Effect of relative humidity on the desorption of volatile organic compounds from paper and board

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Introduction

Paper and board are used for the packaging of moist food (e.g. pizza, baked goods) as well as dry food (e.g. sugar, pasta). According to Regulation (EC) No. 1935/2004, food contact materials must not have an influence on the organoleptic properties of foodstuffs. For testing the transfer of off-flavor (taint) from packaging to food via gas phase according to DIN EN 1230-2:2018, the relative humidity (rH) has to be adjusted (53 or 75% rH). In contrast, rH is not taken into account when testing the odor according to DIN EN 1230-1:2010, nor in chemical migration of volatile organic substances (VOC) onto the adsorbent Tenax® according to DIN EN 14338:2004.

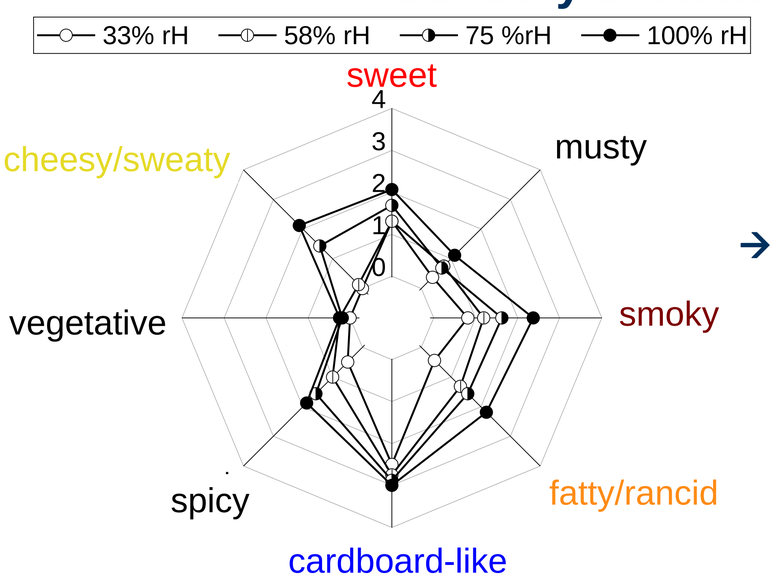
In this project, the effect of different rHs on the desorption of VOC from paper and board was investigated. For this purpose, the sensory profile of a paper incubated at four different rHs (33, 58, 75 and 100%) was evaluated. Additionally, migrates obtained at 33, 53, 75 and 100% rH were compared by GC-MS. Depending on the migration chamber, the paper was either in direct or indirect contact with Tenax®.

Conclusion

An increase in humidity resulted in a qualitatively as well as quantitatively changed odor profile. At **33 and 58% rH** the paper was described as **cardboard-like**, **sweet** and **smoky**. The increase to **75 and 100% rH** resulted in the additional perception of **cheesy/sweaty** and **fatty/rancid** impressions. The results of the sensory evaluations were confirmed by the analytical investigations: increasing humidity leads to an increase in VOC transfer. This effect was observed both with direct and indirect contact between paper and Tenax®. At **33 and 53% rH**, a much lower number of substances, primarily **aliphatic aldehydes**, could be detected. With an increase to **75% rH**, many **terpenoids, aromatics and carboxylic acids** were detected additionally. An increase of the rH to **100%** resulted in the detection of more **terpenoids** as well as the strongest increase in peak areas of all substances.

As consequence, the rH should be set to a defined level when determining the transfer of VOC from paper and board packaging according to DIN EN 14338:2004 as well as in testing their odor according to DIN EN 1230-1:2010.

Sensory evaluation



→ **Increasing rH results in:**

- **increasing intensity** of all odor categories
- especially the attributes **cheesy/sweaty** and **fatty/rancid** increased

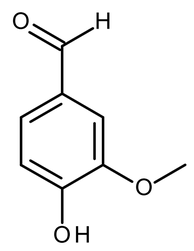
Fig. 1. Sensory profiles (according to DIN EN 13299:2016) of the paper (6 dm^2) incubated at different rHs for 24 h at 23 °C; average intensities assessed by 8 trained panelists.

GC-Olfactometry of extracts

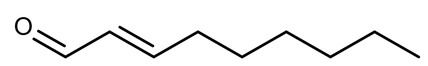
VOC isolation by simultaneous distillation-extraction of 12 g paper, concentration to 0.5 mL, GC-FID/OPD and GC-MS using DB-5 and DB-WAX column

→ **Impact substances for the odor categories:**

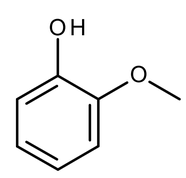
vanillin
sweet



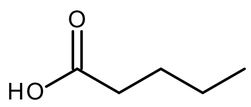
(E)-2-nonenal
cardboard-like



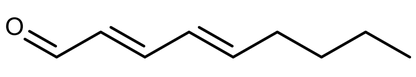
2-methoxyphenol
smoky



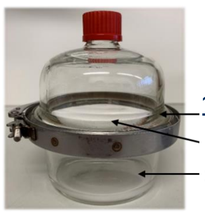
short chain fatty acids
cheesy/sweaty



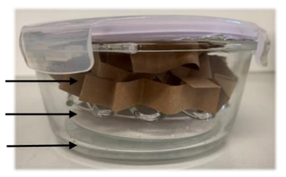
di-unsaturated aldehydes
fatty/rancid



Migration to Tenax®



Sample: kraftliner for corrugated board (80% long fiber softwood, 20% recycled fiber)
Migration conditions: 48 h, 23 °C, rH adjustment by saturated salt solutions of $MgCl_2$ (33%), $Mg(NO_3)_2$ (53%), NaCl (75%), H_2O (100%)



Direct contact (touching)

according to DIN EN 14338:2004

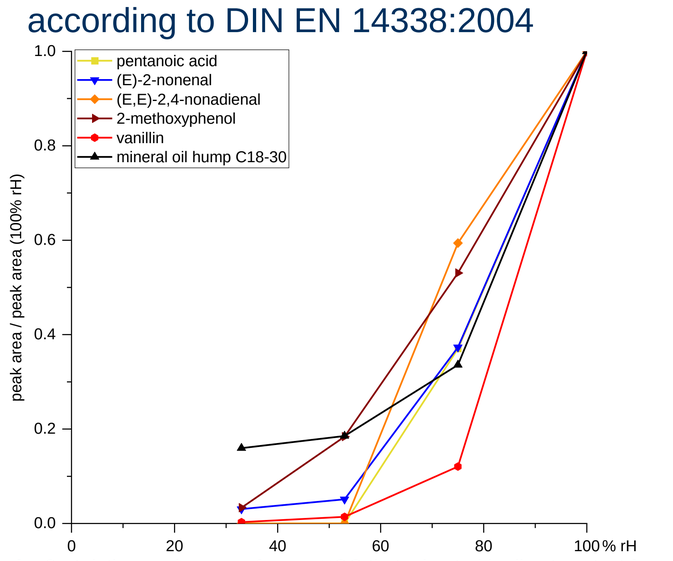


Fig. 2. Relative peak areas of some VOC that migrated in direct contact from paper to Tenax® at different rHs, representative examples of different odor and substance classes.

→ **Increasing rH results in:**

- **exponential increase** of peak areas for all substances
- **strongest effect at 75 and 100% rH** like in sensory evaluation
- **polar substances** are **more influenced** by increasing humidity
  → this effect is stronger during migration in indirect contact

→ **Direct vs. indirect contact:**

- higher amount of migrating substances in direct contact than in indirect contact, especially for lower volatile compounds

Identified substances:

number of substances and mainly identified substance groups

26	**33% rH:** mainly aliphatic aldehydes and terpenes	29
29	**53% rH:** some additional alcohols	34
48	**75% rH:** additional carboxylic acids, aromatics, terpenoids	45
56	**100% rH:** additional terpenoids	50

Indirect contact (gas phase)

according to DIN EN 1230-2:2018

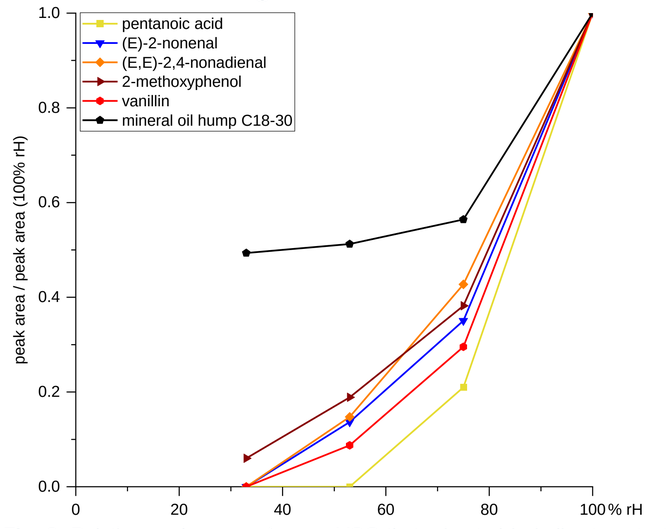
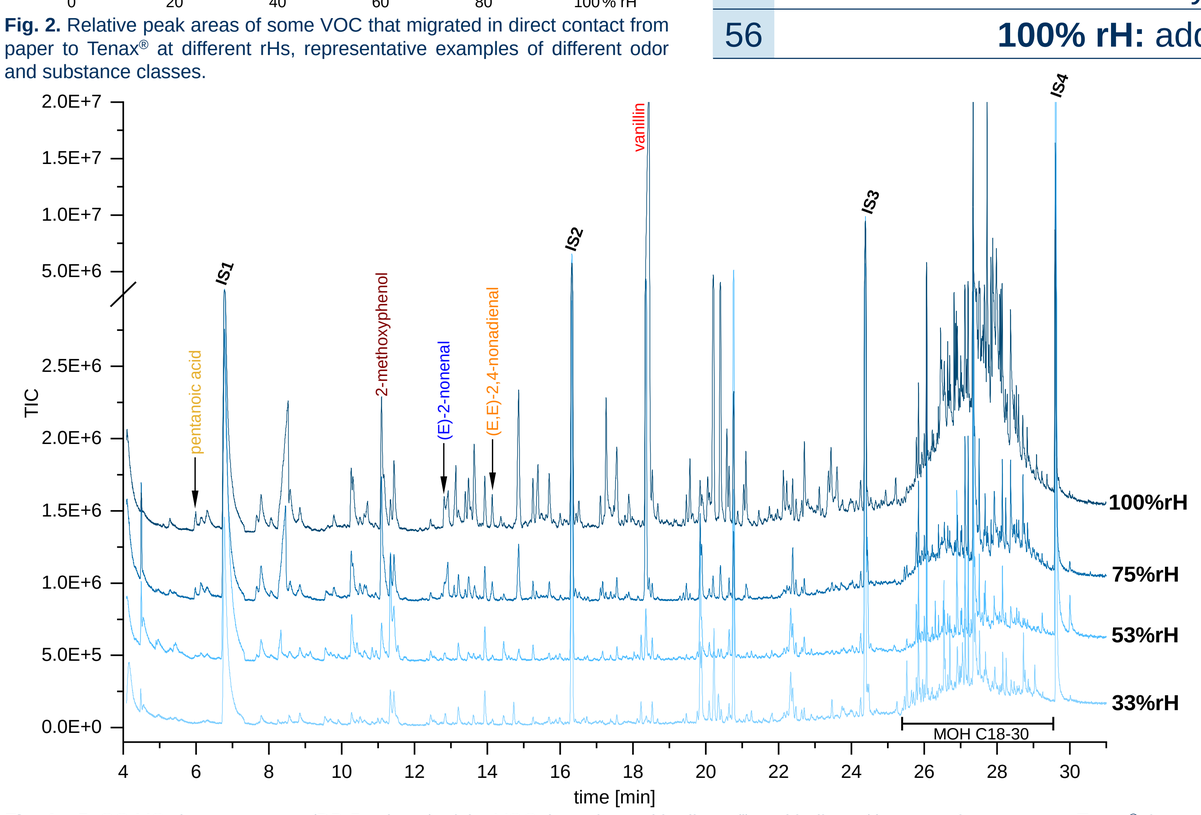


Fig. 3. Relative peak areas of some VOC that migrated in indirect contact from paper to Tenax® at different rHs, representative examples of different odor and substance classes.



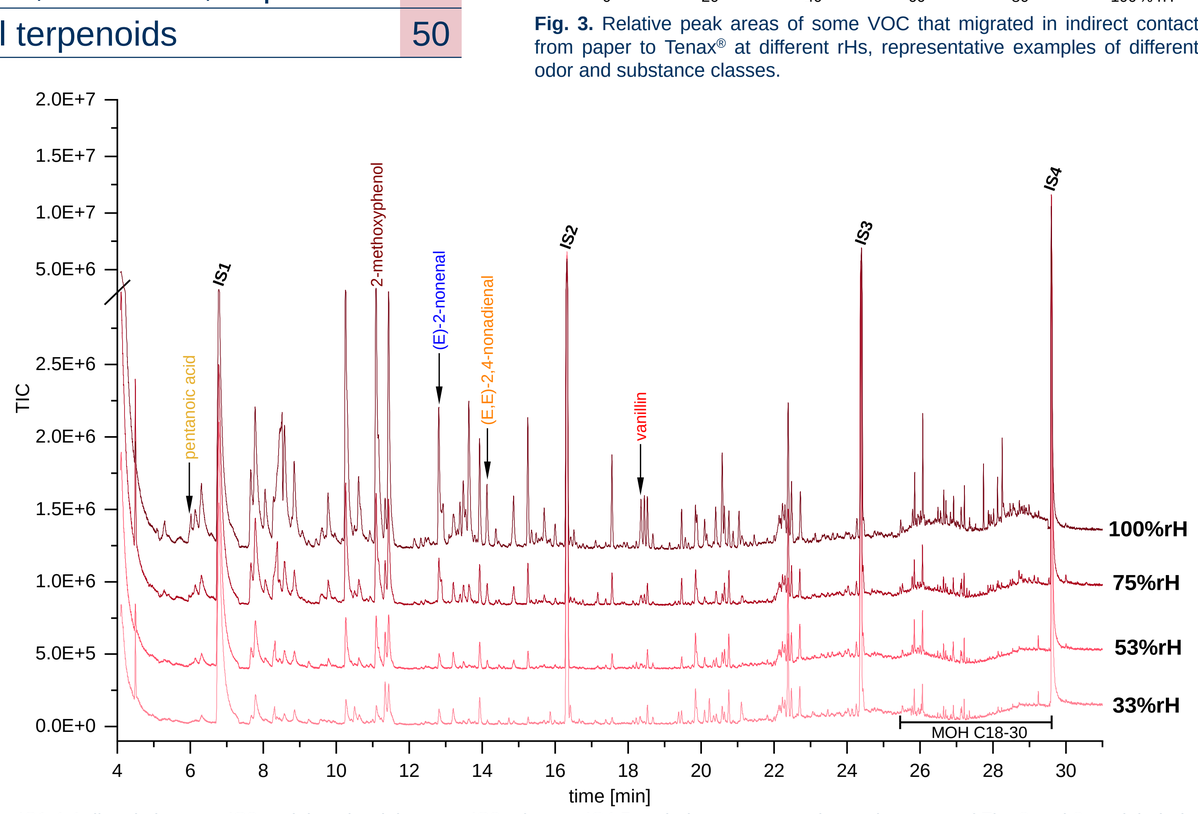


Fig. 4 + 5. GC-MS chromatograms (DB-5 column) of the VOC that migrated in direct (l) and indirect (r) contact from paper to Tenax®; internal standards: IS1 4,4-dimethyloctane, IS2 cyclohexylcyclohexane, IS3 pristane, IS4 5-α-cholestane; exemplary substances of Fig. 2 and 3 are labeled.