



Permeation of volatile organic compounds into packaged beer

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Tools for practice oriented simulation and analysis

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The Science of Beer



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tool for advanced packaging testing, simulation of long term beer storage/distribution

~~Tools for practice-oriented simulation and long term beer analysis~~

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VOC permeation and flavor/product stability?

- industrial brewing is a highly optimized process, huge efforts are made to ensure stable and consistent products

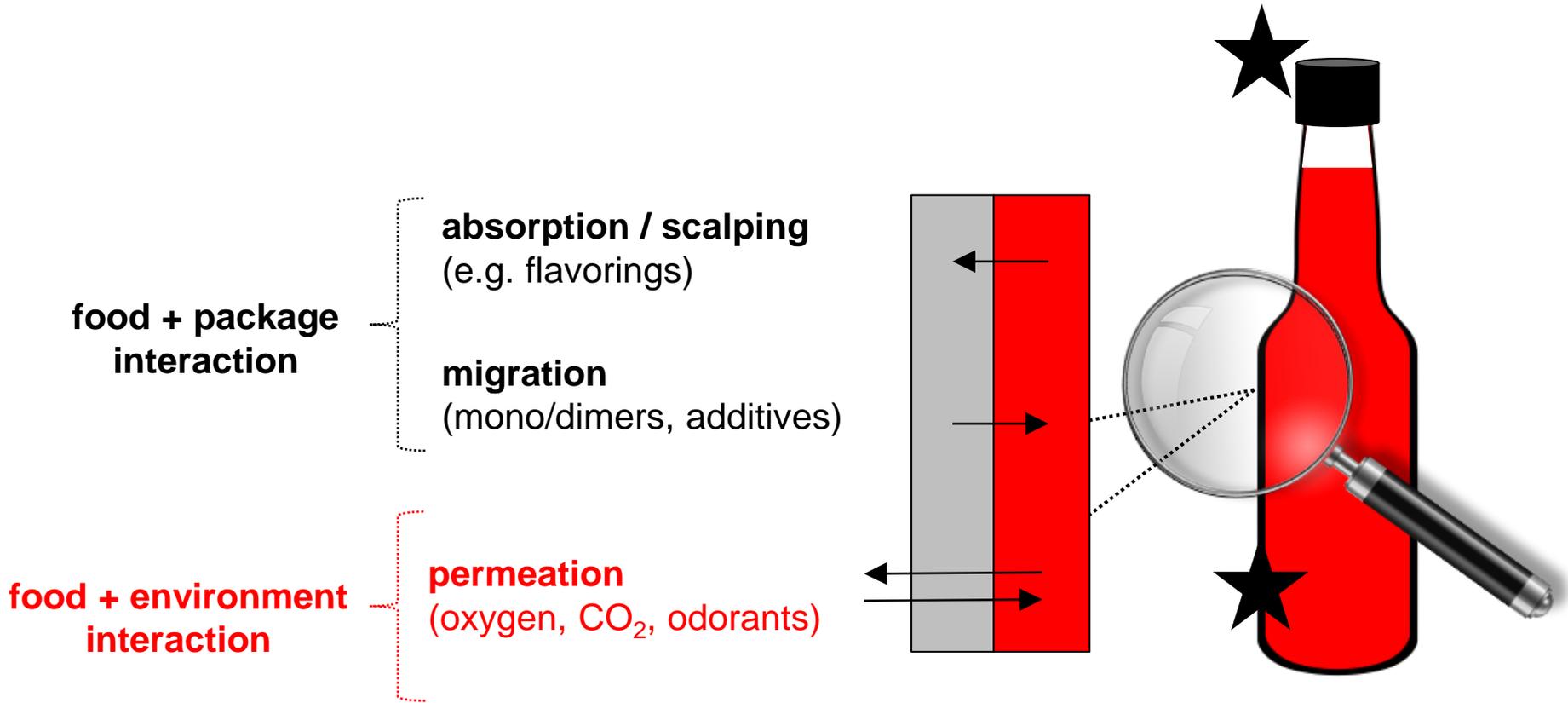
Measures of “control” when packaged products leave the brewery (distribution and storage at point of sale)?

... best as possible product protection by packaging!

- light ?
- oxygen uptake ?
- atmosphere containing aroma compounds (VOC) ?

Interaction between food and packaging material

- packaging needs to ensure high product quality
- minimize environmental impact



A non comprehensive list of influencing factors

Package type

Surface

PET > glass + can

PET technology

- blends
- multilayer
- use of additives

Sealing

- closures materials
- use of liners
- material of liners and compounds

Env. conditions

- concentration (difference)
- temperature
- time

VOC structure

- carbon chain length
- functional groups
- boiling point
- molecular weight

Shimoda et al. (1988), J Sci Food Agric 42

Linssen et al. (1991), Int Dairy J

Strandburg et al. (1991), Food and packaging interactions

Charara et al. (1992), J Food Sci 57

Permeation of VOCs through packaging materials might impair food quality. What are the origins of VOCs?

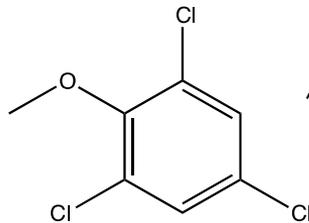
- VOCs are widely spread - highly polluted areas are related to traffic / filling stations / power generation / use of dyes and solvent

In special regard to beer distribution:

- improper storage and transport (especially long distance) can lead to an exposition of packed foods to VOC-enriched atmosphere
- certain packaging material (freight containers, wood, cardboard, etc.) release VOC in close contact to beer

TCA or “the wine cork taint”

- degradation of chlorophenols used in wood preservation (e.g. 2,4,6-Trichlorophenol =TCB) releases a series of potent odorants
- 2,4,6-Trichloroanisol (wine cork taint) is most famous and feared
- extremely low flavor threshold in water (3 ng/L) and wine (14 ng/L)
- has been traced in beer (massive customer complaints)



Literature on VOC permeation

G. Möller-Hergt et al. (2003) – Warsteiner Brewery, Germany

- a “permeation model” using highly concentrated naphthalene was introduced
- naphthalene was traced in cans, glass bottles and PET
- resistance against naphthalene was proposed as a quality parameter for packaging materials

M. Orzinski (2007) – VLB Berlin / TU Berlin

- VOC permeation through PET bottles was studied using toluene and limonene
- PET bottles/closures differed in respect to their barrier properties
- no correlation VOC/Oxygen/CO₂ permeation

= VOC permeation is relevant for all common packaging materials

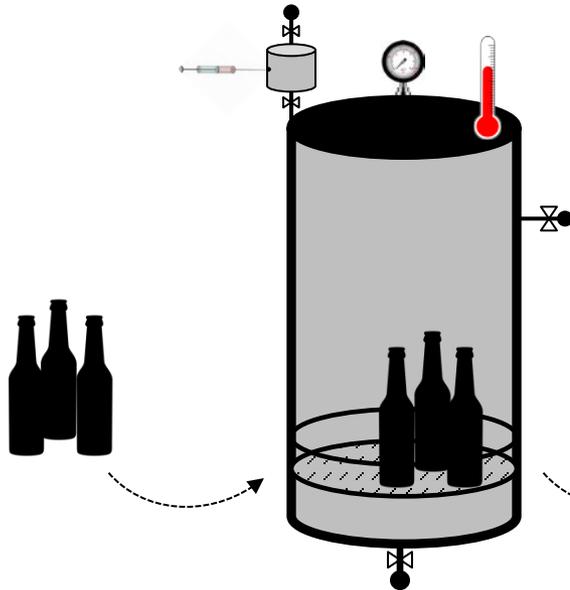
Simulation of permeation of VOC into beverages

Aims:

- screen the barrier properties of packaging materials towards VOCs
- ensure high packaging standards by a “near real life” testing system
- precautionary measure

Packaging testing - Experimental setup

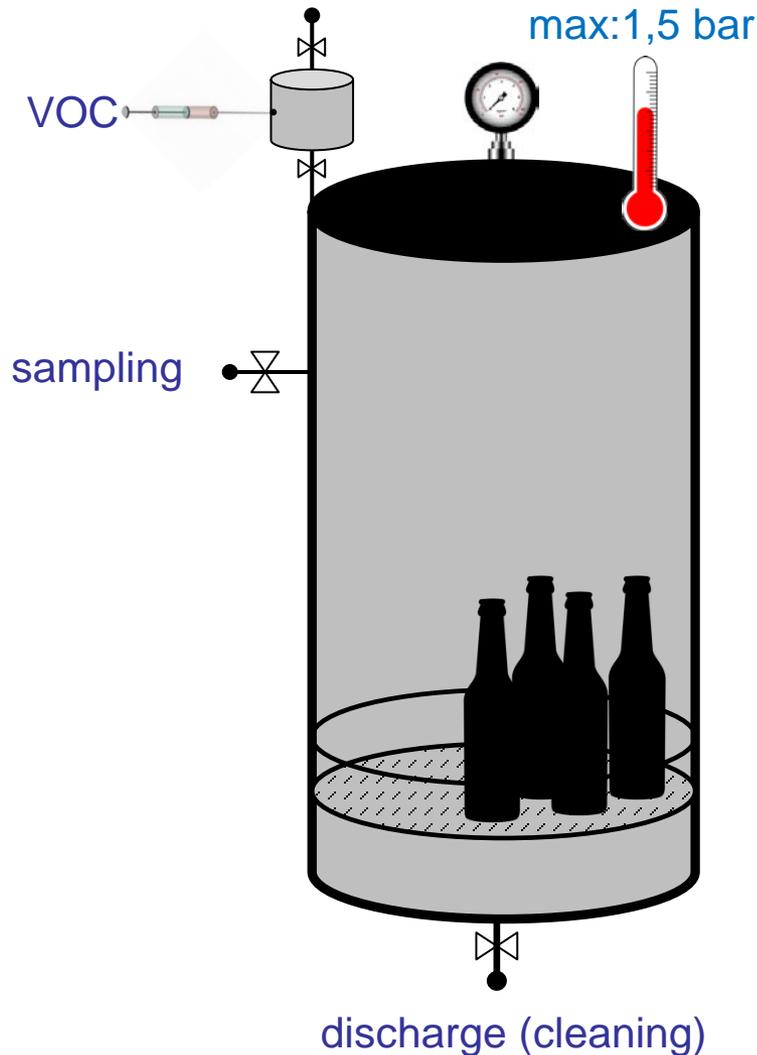
1) incubation of packaging materials in a defined, VOC-enriched atmosphere.



2) Quantification of VOC in beverages or beverage simulants by means of GC-MS and GC-MS/MS



1) Incubation in 150 L stainless steel vessels



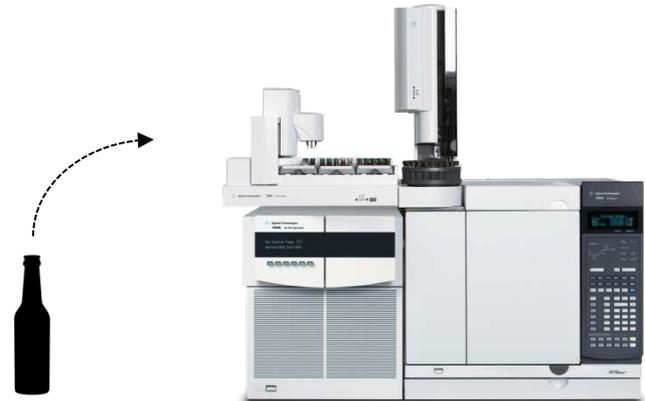
Parameters to be varied :

- pressure
- temperature
- relative humidity
- use multiple VOCs (different chemical properties i.e. polarity)
- VOC concentration
(5 – 25 - 50 mg/150L)
- duration
(2 – 4 – 6 weeks)

2) VOC analysis – sensitivity is required!

- previous works: lack of sensitive analytical assays – therefore harsh reaction conditions (e.g. 1g/L naphthalene, 40°C)
- in practical assays VOC concentrations are low (<μg/L)
- advantage of incubation: Targeted analysis
- GC with mass selective detection (SIM / MRM)
- highest demands for calibration, standards, blind values,...

2) Quantification of VOC in beverages or beverage simulants by means of GC-MS and GC-MS/MS



Case study 1:

Screen different closures and liner materials for PET bottles in respect to their “VOC barrier properties”

- Incubation of PET bottles under benzene, octane, and hexanol atmosphere
- Stable isotope dilution assay
- LLE + GC-MS

experiment to look at closures and liners only

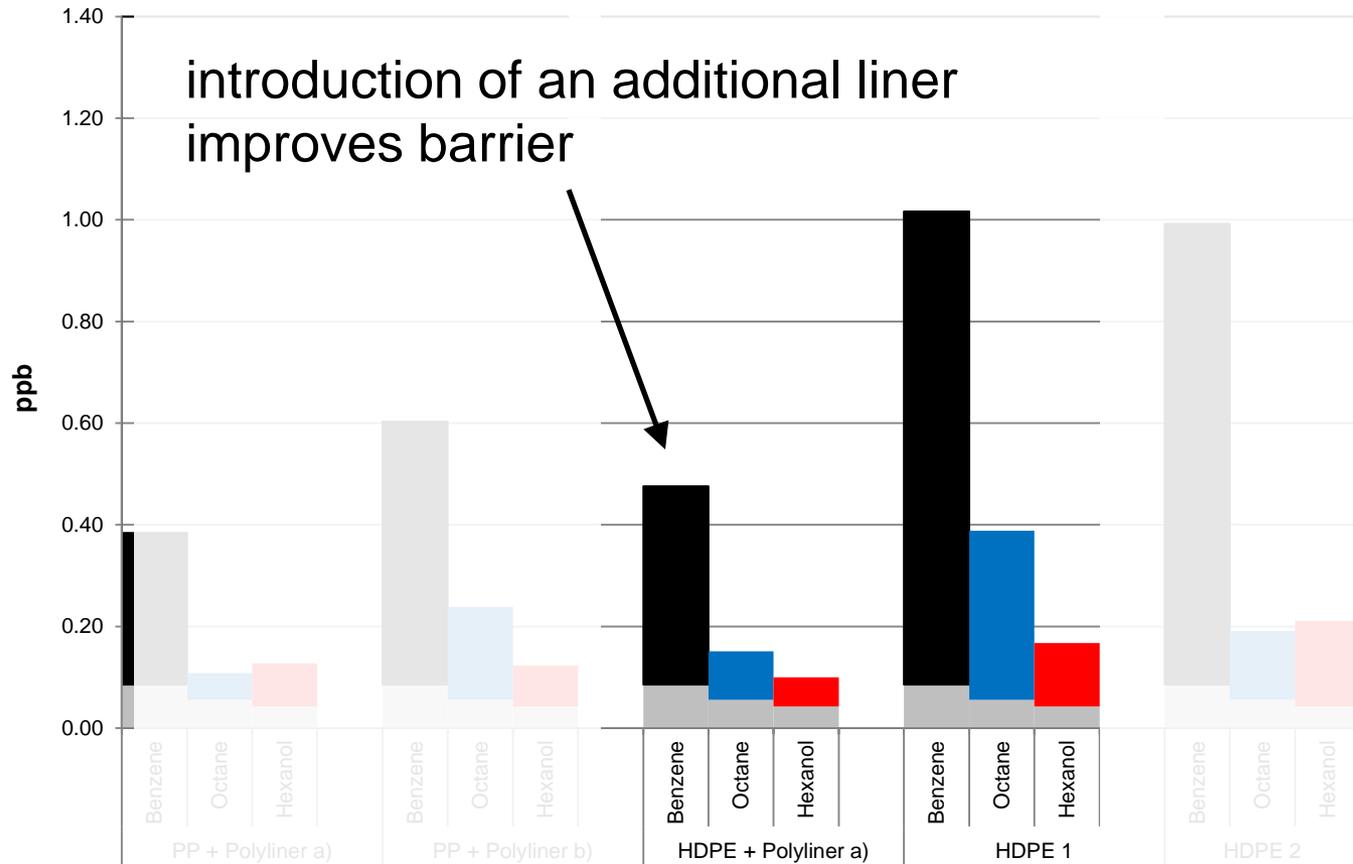


- 1) special multi-layered cap that doesn't allow any permeation (VOCs found in those bottles passed to bottle itself and not the cap)
- 2) closures and liners to be checked for barrier properties (VOS found in those bottles passed cap and bottle)
- 3) subtract the concentration of VOC that have passed the bottle to obtain information about the cap barrier

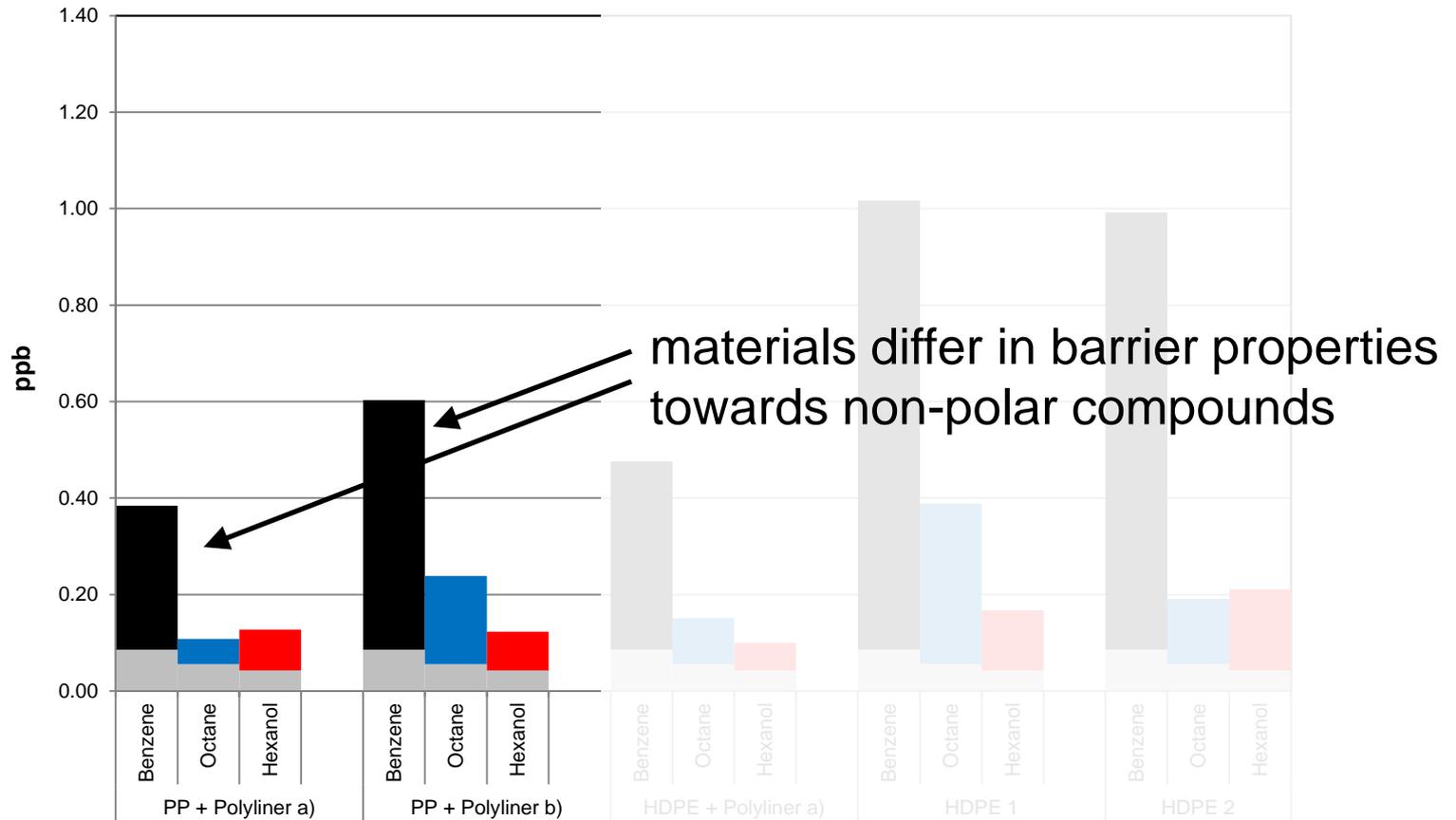
Permeation – closure vs. bottle wall (PET)



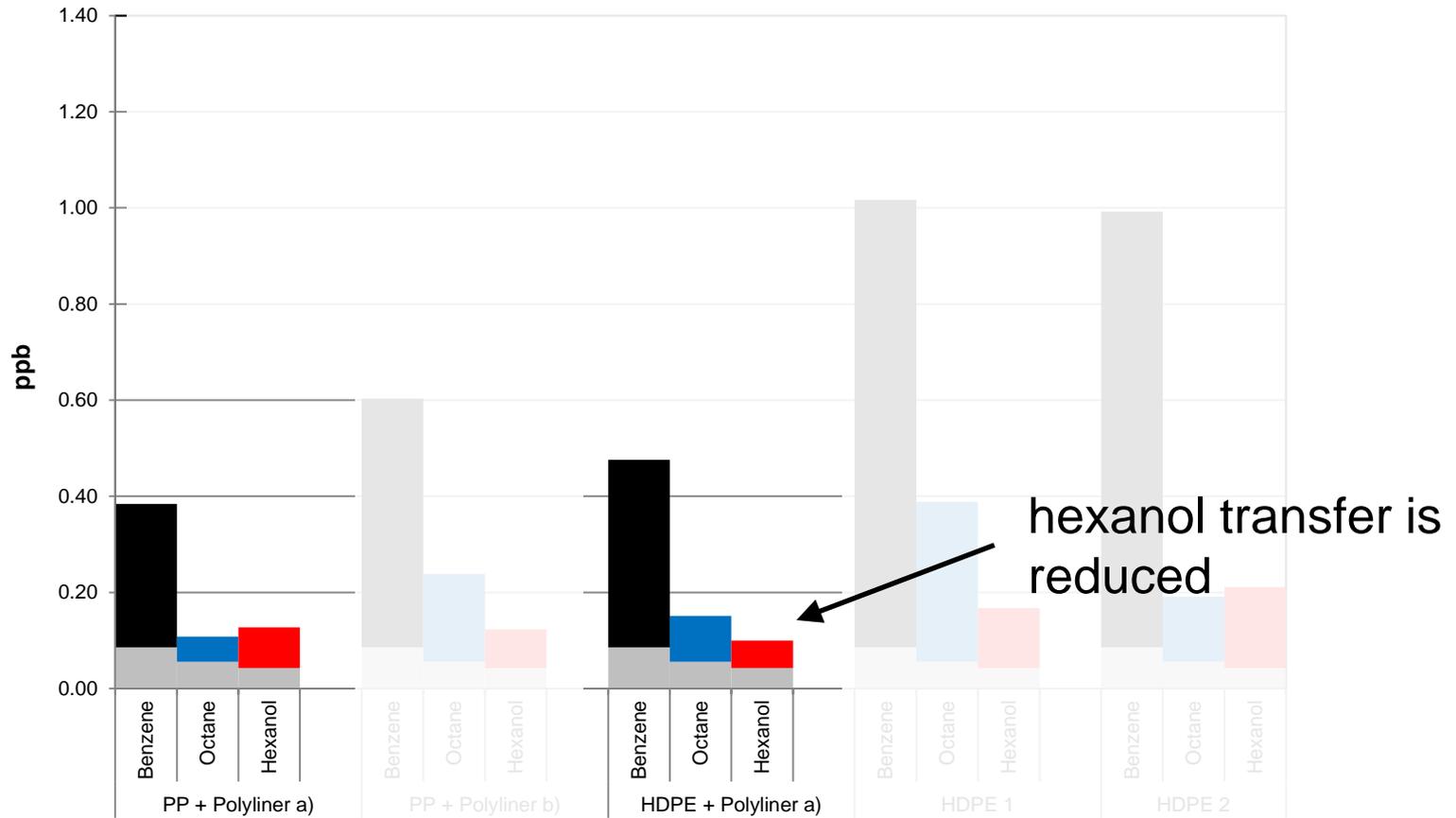
Permeation – effect of using cap liners



Permeation – effect of liner material



Permeation – effect of cap material

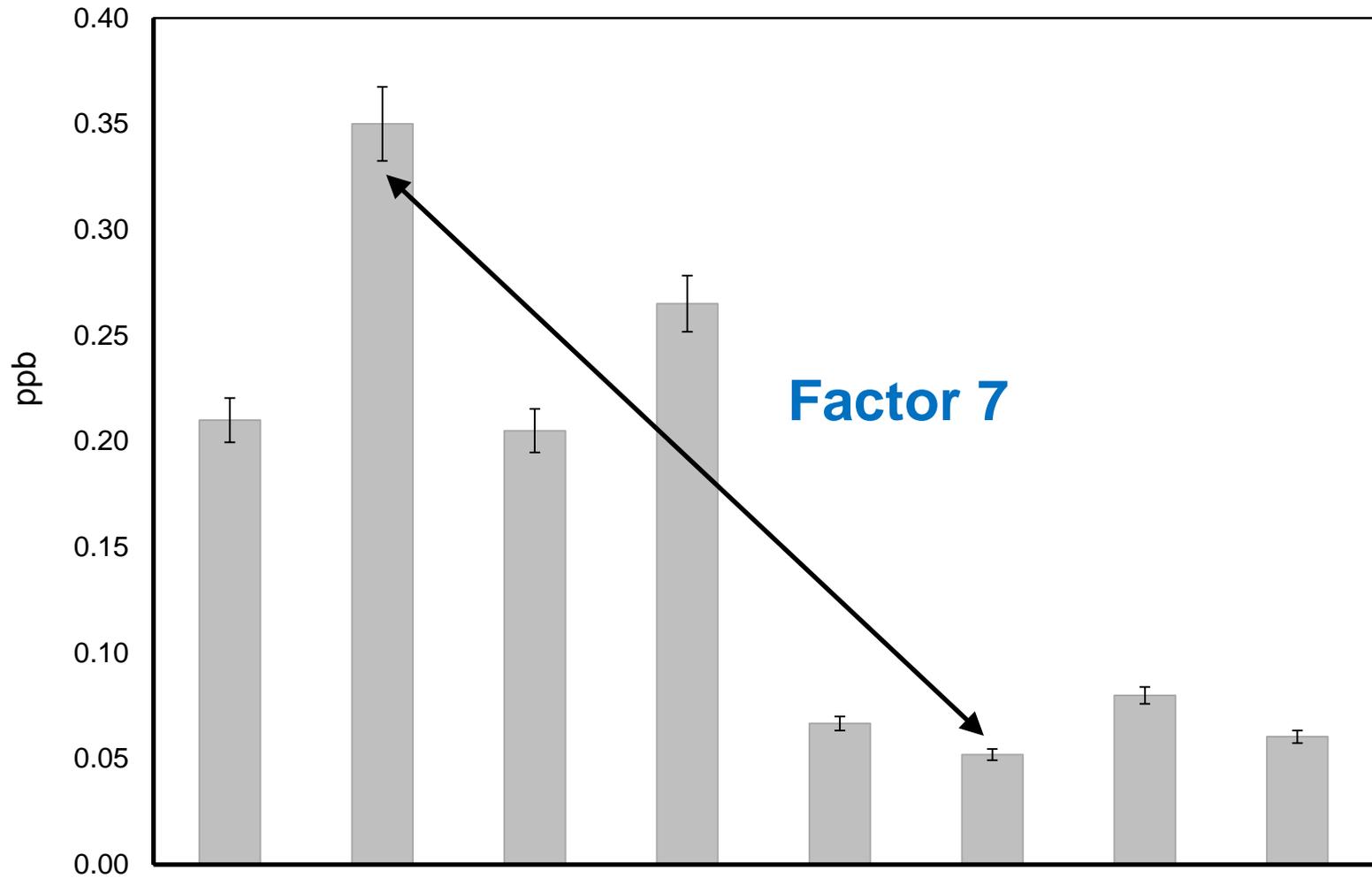


Case study 2:

Crown liner barrier testing towards TCA

- Incubation of glass bottles with 8 different crown liners
- Stable isotope dilution assay using D₅-TCA
- GC-MS/MS analysis

Crown liners vs. TCA



Summary

- odor active Volatile Organic Compounds (VOC) can permeate into foods and beverages
- odorants such as TCA can impair the product quality and cause customer complaints
- rate of permeation depends on numerous environmental factors, most importantly those can not/hardly be controlled by brewers
- VOC permeation can be reduced/prevented by choosing best available packaging materials
- permeation testing is performed to evaluate the barrier properties of (new) packaging materials

Thank you very much!

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