Magnetic Resonance Absorption of Protons in Water Adsorbed on Carbon and Cellulose

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The line shapes of the proton magnetic resonance absorption in water adsorbed on carbon and cellulose was studied by an autodyne oscillator circuit[1]. We report here the derivatives of the absorption lines obtained with these substances at 20°C. The proton magnetic resonance absorption was observed by the variation of the resistance part of the oscillator coil, in which the sample was inserted. This phenomenon occurred as a resonance between the frequency of the oscillator and the transition frequency, a function of the static magnetic field applied to the sample. The derivatives of the absorption lines were recorded on photographic paper. The second moment was calculated from the curves of the recorded derivative and then the line width of the absorption curves was graphically determined.

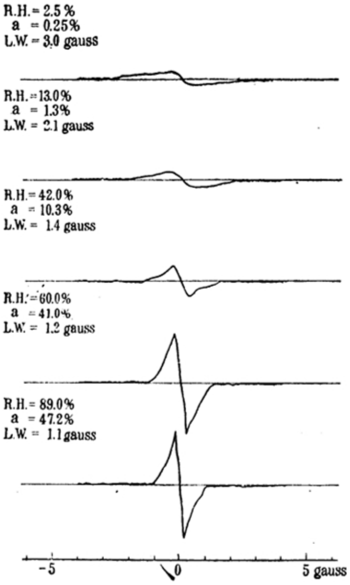

Fig. 1 Resonance line derivatives for carbon.
R.H. = Relative humidity (%)
a = Amount of adsorbed water vapor (%)
L.W. = Line width (gauss)

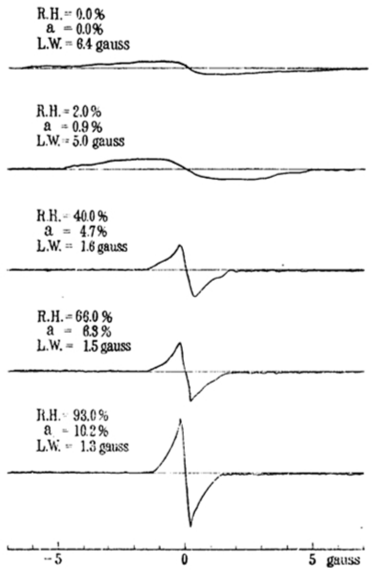

Fig. 2 Resonance line derivatives for cellulose.

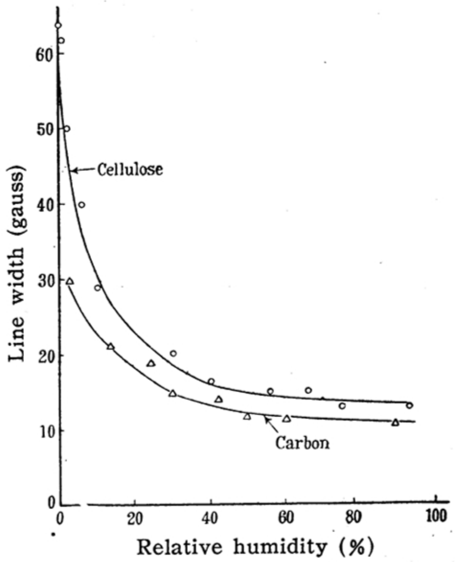

Fig. 3 The variation of line width of resonance absorption with relative humidity.

Carbon.—We used a vegetable active carbon (Takeda Co.) and freshly prepared conductivity water. The water vapor was adsorbed on the sample at 20°C for a period of 3 days in a desiccator of constant relative humidity. The curve of the magnetic resonance absorption of protons in water adsorbed on carbon at 20°C and the line width vs. relative humidity are shown in Fig. 1 and Fig. 3 respectively.

As shown in Fig. 1 the line shape becomes gradually sharp with the increase of relative humidity. In the higher relative humidity, the part of broad line shape practically disappears by the

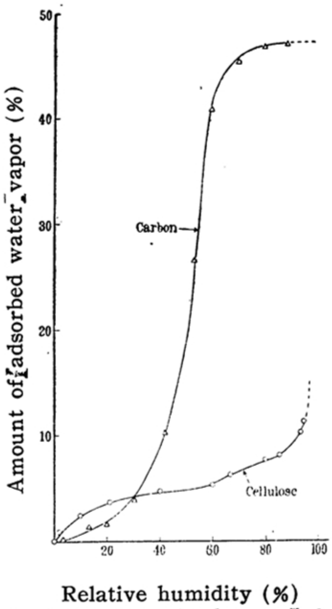

Fig. 4 Adsorption isotherms of water vapor on carbon and cellulose at 20°C.

influence of a large quantity of adsorbed water, although it should theoretically be observed.

The adsorption isotherm of water vapor on the active carbon measured at 20°C by spring balance method is shown in Fig. 4. By using the method of Brunauer, Emmett and Teller[2] it has been found that water is adsorbed on this sample with a mono-molecular layer, where the relative humidity is about 20%, so that we may conclude that the adsorbed water vapor of this monolayer is firmly held on the active carbon.

It is a remarkable fact that the line width (Fig. 3) rapidly decreases with the increase of relative humidity in the region of about 20% and that the sharp line shape (Fig. 1) overlaps gradually on the broad line shape. This is probably due to the considerable difference between the Brownian motion of protons in the water adsorbed in and above the mono-molecular layer. Thus it is demonstrated that the protons above the mono-molecular layer are movable, while the protons in the mono-molecular layer are rigid.

Cellulose.—A quantitative filter paper of best quality (Toyo Filter Paper No. 7) was used as cellulose material. Water vapor was adsorbed on the filter paper, previously dried in vacuo at 100°C, for a period of one day in a desiccator of constant relative humidity. In Figs. 2 and 3 are shown respectively the curves of the proton magnetic resonance absorption in water adsorbed on the cellulose at 20°C and the line width determined graphically vs. relative humidity.

The adsorption isotherm of water vapor on the filter paper measured at 20°C by spring balance method is of the usual sigmoid type as shown in Fig. 4. Resonance absorption of protons was found with cellulose even in the neighborhood of zero relative humidity, in contrast to carbon, and the line width was found to be about several gausses. This resonance absorption may be due to the protons in the cellulose molecule itself, but not to the adsorbed water. The line width both of cellulose and carbon decreases rapidly in the neighborhood of the relative humidity of 20%. When the relative humidity is above 40%, a sharper line shape appears in the case of cellulose, overlapping on the broad curve, and above 90% the line shape becomes strikingly sharp, quite in contrast to corbon. This is attributable to the known fact that the adsorption of water on cellulose suddenly increases in the neighborhood of saturated vapor pressure. It is a remarkable fact that the line shape of cellulose changes more rapidly than that of carbon, suggesting that the adsorption layer of water on cellulose has a character of a multiple layer, in contrast to that on the carbon.

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1) K. Sano, *Proc. J. Phys. Soc. Japan*, **6**, 228 (1951).
2) S. Brunauer, S.H. Emmett and E. Teller, *J. Am. Chem. Soc.*, **60**, 309 (1938); ibid., **62**, 1723(1940).

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