Breakthrough Curves of Propane at Different Relative Humidities

R. Eschrich[1], C. Reichenbach[1], A. Möller[1], A. Seidler[1], D. Klank[1], D. Forberg[2]

[1] Quantachrome GmbH, Odelzhausen/D

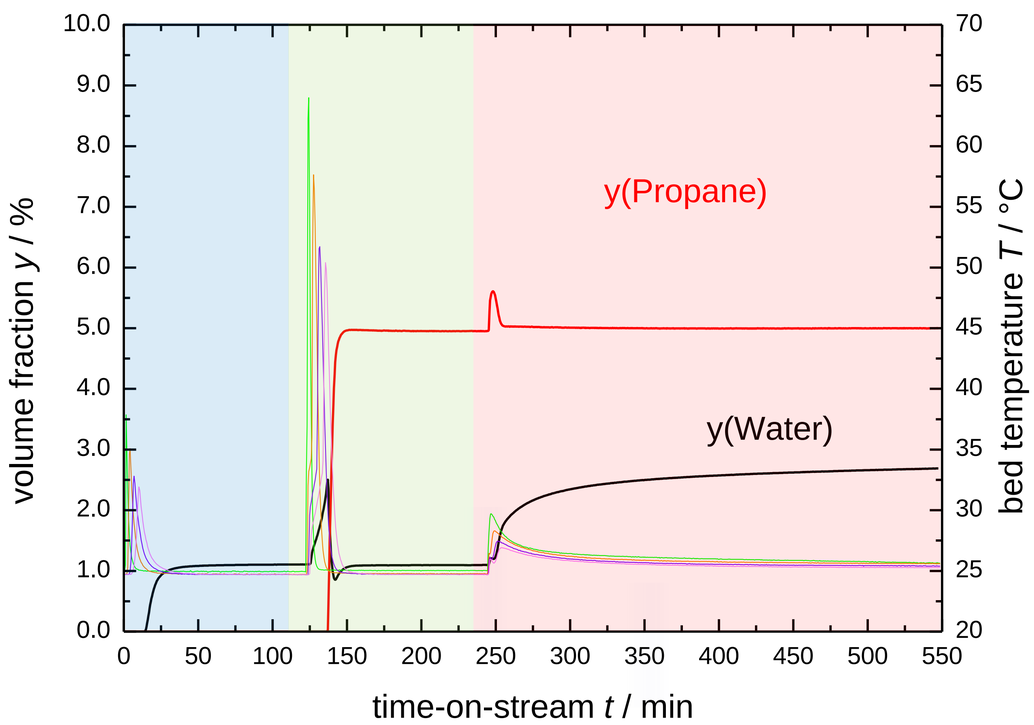
[2] helsatech GmbH, Bayreuther Straße 9-11, 95482 Gefrees

Introduction

In many separation processes, the adsorption of different components takes place in the presence of water. In fact, the competitive adsorption of water can have a tremendous influence on the separation performance of the adsorbents. This is important for waste air and indoor air cleaning but also for health protection gas masks.

However, often also the preconditioning of the samples has a large effect. The adsorption of propane in the presence of water was investigated on an activated carbon at 298 K and 1 bar with a flow rate of 4000 mL min^{-1} with a dynaSorb BT coupled with a Pfeiffer ThermoStar mass spectrometer.

Sequence of Three Breakthrough Curve Experiments



Segment 1

volume fraction $y(H_2O)$ = **0.95 %**,
relative humidity approx. **30 % @ 25 °C**

Segment 2

volume fraction $y(C_3H_8)$ = **5.00 %**,
volume fraction $y(H_2O)$ = 0.95 %,
relative humidity approx. 30 % @ 25 °C

Segment 3

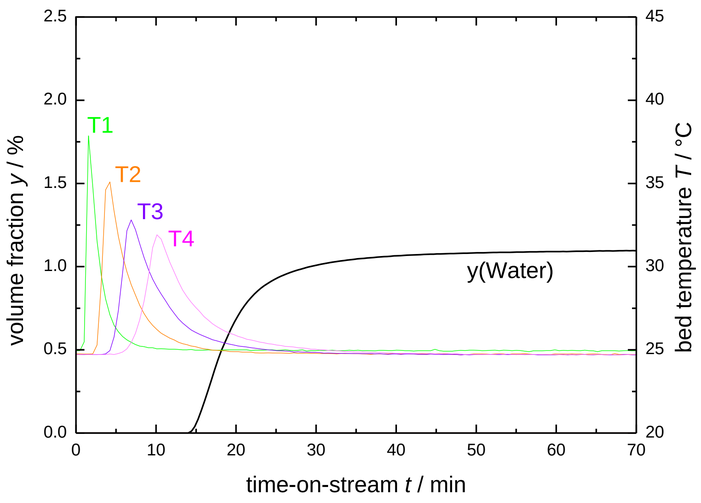
volume fraction $y(C_3H_8)$ = 5.00 %,
volume fraction $y(H_2O)$ = **2.70 %**,
relative humidity approx. **85 % @ 25 °C**

dynaSorb BT

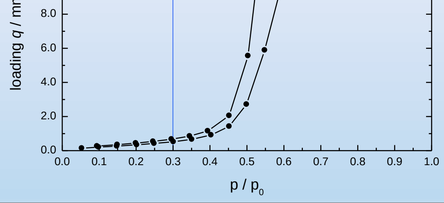
Breakthrough curves were recorded with a dynaSorb BT by Quantachrome Instruments. The results were compared to high pressure propane isotherms (measured with an iSorb HP) and water isotherms (measured with an AutoSorb iQ)

Segment 1

Breakthrough of RH 30% @ 25 °C

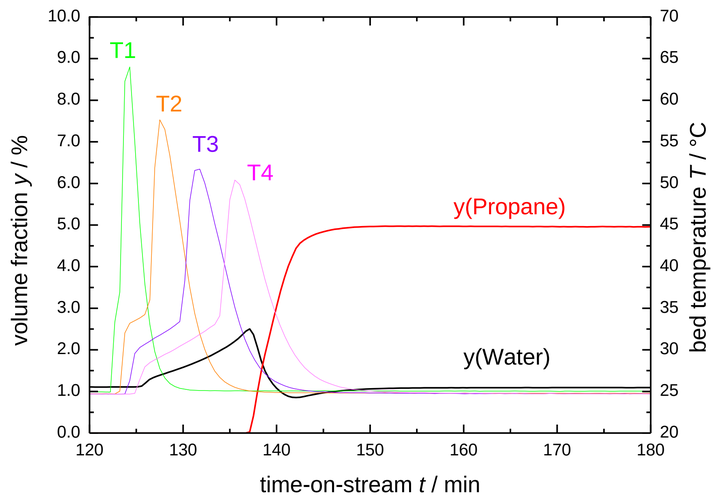


- Breakthrough curve and temperature curves show regular shape
- **No distinct condensation** observable
- Loading: $q(H_2O)$ = **0.64 mmol g^{-1}**
- Very good agreement with water isotherm measured on an AutoSorb iQ

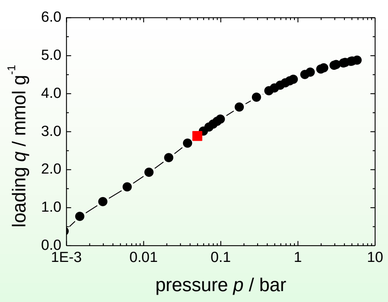


Segment 2

Breakthrough of Propane in N_2 with RH 30% @ 25 °C



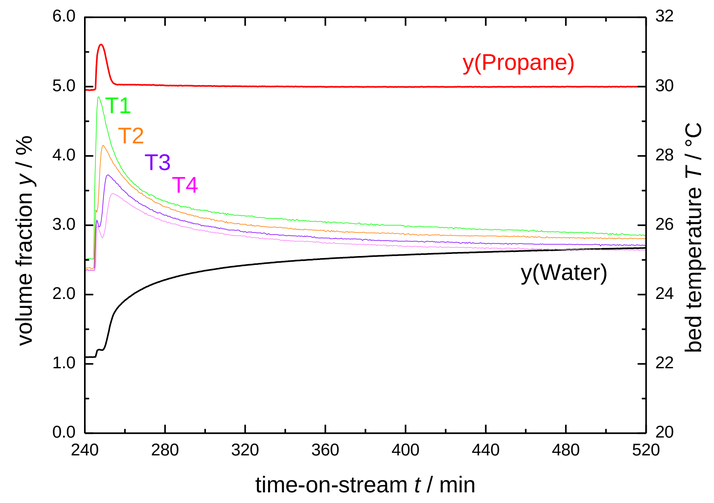
- Loading: $q(C_3H_8)$ = **2.84 mmol g^{-1}**
- Good agreement with loading at dry conditions: **2.88 mmol g^{-1}** and isotherm



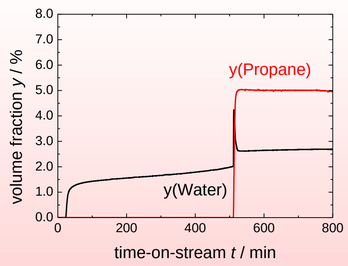
- Heat of adsorption by propane is used to desorb water
- Released water can now adsorb in the next adsorbent layer, which is also exothermal process.
- Small slope on the temperature, before big peak caused by propane adsorption

Segment 3

Increasing RH to 85 % in the presence of Propane



- **Only little displacement** of propane
- Not equilibrated after 5 h → very slow process
- **Condensation** of water in the pores
  → No replacement of propane on the surface
- When the experiment is performed inverted (1. breakthrough curve with RH 85 % and 2. adding propane)
  → Only small propane loading (**0.79 mmol g^{-1}**)



- When adsorbent is pre-saturated with high RH → pore filling → limited access to adsorption sites

Conclusions

It could be shown that the propane loadings for rel. humidity between 0 and 30 % are similar. The loadings calculated by integrating the breakthrough curves are very consistent with volumetrically determined equilibrium data. For a high humidity, large differences could be observed. An increasing humidity after a propane breakthrough has only a small effect, whereas a drastic reduction in the propane loading at a previously strongly humidified activated carbon is observed. Thus, in a dynamic process, the order in which the offered gas compositions are varied is very important. Furthermore, the influence of the conditioning could be demonstrated. Too short selected humidification of the adsorbers can lead to misjudgments in the interpretation of the breakthrough behavior. In the present case, the exact temperature measurement within the fixed bed by the instrument helped to correctly evaluate the results.

www.dynamicsorption.com
www.quantachrome.de

Quantachrome GmbH & Co. KG
Tel. +49 8134 9324 0
Fax. +49 8134 9324 25
info@quantachrome.de