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DETERMINATION OF PORE RADIUS AND ACTIVATION TEMPERATURE OF ALUMINA

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ABSTRACT

Alumina (MERK) was soaked with water. The triple point temperature of water, which is condensed in alumina was observed. It has been found 11°C below the bulk water temperature measured by thermal analysis method. The mean radius of pore of alumina has been calculated as 43 A° from the triple point depression of the capillary condensed water. Using this value, the activation temperature of alumina has been calculated as 580 K under the atmospheric pressure.

ÖZET

Alümina (MERK) su ile iyice doyurulmuştur. Aluminada kondense olan suyun üçlü nokta sıcaklığı tayin edilmiştir. Bu sıcaklık termal analiz yöntemiyle normal suyunkinden 11°C daha aşağıda bulunmuştur. Kapilerlerde yoğunlaşan suyun üçlü nokta düşmesinden alümina gözeneklerinin ortalama yarıçapı 43 A° olarak hesaplanmıştır. Bu değer kullanılarak normal atmosfer basıncı altında alumünanın aktivasyon sıcaklığı 580 K olarak hesaplanmıştır.

INTRODUCTION

The quantity of adsorbed and capillary condensed materials, on the porous adsorbents can be found gravimetrically and volumetrically. The structure of porous adsorbents and the phase change of capillary condensed liquid can be examined. The surface area of adsorbent can be found from the monomolecular layer capacity measurements [1]. Furthermore, the mean pore radius of adsorbent can be calculated from the triple point depression of the capillary condensed water [2].

By this study, the mean pore radius, and the activation temperature of alumina have been determined.

EXPERIMENTAL

Th triple point temperature of capillary condensed water in alumina has been investigated by the thermal analysis. After the alumina - water system was cooled down to −170°C, it has been heated slowly in the thermal analysis apparatus. The temperatures were read from the po-

tentiometer which is calibrated to temperature against μV and Δt time intervals (required for rising the temperature for each 100 μV) was read from the chronometer. The thermal analysis curve for low temperatures of alumina - water system is shown in Fig. 1. The triple point temperature of the water which is condensed in alumina was read as $-11^{c}C$, below the bulk water temperature as can be seen from the maximum point in Fig. 1.

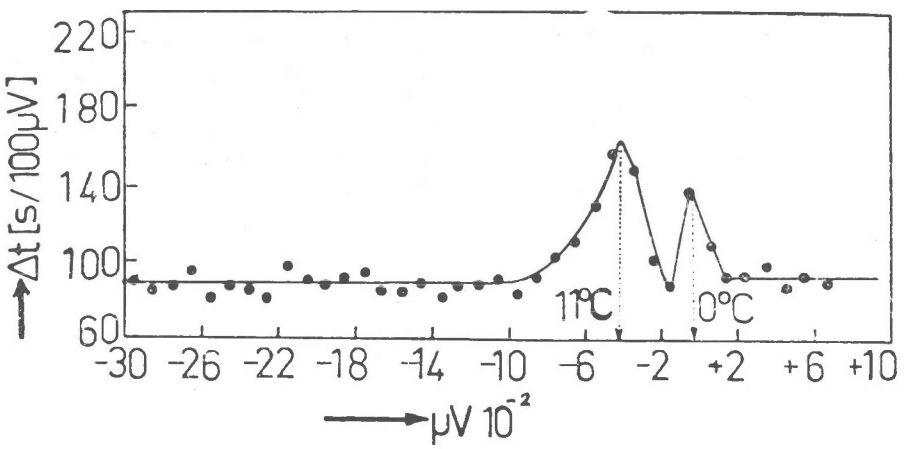

Fig. 1. Thermal analysis curve.

CONCLUSION

In literature there are two equations which give the relation between the mean capillary radius of porous adsorbent and the triple point depression of capillary condensed liquid.The first equation which is empirically derived as [3].

$$T - T_o = \frac{2T}{r}\left[\frac{V^l \sigma^{l\cdot g} - V^s \sigma^{s\cdot g}}{\Delta H_f}\right] T_o \qquad (1)$$

The second which is theoretically derived and is given as [4]

$$\ln \frac{T}{T_o} = -\frac{V^s}{\Delta H_f} \quad \frac{2\sigma^{s\cdot l}}{r} \qquad (2)$$

In these equations T_o and T represent the triple point temperatures of the bulk and capillary liquid respectively, and r is the mean radius of

capillaries. Also, ΔH_f is the molar heat of fusion; V^l and V^s are the molar volumes of liquid and solid respectively; $\sigma^{l\text{-}g}$ and $\sigma^{s\text{-}g}$ are the surface tension of the liquid - gas and solid - gas interface, respectively, and $\sigma^{s\text{-}l}$ is the surface tension of solid - liquid interface. All these quantities should be at 273 K. The corresponding values [4] at 273 K are

$V^l = 18.05\ cm^3\ mol^{-1}$; $V^s = 19.62\ cm^2\ mol^{-1}$

$\sigma^{l\text{-}g} = 75.7$ dyne mol^{-1}; $\sigma^{s\text{-}g} = 100$ dyne cm^{-1}.

$\Delta H_f = 6012 \times 10^7$ reg mol^{-1}

The triple point temperatures of bulk and capillary water has been found as $T_o = 273$ K and $T = 262$ K respectively. If the values are substituted in Eqs. 1, 2, the average radius of capillaries in alumina were calculated as 47 A° and 38 A° respectively. The arithmetical average is 43 A°. This is taken as the mean radius of the capillaries in alumina.

It was assumed that activation temperature of adsorbent is equal to the vaporization temperature of water condensed in the capillaries of adsorbents. According to this assumption, if the vaporization temperature of capillary condensed water in alumina could be calculated the activation temperature of alumina would have been determined.

The heat of vaporization of water [4] depends on the temperature as follows

$$\Delta H_v = a - bT = 50560 - 27.225\ T\ [Jmol^{-1}] \qquad (3)$$

The vaporization temperature of water condensed in capillaries with the mean radius r can be calculated under the atmospheric pressure p from the following equation [4].

$$f(T) = a\left(\frac{1}{T_o} - \frac{1}{T}\right) - b\ \ln\frac{T}{T_o} - R\ \ln\frac{(2\sigma^{l\text{-}g}/r) + p}{p} = 0 \qquad (4)$$

Here $\sigma^{l\text{-}g}$ is the surface tension of the liquid - gas interface at the vaporization temperature of capillary condensed water T, R is the gas constant. The values of these quantities are given as,

$R = 8.314 \times 10^7$ erg $mol^{-1}\ K^{-1}$; $T_o = 373$ K

$r = 43 \times 10^{-3}$ cm ; $p = 1.013 \times 10^6$ dyne cm^{-2}

If the temperature and surface tension pairs inserted in Eq. 4 succesfully the value of f(T) can be calculated with positive and negative sign. The graph of the values of f(T) against the temperature is shown in Fig. 2. The temperature, satisfying Eq. 4 can be read from straight line at the point $f(T) = 0$ as 580 K.

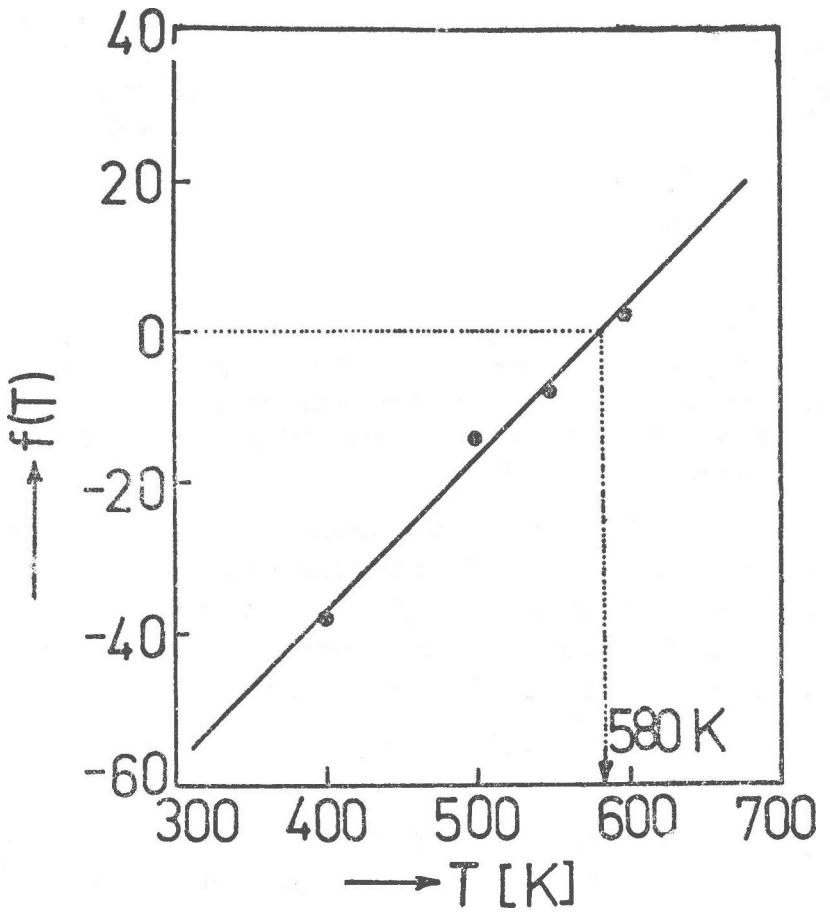

Fig. 2. Graph of f (T) versus temperature.

This value is in agreement with the experimental results which are given near the 537° K. As a result it can be proposed that this can be a procedure for the calculation of the activation temperature of porous material.

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