

Porous Carbons for Environmental Cleanup

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Abstract:

Porous carbons are used primarily for purification purposes through adsorption of contaminants on the surface of the activated carbon. The specific functional groups on the activated carbon are important to know since different functional groups adsorb different chemicals. Because different functional groups have different pKa values, a titration of an activated carbon indicates which functional groups are attached to the carbon. Also, a titration of two activated carbons with varying ionic strengths indicates the pH of zero charge for that activated carbon. This project's focus is to determine the appropriate equilibrium time for various activated carbons in titrations used for these purposes.

Introduction:

Activated carbons are aromatic carbons used in a variety of both liquid and gas purification applications. The name "activated carbon" originates from any of a variety of processes whereby the carbons are activated and become excellent adsorbing materials. Thus, these carbons are excellent purifiers for such reasons as their high volume, high surface area, high surface reactivity, and favorable pore size.

The specific functional groups on these activated carbons largely determine the ability of the activated carbons to adsorb various chemicals. Titrations of these activated carbons are important since through these titrations one can determine the functional groups on the activated carbon. Consequently, the task of determining a standard protocol, specifically proper equilibrium times, for titrations of specific activated carbons is crucial in accurately carrying out these titrations.

This project's primary purpose was to establish this standard protocol along with aiding in the characterization of these carbons when appropriate.

Experimental Procedure:

Various activated carbons were ground to the appropriate mesh size (200 x 400 holes per square inch) and kept in a desiccator until use. Each activated carbon was titrated twice to allow solutions of different ionic strengths to be tested; the two solutions used were 0.01 and 0.1 molar sodium chloride solutions. The protocol used included acid addition, pH electrode calibration, and base addition prior to the addition of the activated carbon. Nitrogen gas was continually bubbled through the solutions both prior to and during the duration of the titrations to expel carbon dioxide from the solutions. The pH was raised immediately prior to the titrations, and the titrations were allowed to run to completion. The chosen equilibrium time between acid additions was 30 minutes with 0.05 milliliter increments of 0.1 molar hydrogen chloride solution until 5.0 milliliters of acid were added.

Results and Conclusions:

Proper equilibrium times were not determined in this project, although work has been done to that end. Titrations of four activated carbons were completed (Symbio, Super Darco, Hydro Darco, and a coconut

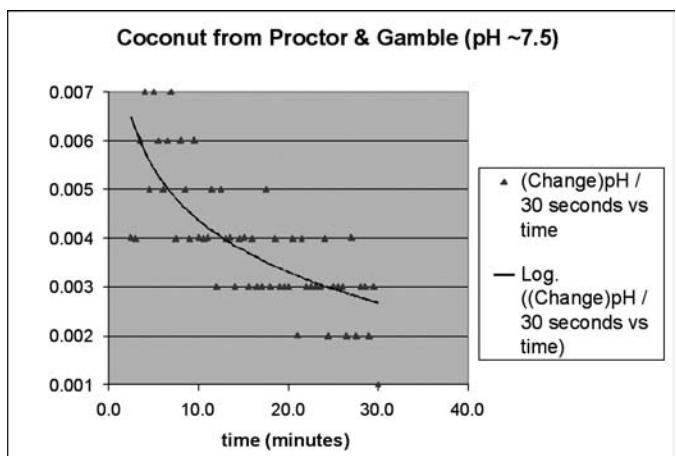


Figure 1: The change in pH over the 30 minute equilibrium time for a coconut carbon from Proctor & Gamble.

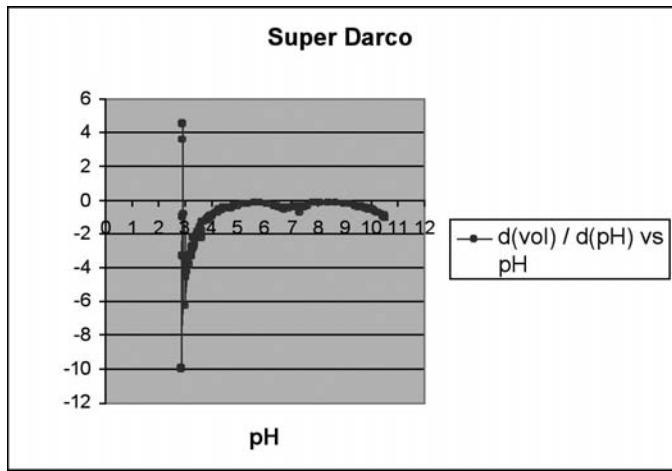


Figure 2: This graph demonstrates how specific functional groups are determined.

carbon from Proctor & Gamble) with 30 minute equilibrium times for each.

Graphs demonstrating the change in pH over the 30 minute equilibrium time give an approximation of the activated carbon's required equilibrium time (see Figure 1 for example). These graphs were ascertained for three activated carbons (Symbio, Hydro Darco, and a coconut carbon from Proctor & Gamble). Also, these graphs give an indication of the approximate pore size of the activated carbon since equilibrium times are related to pore size. Clearly, larger pore sizes require shorter equilibrium times.

The primary purpose for titrations can be seen in Figure 2; determining the functional groups on the activated carbon. From peaks on this graph, one can postulate that Super Darco contains a lactone group ($\text{pK}_a \sim 7$) and a carboxyl group ($\text{pK}_a \sim 3$). However, because this is purely raw, unduplicated data, more work must be done to confirm this. The general concavity of the graph is due to the influence of water; only the distinct peaks on the graph are of interest here.

In addition, the point of zero charge (pzc) of three activated carbons (Symbio, Super Darco, and Hydro Darco) was determined through the graphs of the solutions of different ionic strengths (see Figure 3 for example). The pzc occurs when these two curves

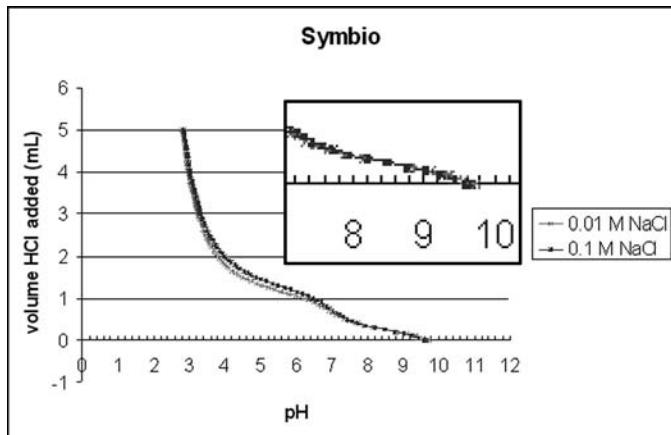


Figure 3: The pzc for Symbio is ~ 8.5 .

intersect, indicating the point where there is zero charge on the activated carbon and the natural pH of the carbon when in water.

Furthermore, slurry pH values were obtained for all four activated carbons, attempted to confirm the values of the pzc obtained. However, the validity of these values is highly questioned since they did not agree well with the pzc values.

Future Work:

Because of the complexity of the exact required equilibrium times for these activated carbons, these values were not obtained for any activated carbon. Also, the exact value for how small the change in pH over time must be was not determined. Thus, more work both in the duplication and evaluation of all data obtained is required in order to obtain this necessary equilibrium time and corresponding standard protocol. Titrations with longer equilibrium times (up to one hour) and the corresponding data would be very helpful in determining these proper equilibrium times.

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