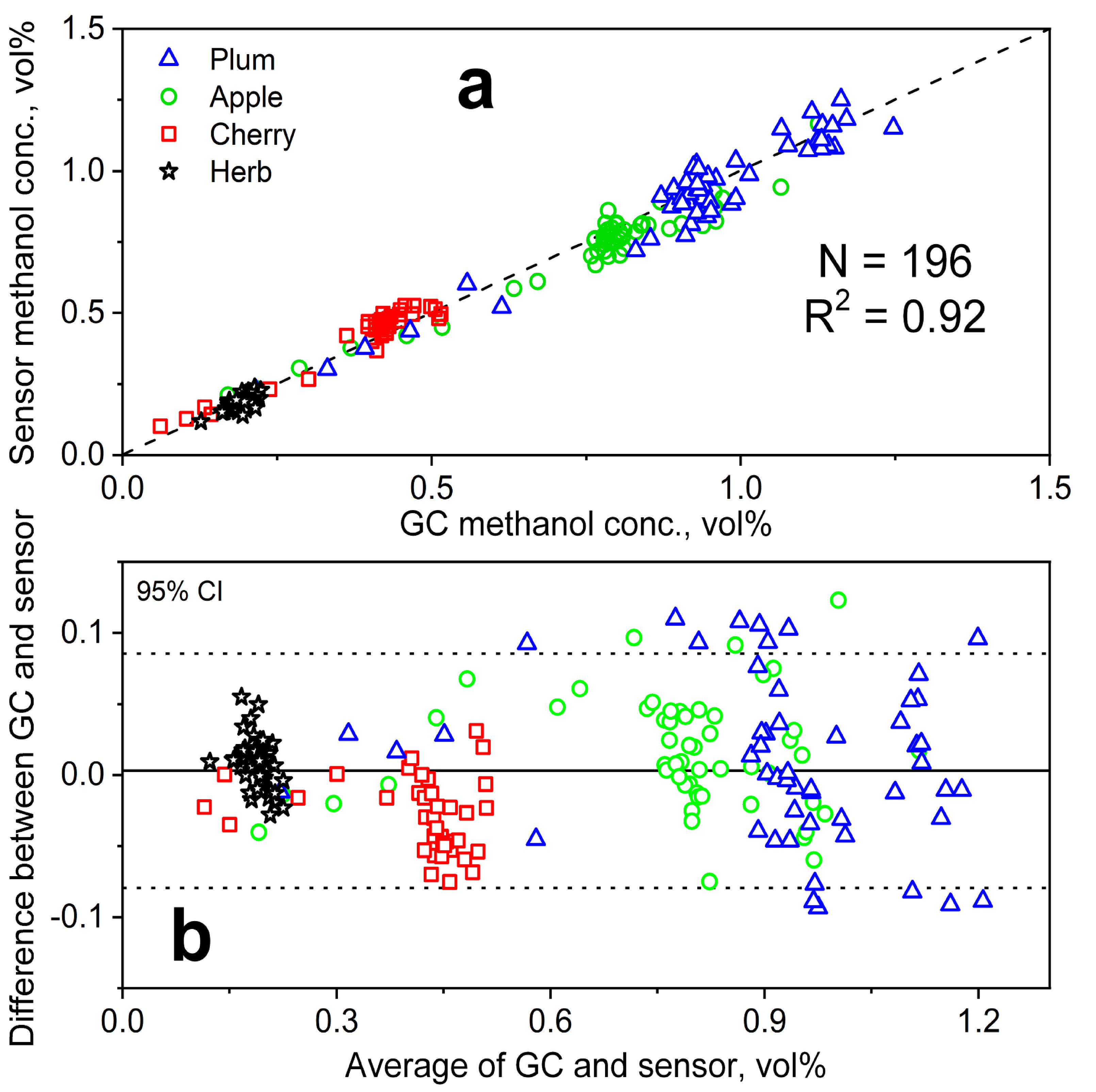
(a) Industrial distillery with the (I) pot still, (II) column amplifier, (III) condenser and (IV) outlet, where the sample is drawn. The device (b) analyzes distillates by drawing head space air through a separation column[2] of non-polar Tenax TA particles retaining analytes based on van den Walls interactions[3]. In fact, methanol emerges after 1.4 min and is not affected by ethanol that comes after 2.6 – 2.8 min. Both are sequentially and therefore selectively quantified by a highly sensitive but non-selective[4] flame-aerosol-made chemoresistive Pd-doped SnO_2[5] gas sensor.

Sensor methanol during distillation



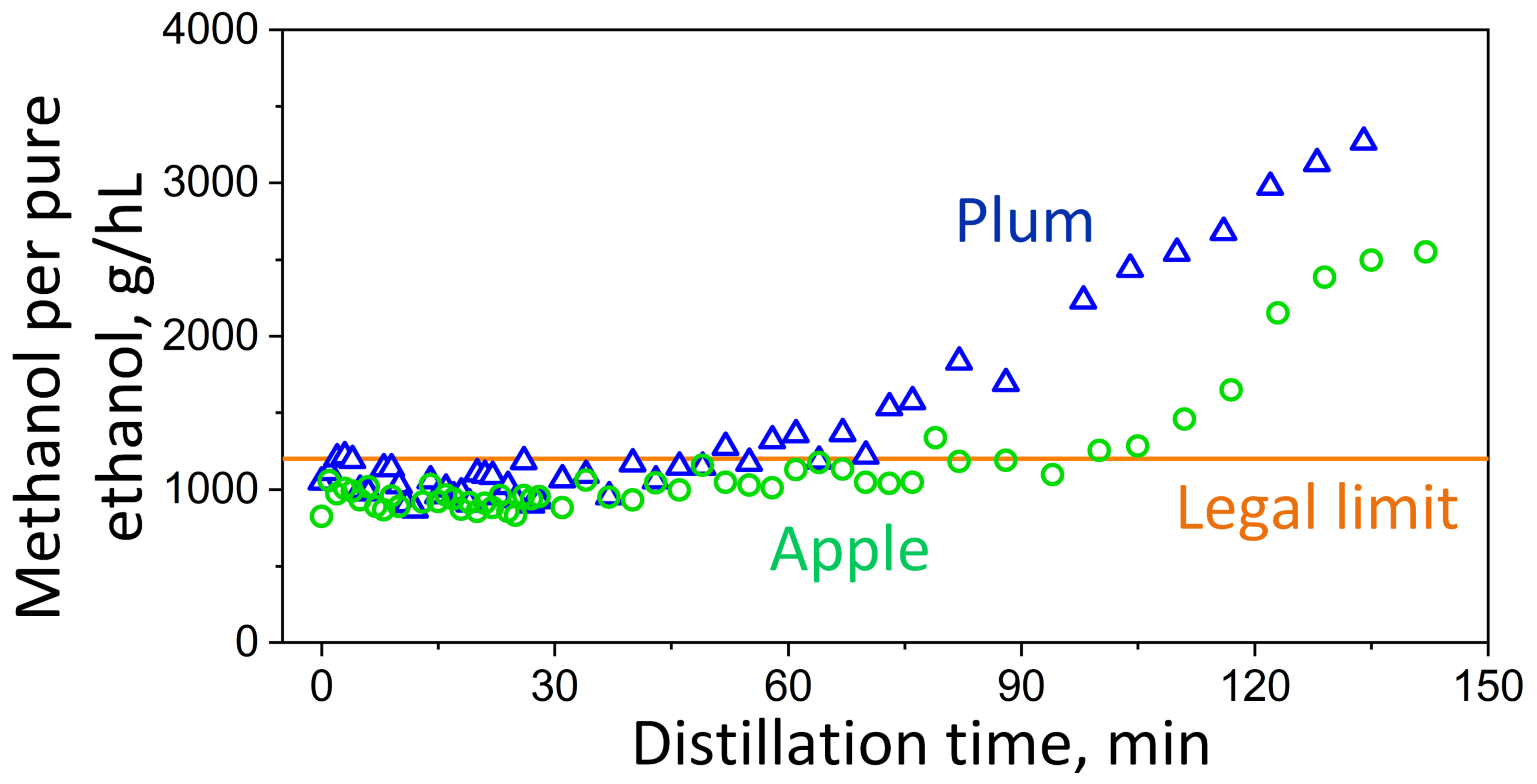
Methanol concentrations of plum (triangles), apple (circles), cherry (squares) and herb (stars) mash (filled symbols) and spirit (open symbols) as a function of distillation time. Adjustments of distillation parameters by the master distiller create the temporal variations of methanol concentrations.

Sensor device vs. GC



(a) Scatter plot of the sensor- and GC-measured methanol concentrations of (N) 196 distillate samples. Ideal line (broken) and coefficient of determination (R^2) are indicated. (b) Corresponding Bland-Altman analysis indicating the difference in methanol concentrations between sensor and GC over their averages. Mean (solid) and 95% confidence intervals (dotted line) are shown.

Adherence to legal limits



Methanol to ethanol ratio during distillation of plum (triangles) and apple (circles) spirit by the portable device along with the corresponding E.U. limit[1] (solid line).

Conclusions

- Accurate tracking of absolute and ethanol-specific methanol during distillation of liquor with a hand-held device is shown.
- Methanol levels exceeding EU limits are detected during distillation.
- This device can help consumers, legal authorities and distillers to prevent deadly methanol poisoning.

[1] The European Parliament and Council, *Official Journal of the European Union* (2019), 2019/787.
[2] van den Broek, J.; Abegg, S.; Pratsinis, S. E.; Güntner, A. T., *Nat Commun* (2019), 4220.
[3] Maier, I.; Fieber, M., *J High Res Chromatog* (1988), 566-76.
[4] Pineau, N. J.; Kompalla, J. F.; Güntner, A. T.; Pratsinis, S. E., *Microchim Acta* (2018), 563.
[5] Pineau, N. J.; Keller, S. D.; Güntner, A. T.; Pratsinis, S. E., *Microchim Acta* (2020), 96.