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DOWEX Ion Exchange Resins

Equilibrium Isotherm Testing For Liquid Phase Applications

This technical data sheet describes a simple method for evaluating the feasibility of various separation media for a desired separation. This method can be used to screen several different media to determine which is most effective. Both loading and regeneration conditions can be quickly evaluated using this technique. The experiments described are simple, requiring very basic laboratory equipment. The goal of these experiments is not to define the final process conditions but to offer insight as to the feasibility of solving a problem with ion exchange and adsorption media.

Methods & Material

An absolute essential for this kind of testing is a good analytical procedure for the solution and its components. Without good analytical, the results become qualitative rather than quantitative and much information is lost.

Equipment requirements will vary with the nature of the solution. Experiments are performed with a sealable container that will appropriately hold the solution. Temperature control for the containers is optional, depending on the needs of the solution itself. The use of a mechanical stirring device is also optional. Glass jars with lids make excellent containers for many applications.

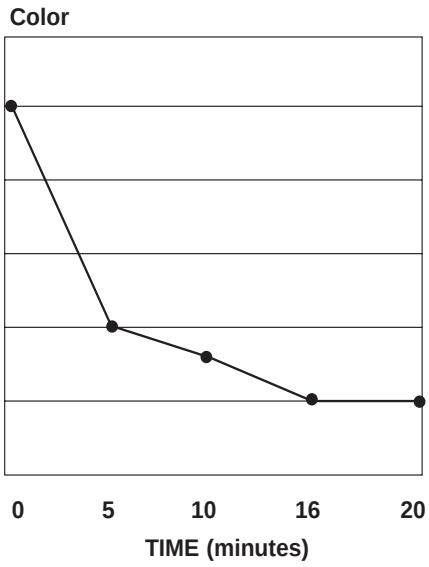
Equilibrium Rate Study

The purpose of this experiment is to determine the time required for a separation to reach equilibrium. For many ion exchange separations, solution equilibration is very fast and this study is not necessary. Many adsorption processes proceed at slower rates, thus valuable information for process design can be obtained.

A quantity of the solution to be treated is placed in contact with the separation media and mixed. With time, small aliquots of the solution are periodically removed, the solution separated from the media by filtration or centrifugation and components of interest in the solution analyzed.

Data for a typical decolorizing experiment is plotted in Figure 1. At 20 minutes, there is no further change indicating that the equilibrium had been reached.

Figure 1. Equilibrium Rate Study. Determines the time required for a separation to reach equilibrium.



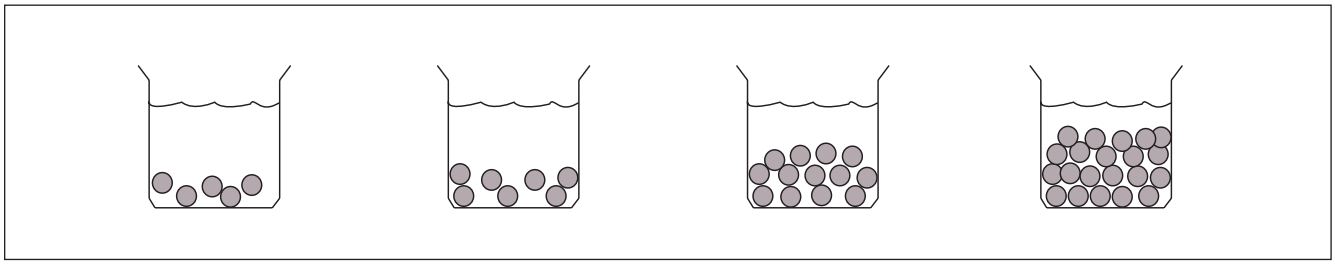
Equilibrium Capacity Study

An equilibrium capacity study is performed by aliquoting the same known amount of the solution to be treated into containers. Next, varying amounts of the preconditioned separation media are added and mixed with the solution and allowed to come to equilibrium, typically for several hours or overnight. Incubation conditions may include controlled temperature or continuous agitation, depending on the requirements of the solution, see Figure 2.

Upon equilibration of the solution and the media, the media is separated from the solution by filtration or centrifugation and the solution analyzed for the components of interest.

Precautions should be taken when large amounts of media are added to keep track of the dilution change caused by the different amounts of separation media.

Figure 2. Equilibrium Capacity Study. By varying the amount of separation media in a fixed volume of solution, the loading capacity of the media can be determined.



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Analysis of Results

The data can best be interpreted by constructing an adsorption isotherm using the following formulas:

X = Mass of separation media
Co = Concentration of component of interest in the untreated solution
Cf = Equilibrium concentration of the component of interest
Ca = (Co - Cf) x volume Amount of component sorbed by the media
Ca/X = Capacity of the media for the component of interest

A Freundlich isotherm can be generated by plotting Ca/X vs. Cf as seen in Figure 3. The shape of the resulting curve indicates the feasibility of the separation media to perform the desired separation under the conditions tested.

The data can be used to determine the cost of a desired separation. The media capacity at the desired final solution concentration is divided into the mass of the component to be removed to determine the amount of media needed to treat a given volume of solution.

$$\frac{\text{Co x solution volume}}{\text{Ca/X at desired Cf}}$$

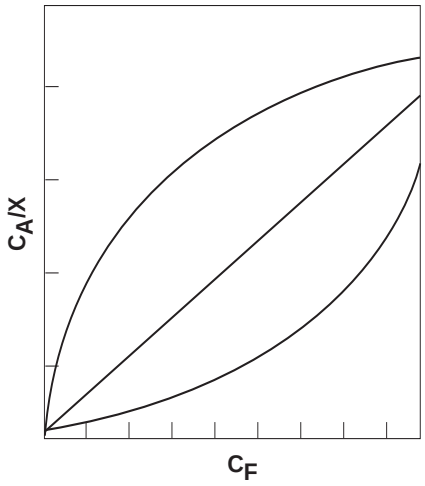
This same method can be used to screen different adsorption conditions such as pH, temperature, ionic strength, solution concentration, etc. In this case the solution parameters are treated as the variable and the amount of adsorbent is held constant. The data is analyzed in a similar fashion.

A sample experiment of this type can be used to quickly screen a variety of separation media and conditions. This information also becomes the basis for the development of a process and ultimate solution of the separation problem.

References

Adsorption Process for Water Treatment by Samuel D. Faust and Osman M. Aly, Butterworth (1987).

Figure 3. Adsorption Isotherm plots the capacity of the media for the component of interest (C_A/X) versus the equilibrium concentration of the component (C_F).



Warning: Oxidizing agents such as nitric acid attack organic ion exchange resins under certain conditions. This could lead to anything from slight resin degradation to a violent exothermic reaction (explosion). Before using strong oxidizing agents, consult sources knowledgeable in handling such materials.

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