NOTES

Permeability to Water of Glow Discharge-Treated Nitrocellulose

We wish to report the results from our preliminary studies on the effect of an electrically discharged vapor on ultrathin nitrocellulose films. We have measured the permeability of nitrocellulose to water vapor as a function of the length of time it was exposed to a toluene glow discharge. There is a decrease in the apparent permeability from 5300×10^9 to 2580×10^9 cm²-mm/sec-cm²-cm Hg. This decrease is ascribed to the crosslinking of the surface of the nitrocellulose films by the glow discharge.

Films of nitrocellulose about 10^{-4} cm thick were prepared by casting them on a water surface from a solution in amyl acetate and acetone. After the solvent evaporated, the films were stretched on frames until they were wrinkle-free. Film thickness was measured by using β-ray transmission calibrated by weighing films of known area. The glow-discharge treatment was carried out by mounting the specimens in the negative glow of a 20 KHz, 400 vac glow discharge in a bell jar. Degassed toluene was used as the vapor, at a pressure less than 1 torr. Gardner-Parke permeability cups[1] were used for the permeability measurements. A sugar solution was placed in each cup, which was sealed with the sample film and stored in a desiccator containing a desiccant. The cups were weighed repeatedly over a period of 30 min, 12 hr being allowed for a steady state to be attained.

Figure 1 shows the change in permeation rate with length of discharge treatment. There is a difference in discharge conditions between the two sets of measurements. Series A was carried out at higher power and lower pressure, and therefore under more energetic conditions, than series B. There is a definite correlation between the decrease in the rate of water transfer through the nitrocellulose with the increase in length of

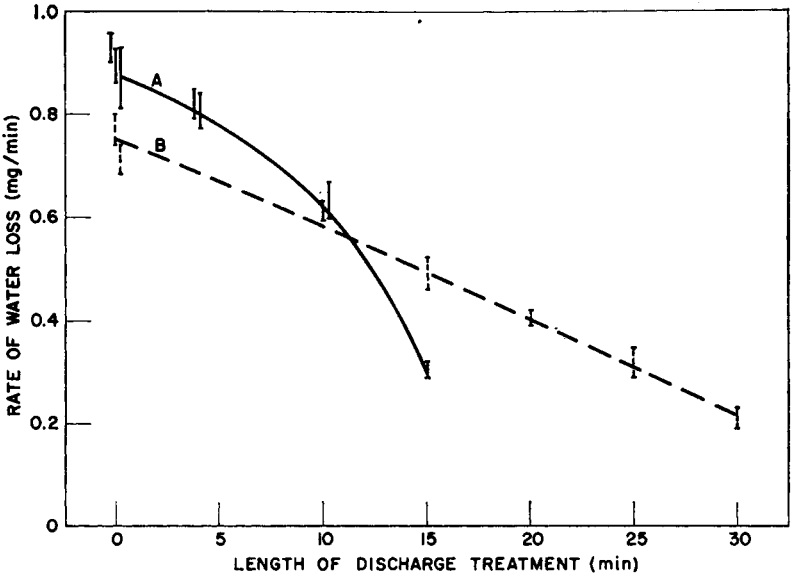

Fig. 1. Lowering of the water permeation rate through glow discharge-treated nitrocellulose films.

discharge treatment. The decrease in the permeability is probably due to the lowering of the rate of diffusion as the polymer becomes crosslinked.

Although discharges through toluene are known to deposit polymeric films on adjacent surfaces,[2] the thicknesses of the nitrocellulose films increased less than 10%, the error of measurement. Further, no trace of infrared bands characteristic of toluene could be detected in the surface-reflection spectrum obtained by a multiple reflection technique. Thus any glow-discharge polymer layer can be no thicker than 10^{-5} cm. In the absence of such a layer, the nitrocellulose film must have been modified to a depth equalling the diffusion length for active species from the vapor. This length has been estimated at about 10^{-5} cm for hydrogen atoms into liquid terphenyl.[3] Thus the barrier layer is not expected to exceed 10^{-5} cm in thickness, but it increases the resistance to water loss by 300%. This implies tha the glow-discharge treatment forms a barrier layer with a permeability less than 1/30 as great as that of the starting nitrocellulose, approaching that of polyethylene.

Similar studies have been carried out with the use of high-energy irradiation of polyethylene.[4,5] The rate of diffusion of gases decreased upon irradiation. However, in the case of water vapor the solubility increased due to oxidation of the polymer. Consequently an increase in the water permeability rate was observed.[6]

References

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