

## The Surface Area of Crystalline Egg Albumen

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## Letter to the Editor

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### The Surface Area of Crystalline Egg Albumen

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June 27, 1944

THE method of Brunauer, Emmett, and Teller (BET)<sup>1</sup> has been used extensively for the determination of the specific surface areas of adsorbents. In most instances so far reported the areas obtained for a given adsorbent are independent of the adsorbate.<sup>2-4</sup> However, a significant difference has been noted for the clay mineral montmorillonite.<sup>5,6</sup> In this instance the surface area evaluated from the water vapor adsorption isotherm exceeds the surface area found from the nitrogen adsorption isotherm by about 50-fold. Recent adsorption measurements on crystalline egg albumen in this laboratory have revealed even larger differences in the surface areas available to water vapor and to nitrogen. Samples of native egg albumen were prepared by dialyzing solutions of previously crystallized egg albumen against distilled water followed by vacuum-drying from the frozen state. The drying was continued at room temperature (about 25°C) until the total pressure in the system was less than  $5 \times 10^{-6}$  mm Hg.

The adsorption of nitrogen at  $-183^\circ$  and water vapor at  $25^\circ$  was measured in an apparatus similar to that described by Emmett.<sup>3</sup> In Fig. 1 are presented the adsorption data plotted according to the BET method. Assuming the average areas occupied by  $N_2$  and by water molecules to be 15.4 and 10.6 Å<sup>2</sup>, respectively,<sup>7</sup> the data in Fig. 1 yield surface areas of 2.42 sq. meters (for nitrogen) and 210 sq. meters (for water) per gram of egg albumen. The difference between the heat of adsorption in the first adsorbed layer  $E_1$  and the heat of liquefaction  $E_L$  is 648 cal./mole for  $N_2$  and 1100 cal./mole for water as calculated from the BET plots of Fig. 1. The water vapor adsorption data of Barker<sup>8</sup> for native egg albumen yield a surface area of 220 sq. m/g and  $E_1 - E_L$  equal to 1280 cal./mole.

If one attempts to interpret these surface areas in terms of an average particle size it is found that the average particle diameter calculated from the surface available to nitrogen is  $2 \times 10^{-4}$  cm. A crystallite of this size would contain about  $10^3$  egg albumen molecules. Similarly the surface available to water would indicate an average particle diameter of about  $2 \times 10^{-6}$  cm, containing about 100 egg albumen molecules.

In the case of montmorillonite, however, it has been conclusively shown<sup>4</sup> that the discrepancy between the areas calculated from  $N_2$  and water adsorption is due to the penetration of water in the polar region between the silicate layers. These polar layers are not penetrated by  $N_2$  and the latter is presumed to cover only the external surface of the crystallites.

It appears of interest to consider the possibility that a similar behavior can account for the surface areas obtained for egg albumen. It has recently been proposed<sup>9</sup> that the native egg albumen molecule is composed of polar layers, giving rise to two intermolecular and one intramolecular polar interfaces, each approximately 1600 Å<sup>2</sup> in area. This model agrees with the experimental value of the surface

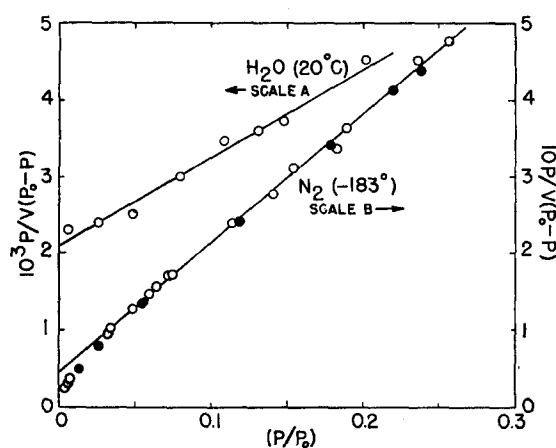


Fig. 1. Adsorption of nitrogen and of water vapor by 1 gram of egg albumen plotted according to the Brunauer, Emmett, and Teller theory. Filled circles are desorption values.  $V$  is volume in cc at S.T.P. adsorbed at pressure  $P$ .  $P_0$  is the liquefaction pressure.

area available to water vapor if it is assumed that water is adsorbed only in the intermolecular polar interfaces. The area then available to water would equal 225 sq. m/g in good agreement with the experimental value of 210–220 sq. m/g. This suggestion is compatible with the fact that Astbury and Lomax<sup>10</sup> have obtained x-ray diffraction photographs for egg albumen showing that only the side chain spacing is affected by water vapor adsorption.

If one were to assume that water vapor is uniformly adsorbed on all external surfaces of the egg albumen molecule the surface available would be either about 675 or 1350 sq. m/g, depending on whether each monolayer of water is assumed to be shared or not. In any case this area would be from 3- to 7-fold larger than the experimental value.

The data presented above serve to emphasize that methods of determining surface areas from adsorption data must be used with due regard for the surface available to the particular adsorbate used. In studies where the area desired is that of the organized crystallites it must be first determined that the adsorbate is not able to penetrate the molecular lattice. Gases such as nitrogen and argon appear to satisfy this requirement in all particulars.

Grateful acknowledgment is made to Dr. K. J. Palmer for his interest and suggestions relative to the above work.

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