Combination of different methods to characterize surface chemistry of activated carbons

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**Highlights**

* New and improved methods for characterization of surface chemistry
* Chemical modification changes surface chemistry but not structural properties
* Increasing number of acidic oxidic surface groups increases polarity
* Change in surface chemistry shows hardly any effect on the heat of adsorption

**1. Introduction**

Carbonaceous adsorbents such as activated carbons are used in many technical adsorption processes. Depending on the raw material and the activation conditions, these materials may have different properties. Adsorption is significantly influenced by structural properties and surface chemistry. To characterize structural properties well established methods are available like mercury porosimetry and nitrogen adsorption. At the same time, the impact of surface chemistry on adsorption is not well understood for activated carbons. The aim of the project is to improve the characterization of the surface chemistry of activated carbons and to distinguish between the influence of surface chemistry and structural properties on adsorption.

**2. Methods**

In this project activated carbons are investigated, which differ systematically in surface chemistry due to chemical modification. To characterize surface chemistry, new and improved methods such as Boehm titration, the measurement of excess isotherms as well as the coupling of volumetric and calorimetric measurements are used. The structural properties are analyzed by nitrogen adsorption

Boehm titration enables quantitative determination of acidic oxidic surface groups of activated carbon using different bases. The ratio of polar, non-polar and aromatic surface groups can be described by excess isotherms [1]. These isotherms reflect the adsorption preference between two competing sample molecules as a function of mole fraction in the liquid phase and thus provide additional information about surface polarity. By coupled volumetric and calorimetric measurements the adsorption enthalpy can be determined, which is a parameter for the strength of interactions in adsorption and allows an energetic characterization of the adsorbent surface [2].

**3. Results and discussion**

The activated carbon surface was oxidized using nitric acid (HNO3). The chemical modification changes the surface chemistry whereas structural properties largely remain the same. Boehm titration shows that the number of acidic oxidic surface groups increases with increasing concentration of HNO3.

In excess isotherms the rising number of acidic oxidic surface groups leads to an increasing ratio of adsorbed polar component over adsorbed aromatic and non-polar components. The increased affinity for the polar adsorptive indicates an increasing polarity of the activated carbon.

In contrast, the heats of adsorption of acetone, toluene and n-heptane are almost identical for the original and for the chemically modified activated carbons . This suggests that the strength of the interactions between surface and adsorptive molecules are dominated by the energetically heterogeneous multimodal pore size distribution of the activated carbon. The surface chemistry plays only a minor role.

To investigate the influence of structural properties in detail, activated carbons manufactured under different activation conditions will be characterized.

**4. Conclusions**

The combination of different methods enables to distinguish between the influence of structural properties and surface chemistry on adsorptive properties. The investigations were carried out on activated carbons with the same structural properties but different surface chemistry. A rising number of acidic oxidic surface groups results in an improved adsorption of a polar component in a binary mixture and increases the polarity of the activated carbon. In contrast, an influence of surface chemistry on the strength of the interactions between surface and adsorptive molecules could not be detected.

**References**

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