Zeolites loaded with VOCs as reference for materials emissions testing

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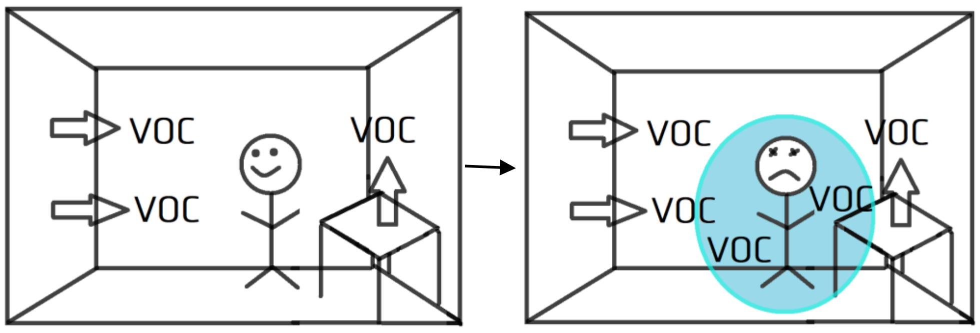
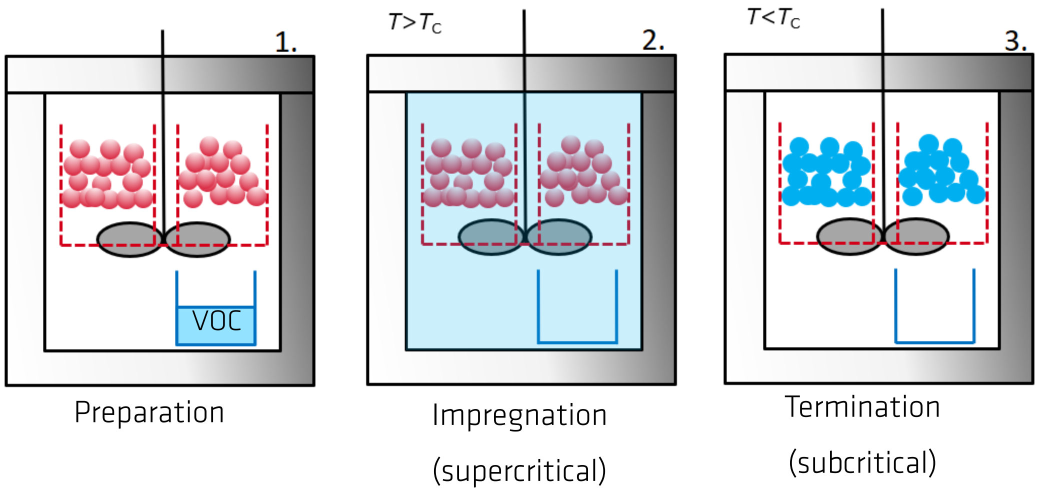
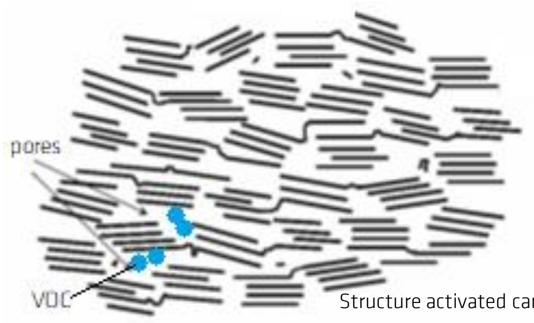
Since volatile organic compounds (VOCs) emitted by furniture and building materials can cause health issues, low emitting materials should be used to improve the indoor air quality. For quality assurance and control (QA/QC) purposess an emission reference material (ERM) with predictable emission rates of VOCs is required. In this project, we studied the use of porous materials impregnated with VOCs as constantly emitting ERM with less than 10% change of the emission rate over 14 days.



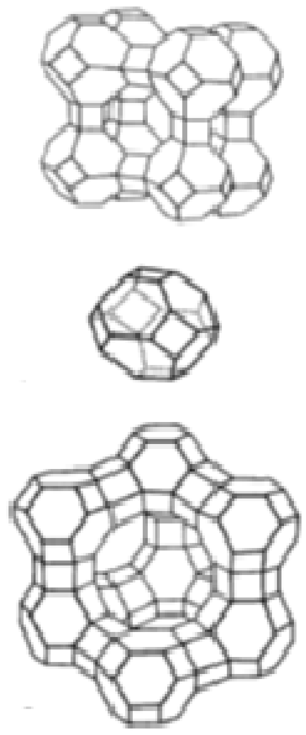
Impregnation process

For impregnation, the porous material and the VOC are added into the autoclave which is then closed and CO_2 is introduced. The autoclave is heated up until the supercritical state (73.75 bar, 31 °C) of CO_2 is reached. The CO_2 in the supercritical state functions as a solvent for the impregnation. With the help of a stirrer, the basket, containing the porous material, is flushed by the CO_2/VOC mixture. For leaving the supercritical state, the pressure and/or temperature is slowly lowered to ambient conditions. The idea is that due to the regular pore structure of zeolites, the release of VOC will be more constant compared to those from the carbons.





Structure activated carbon


Sodalite cages, structure zeolites

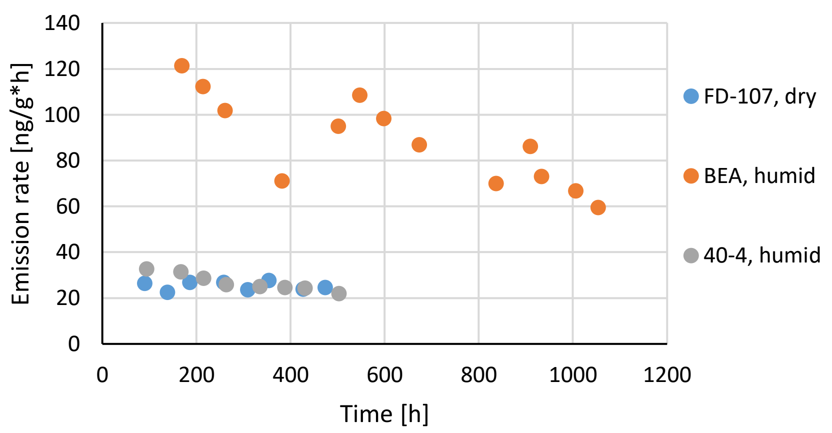
Measurements

The impregnated samples are placed into emission test chambers (here: 270 L chambers). Emission samples were taken every 2–3 days using Tenax® TA tubes. Those were analyzed using a gas chromatograph (GC) coupled to a mass spectrometer (MS).

Results

By variations in pressure, temperature and impregnation time the impregnation process was optimized. Testing different zeolites in dry air, it was found, that such a material can achieve the projects' aim of less than 10 % change in emission rate over 14 days (5.0% change). However, emission tests have to be carried out at a relative humidity of 50 %. For these "regular", hydrophilic zeolites no emission was found under humid testing conditions. In contrast, non-hygroscopic zeolites (with Si/Al ratio > 150) exhibit a change in emission rate of 16–35 % over 14 days. Another non-hygroscopic and porous material type is (activated) carbon. The change in emission rate of tested carbons is worse (29.4 %) but after ~200 h the emission rate becomes more constant (20-30%). The next step is to try to reduce the change in the emission rate of these materials to achieve the target change of ≤ 10% over 14 days.

Comparison of materials impregnated with hexane



Further VOC tested
Heptane
Toluene
N-Hexane
2-ethyl-1-hexanol
Butylglycol
N-Hexadecane

Conclusion

The emission behavior of impregnated zeolites in dry testing conditions already exhibits the desired stability of ≤ 10 % change in emission rate over 14 days. Furthermore, it was proven, that non-hygroscopic zeolites and activated carbons can be used for humid testing conditions, though the change in emission rate is yet relative high (20–35 % change). It is focussed on continuing the study of the influence of material properties like the pore build-up on the stability of emission, and finding better candidate materials or functionalization for the presented materials. In addition the number of VOCs that are tested is enhanced. Their results are pending.

Sicherheit in Technik und Chemie

References: EN (2020). Construction products - Assessment of release of dangerous substances - Determination of emissions into indoor air (EN 16516:2020). Beuth, Berlin.
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