

# Development of a device for staged determination of water activity and moisture content

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## Experimental setup

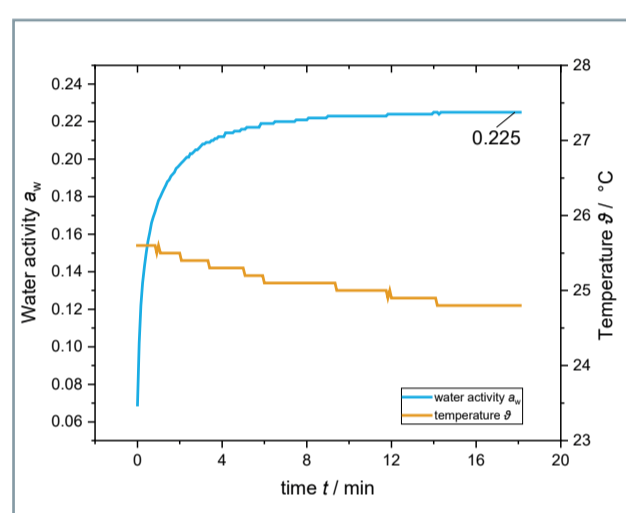
- the designed MOISHUM measuring cell includes two humidity sensors - a capacitive SHT-25 for water activity ( $a_w$  value) and a coulometric<sup>[1]</sup> for water mass determination, two Pt100 temperature sensors and two Peltier devices for precise temperature control of the chamber (Figure 1)
- $a_w$  value (temperature range 20 °C to 40 °C): equilibrium relative humidity ( $U_{w,ERH}$ ) which correspond to water activity  $a_w = U_{w,ERH} / 100 \%$  (isothermal)
- water content (at 105 °C): determination is based on FARADAY's law of electrolysis  $m_w = (Q \cdot M_w) / (F \cdot z)$
- reference hygrometer for water activity determination HygroPalm (Rotronic)

## Results

### Functionality test

- functionality tests were performed by investigations of deionised water
- determined  $a_w$  values are in the range higher than 95 %
- electrolytically obtained water masses have a relative deviation in the range of -2.2 % to 2.0 % in comparison to the measured water on an analytical balance

Figure 2: Determination of the  $a_w$ -value of powdered coffee by MOISHUM at  $25 \pm 0.2$  °C. ▶



### Water activity, moisture determinations and sorption isotherm of a powdered coffee

- $a_w$  value by MOISHUM measuring cell: 0.225 (Figure 2) - reference  $a_w$  value 0.27
- both determined  $a_w$  values of the powdered coffee sample are in the range from 0.1 to 0.3<sup>[2]</sup>
- electrolytically determined water content by MOISHUM measuring cell (Figure 3) is the basis for calculation of a sorption isotherm applying the Guggenheim, Anderson, and de Boer (GAB) function according to least square method (Figure 4)

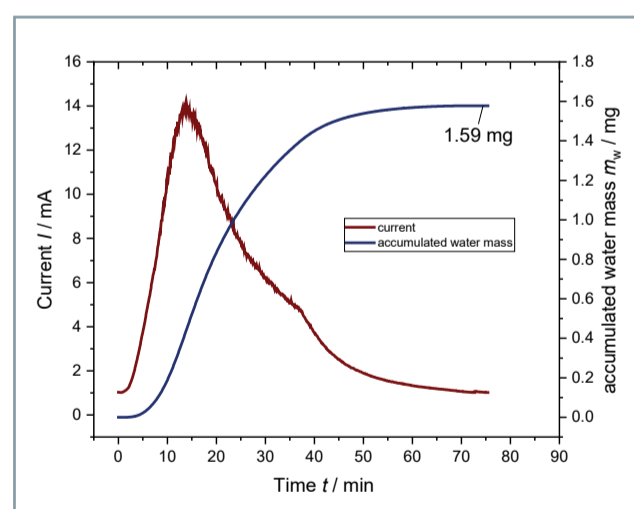


Figure 3: Water amount determination by the MOISHUM measuring cell - DC voltage 18 V, shunt resistance 100  $\Omega$ , Peltier device 105 °C.

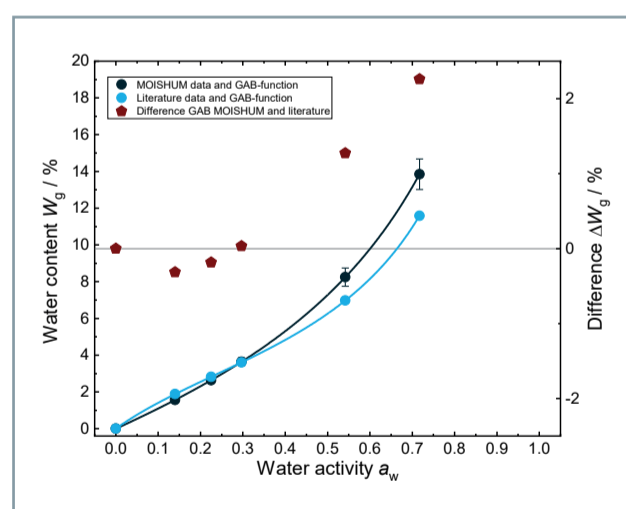


Figure 4: Sorption isotherm at  $25 \pm 0.2$  °C of powdered coffee with MOISHUM data and GAB-function in black and the difference in brown pentagons - MOISHUM GAB-parameters:  $X_m = 8.230$ ,  $C = 1.556$  and  $K = 0.822$  in comparison to Cepeda et al.'s parameter:  $X_m = 4.203$ ,  $C = 4.186$  and  $K = 0.941$ .<sup>[3]</sup>

## Conclusion

- The developed MOISHUM measuring cell's applicability was tested and proven on powdered coffee in comparison to data from literature.
- MOISHUM measuring times for  $a_w$  values are in the range of 20 min to 90 min (5 % to 95 % relative humidity) and for water content determinations in the range 45 min to 180 min.

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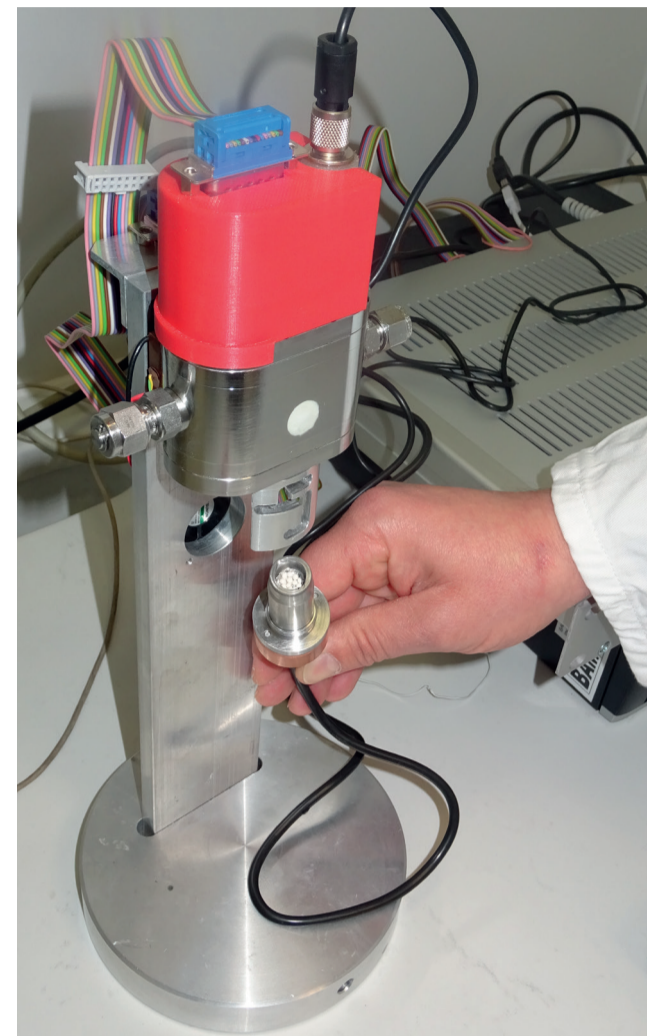


Figure 1: View on the MOISHUM measuring cell.

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### References

- <sup>[1]</sup> VDI/VDE 3514-2:2013-03, Measurement of gas humidity - Methods of measurement.
- <sup>[2]</sup> Shelly J. Schmidt, Jr. Anthony J. Fontana, Water Activity Values of Select Food Ingredients and Products in Water Activity in Foods, Vol. 1 (Eds.: Gustavo V. Barbosa-Cánovas, Anthony J. Fontana Jr., Shelly J. Schmidt, T. P. Labuza), Wiley-Blackwell, 2007, pp. 407-420.
- <sup>[3]</sup> E. Cepeda, R. O. de Latierra, M. J. San Jose, M. Olazar, Water sorption isotherms of roasted coffee and coffee roasted with sugar *International Journal of Food Science and Technology* 1999, 34, 3, 287-290.

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