

CUSTOMIZED HUMIDITY CONTROL FILTERS FOR ENCLOSED AND VENTED SYSTEMS

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Introduction

The moisture level within electronic enclosures is usually maintained and regulated for proper operation. Outside specified ranges, moisture can interfere with mechanical and electrical operations of the components and equipment. For example, the interior of a hard disk drive (HDD) generally requires a relative humidity different from that of its external environment. HDDs typically have a breather port as part of the enclosure in order to allow air to enter and exit from the drive. In such applications, high humidity can lead to corrosion of susceptible components of the drive and too little humidity can lead to static electricity which can damage sensitive electrical components.

Adsorbents are generally employed to control the level of humidity inside enclosures. Each application, however, has specific relative humidity requirements and thus adsorbents must be chosen so as to perform properly in each particular relative humidity range. High capacity and efficiency is increasingly required since most of the enclosures assemblies are getting smaller and the size of the filter is becoming a critical factor. In general, the choice of the adsorbent is based on its ability to control humidity in a given range, the nature of its surface chemistry and its water adsorption capacity [1].

In this study, the water adsorption isotherms of adsorbent materials are customized by chemically modifying the surface chemistry of activated carbon adsorbents using different methods and to varying degrees of modification. In addition to water, such modifications can also enhance the adsorbing capacity and efficiency of the adsorbent toward low molecular weight water-soluble compounds [2].

Experimental

The base adsorbent/absorbent materials used in this study are zeolites, silica gel, activated carbon and superabsorbent polymer. Two activated carbons, labeled as Carbon C and Carbon F, of different surface chemical and structural properties were chosen. The surface properties of the activated carbon adsorbent was modified by introducing chemical functionality through surface reactions or impregnation with a series of compounds that vary in their chemical nature. The chemical compounds are classified as acids, bases and salts. Samples of the two adsorbents were soaked in solutions of the above compounds while stirring. The impact of time, concentration, and mass-to-volume ratios on the extent of modification are evaluated in this study

The amount of acidic and basic groups on the surface of activated carbon adsorbents is determined using Boehm

titrations and calculated from the amount of NaOH and HCl that reacted with the carbon, respectively [3].

The pH of the initial and modified carbon samples is measured by adding 20ml of water to a 0.4g of dry carbon powder. The suspension is stirred overnight to reach equilibrium. Then the sample is filtered and the pH of solution is subsequently measured.

Water isotherms are measured using a VTI thermo-gravimetric analyzer with a dew point analyzer. Samples, approximately 15mg, are dried by heating in dry air ($dp < -30^{\circ}\text{C}$) at 80°C . The samples are then subjected to humidity ranging from 5-95% RH (relative humidity) in 5% RH increments, in both the adsorption and desorption directions. Advancement to subsequent humidity steps is controlled by specific equilibrium criteria: $<0.001\%$ /min weight change rate or 3 hours after the last step, whichever occurs first.

In order to evaluate the adsorption capacity of low molecular weight water-soluble compounds, acetone breakthrough curves are measured. The experimental conditions used are as follows: 50ppm acetone challenge concentration, 30 LPM flow rate, 50% RH and 25°C . The samples are conditioned at 50% RH prior to starting the test.

Results and Discussion

The authors note that due to limitations regarding manuscript size, herein we will only discuss primary results and observations; however, more details will be discussed in the presentation.

Figure 1 shows comparison of water isotherms on a variety of materials that covered all ranges of RH applications. Zeolites are very efficient at very low RH while impregnated salts and superabsorbent polymer (SAP) have higher capacity at very high RH. Activated carbon (AC) typically has increased capacity at moderate RHs, but is dependent on the chemical modification approach used.

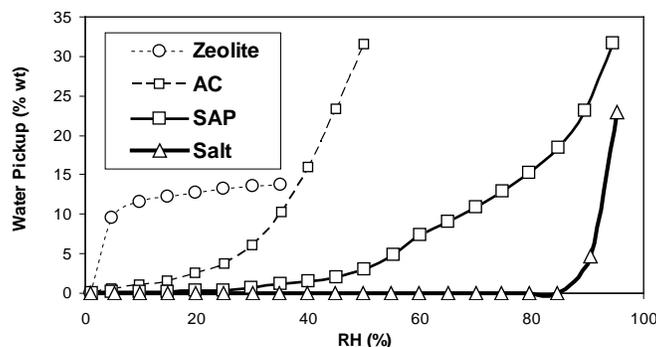


Fig. 1 Water isotherm on variety of materials.

Figure 2 shows water adsorption isotherms on Carbon C modified by introducing different amounts of oxygenated surface groups. As the oxidizing reagent concentration increases, the entire water adsorption isotherm is shifted to higher water adsorption capacity, especially below 70% RH.

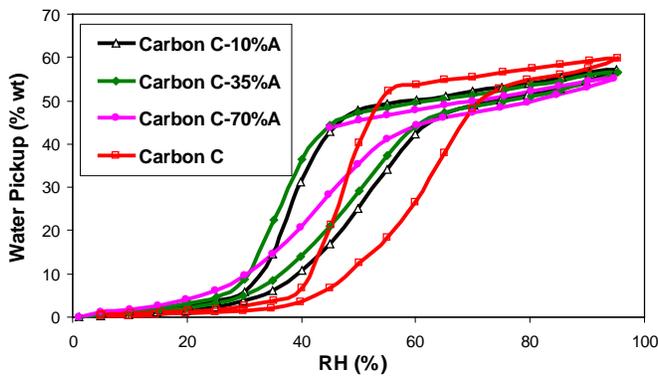


Fig. 2 Water isotherms on Carbon C modified by treatment with different concentrations of oxidizing reagent “A”.

Figure 3 demonstrates the effect of surface oxidation on the water adsorption capacity and kinetics for Carbon F. Treatment of Carbon F with oxidizing reagent “A” partially oxidizes the surface of activated carbon and increases its water adsorption capacity, especially at lower relative humidity. By comparing, with its oxidized sample Carbon F-O, it is clear this treatment does indeed shift the water adsorption isotherm to lower humidity levels, indicating the higher hydrophilic characteristic of the oxidized surface.

Figure 4 demonstrates the effect of surface modification of Carbon F on its capacity for acetone. Surface treatment increased the 10% breakthrough time of Carbon F for acetone from 340 minutes to about 480 minutes, a 41% increase in acetone capacity. Thus, Figure 3 demonstrates that oxidized activated carbon adsorbs more acetone compared to the non-oxidized activated carbon. The increased acetone capacity upon oxidation is attributed to the solubility of acetone in water entrapped on the activated carbon surface and also due to direct hydrogen bonding and acid/base interactions between acetone and adsorbent surface groups.

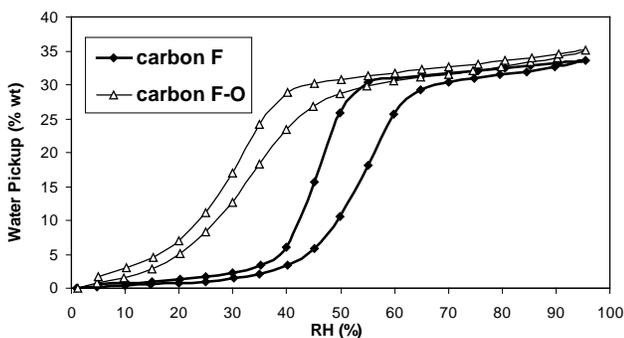


Fig. 3 Effect of surface oxidation on the water adsorption/desorption isotherm of Carbon F.

Figure 5 shows the dependence of the water adsorption capacity at 60% RH on the adsorbent surface chemistry as measured by the surface pH. It is clear the water adsorption

capacity at 60% RH increases as the surface pH of the activated carbon surface decreases.

Conclusions

The water adsorption isotherm of activated carbon adsorbents is customized through the modification of adsorbent surface chemistry. By controlling how and to what extent the surface chemistry of an adsorbent is modified, it is possible to customize an adsorbent’s surface properties in order to provide increased adsorption capacity in a given range of humidity. Such modification can enhance the adsorbing capacity and efficiency of the adsorbent, especially with regard to low molecular weight water-soluble compounds.

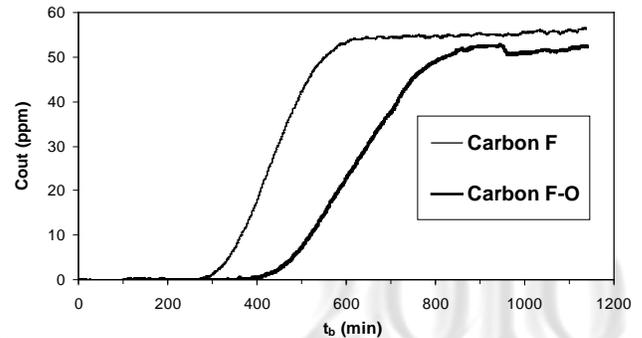


Fig. 4 Acetone breakthrough curves for Carbon F before and after treatment.

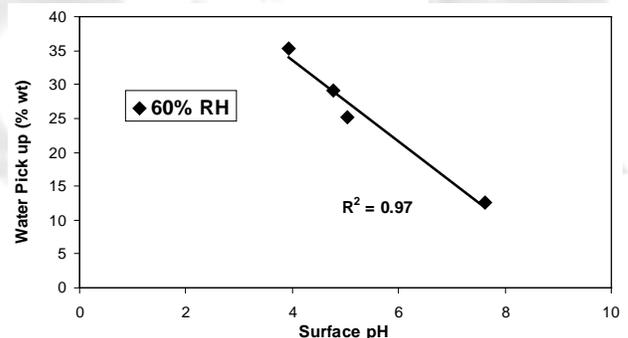


Fig. 5 Dependence of water adsorption capacity on the pH of the carbon surface.

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References

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