

# **Studies of the Chemical Modifications of Wool and Their Effects on the Wool-Water Relationship. Part II. Wool-Water Relationships of Modified and Unmodified Wool**

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## **Synopsis**

The wool-water relationships of the modified wools prepared as described in Part I of this series have been studied. The drained water content of fabric and the solution isotherms and diffusion constants of water vapor into untreated and modified wools have been measured. Most of the treated wool fabrics showed considerable decreases in the drained water contents compared with the untreated wool. However, the degree of improvement depended markedly on the conditions of modification, particularly with the styrene grafted materials. In some cases values close to those of a comparable polypropylene fabric were found. The sorption isotherms also showed that the modifications reduced, substantially in some cases, the regains even when calculated on the wool content only. The diffusion constants were difficult to measure because of the heats of sorption causing temperature changes during the sorption; however, at lower regains this effect could be corrected. It was found that both the direct chemical modification and the grafted wools showed a diffusion behavior which was more characteristic of hydrophobic materials in that the diffusion constants tended to decrease with increasing concentration. At low humidities the diffusion constants were larger than in the untreated wool, but at higher humidities lower diffusivities were found with the modified wools.

The modified wool fabrics prepared as described in Part I<sup>1</sup> have been studied from the point of view of their drying qualities. This paper will discuss the results of this investigation. Among the fundamental wool-water relationships which may be considered of practical importance in the design of apparel fabrics are undoubtedly the diffusivity of water in the fibers and the equilibrium water content, i.e., the regain. A further fundamental quantity of practical significance is the heat evolved or absorbed during the sorption or desorption of the water vapor. In considering the rate of drying of a wet fabric other factors must be included. The problem has been extensively studied by Steele,<sup>2</sup> who has divided the loss

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of water from a wet fabric into three regions: (1) the drainage of loose water from the fabric, (2) the constant rate of evaporation of water from the fabric surfaces, and (3) the diffusion-controlled loss of water from the fibers themselves. The process is shown graphically in Figure 1. A major factor in determining the practical drying time of a fabric is obviously the drained water content, since it determines the starting point of the drying

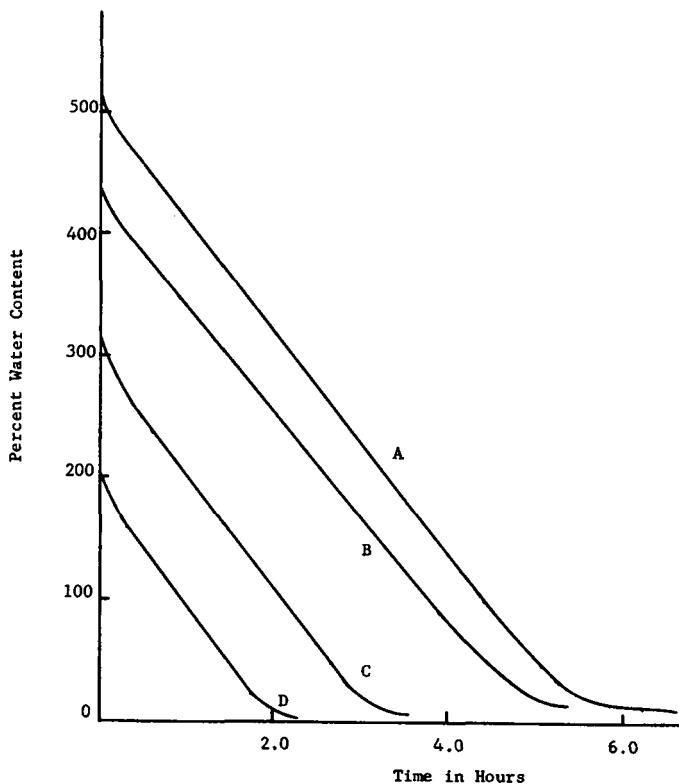


Fig. 1. Drying curves measured at 65% R.H. and 70°F.: (A) wool; (B) wool grafted with 37% 2-ethylhexyl acrylate; (C) wool grafted with 11.1% styrene; (D) polypropylene.

process. The diffusion-controlled part of the drying process is the interval in which the water content drops from that at 100% R.H. to that at the relative humidity of the atmosphere where the drying takes place. This process occupies only a comparatively small proportion of the overall drying time.

A number of modified samples of a standard wool fabric have been studied with respect to their drained water contents, water contents (sorption isotherms), and water vapor diffusion constants. The heats of sorption and desorption have also been measured in the case of the untreated wool and one grafted wool sample.

## EXPERIMENTAL

### Drained Water Content

Wool fabric samples were cut into rectangular pieces,  $1 \times 4$  in., and one end was cut into the shape of a  $90^\circ$  angle. During the drying experiments the samples were suspended from the square end; the pointed tip facilitated drainage of the sample. The sample was attached to a wire hook and suspended from the balance arm of an Ohaus Cent-O-Gram balance. The balance was graduated in 0.01 g. divisions. The dry weight of the wool samples was approximately 0.6 g. and the initial wet weight of the samples approximately 3 g.

The experimental procedure was to soak the samples in water for 24 hr.; the sample was then suspended on a wire hook from the balance arm and the weight at various time intervals recorded. Figure 1 shows typical drying curves for the untreated control and treated wool samples. These curves were similar to those given by Steele<sup>2</sup> with one exception: the constant drying rate portion of the curves were not straight but slightly concave upwards. Visual inspection of the samples during drying showed a continuous water phase in the bottom portion of the sample at the beginning of the constant rate period. This gave a nonuniform water content which is probably the reason for the slight curvature in the constant rate region. The value obtained by extrapolating back the constant rate portion to zero time gives the drained water content.

Since this method was used to measure only the drained water content and constant drying rate, drying curves were made for the first hour on each sample (complete drying curves required over 6 hr.). The constant drying rates for all the wool samples were similar and were  $1.7 \times 10^{-4}$  g./cm.<sup>2</sup>/min. All determinations were made in a physical testing laboratory maintained at  $70^\circ\text{F}$ . and 65% R.H.

### Water Vapor Sorption Isotherms

The actual sorption isotherms were measured on a number of modified wools using a quartz helix microbalance contained in closed cabinet which could be regulated to various temperatures and regulated to  $\pm 0.5^\circ\text{C}$ . Most isotherms were measured at  $25^\circ\text{C}$ . The end of the balance tube was well immersed in a thermostatted water bath which could be controlled to  $\pm 0.05^\circ\text{C}$ .

After attaching the wool sample (about 0.1 g.) to the hook of the helix the balance was pumped out overnight to  $10^{-5}$  mm. Hg. Water vapor was then admitted to the reservoir section to the approximate pressure needed and finally admitted by opening a stopcock to the balance itself. The weight of the sample before and after equilibrium was calculated from the extension, measured by using a cathetometer, and the Hook's law constant of the spiral. The final pressure reached was measured by means of the Zimmerli gauge. The pressure was then increased to the desired value and the increase in weight at equilibrium again recorded. In this way the

sorption isotherms were determined on the untreated and modified wool fabrics.

### Diffusion Constants

The apparent diffusion constants were measured by the quartz helix microbalance technique used for the sorption isotherms. The increase of weight with time was recorded and plotted in the familiar manner as a function of the square root of time. The diffusion constants can then be calculated by using the simplified expression based on a cylindrical model:

$$W/W_{eq} = (4/a)(Dt/\pi)^{1/2}$$

where  $W$  and  $W_{eq}$  are the increase in weight at time  $t$  and at equilibrium, respectively,  $a$  is the average fiber radius, and  $D$  the diffusion constant. Measurement of the true diffusion constants presented considerable difficulty. One difficulty is that with the small fiber diameters the rate of sorption soon becomes too rapid to measure by normal means. For example, when the diffusion constant is greater than  $10^{-9}$  cm.<sup>2</sup>/sec., the half sorption time becomes less than 1 min. Furthermore, the heat of sorption coupled with the rate of sorption, leads to large temperature changes in the fiber. These heat effects can be corrected at low regain, but the correction method soon becomes too sensitive to small changes in the various parameters to be accurate.<sup>3</sup> At low regains, however, reasonable values can be obtained and these have been determined for the untreated wool and three modified samples.

The temperature changes accompanying the sorption and desorption of water vapor have been measured directly by "sewing" a copper-constantan thermocouple into the wool sample and carrying out sorption and desorption experiments as before.

## RESULTS AND DISCUSSION

The drying curves for the untreated wool, two grafted samples and a sample of polypropylene fabric of similar porosity are presented in Figure 1. Similar curves were obtained on all the other samples examined; the drained water contents are presented in Tables I-III. It can be seen that the results obtained with both the chemically treated and radiation-grafted wools vary greatly, even when the level of added substance is similar. In the best cases drained water contents approaching that of the polypropylene fabric were obtained with about 20% of modifying substance. It is highly probable that the drained water content of fabrics of similar geometry and porosity (as are the present samples, which were all made by treating the same fabric) depends on the surface properties of the fibers. The more hydrophobic the surface, the more likely it is that rapid draining will occur. It is clear, therefore, that the chemical modification including grafting should be more effective when carried out under low swelling conditions, i.e., when the bulk of the hydrophobicity is introduced at the surfaces.

This leads to wide variation of drained water contents even at the same degree of add-on. Thus, in the case of lauroyl chloride 3.9% introduced in the comparatively low swelling pyridine is as effective as 10% introduced in the higher swelling dimethylformamide solvent. In general, lauroyl chloride was found to give the most consistently good results and dodecyl chloride the poorest. The tendency of the latter reagent to quaternize as discussed in Part I may account for the high results, since in many cases the values were higher than the untreated wool. With reaction in dimethyl sulfoxide, however, good results were also obtained.

TABLE I  
Drained Water Contents of Chemically Treated Wools

Sample	Swelling agent	Time, hr.	Temp., °C.	Drained water content, % <sup>a</sup>	
				Total	Wool
Control				511	511
9.5% Stearoyl chloride	Benzene (60%) + DMSO (40%)	2	90	269	294
3.9% Lauroyl chloride	Pyridine	4	70	333	342
10% " "	DMF	4	70	332	364
19.3% " "	Pyridine	2	76	176	216
24.3% " "	DMF	1	105	176	219
26.3% " "	Pyridine	1	105	150	192
3% Benzoyl chloride	Pyridine	24	25	336	346
13.1% " "	DMSO	4	70	346	392
18.9% " "	Pyridine	4	70	324	386
30.5% " "	Pyridine	1	105	214	280
3.1% Dodecyl chloride	Tetrahydrofuran	24	25	566	583
5.3% " "	Pyridine	24	25	583	613
6.8% " "	DMF	24	25	525	561
12.5% " "	DMSO	24	25	327	368
18.3% " "	Pyridine	2	70	512	606
25.4% " "	Pyridine	4	70	461	578
14.6% Trifluoroacetic anhydride	DMSO	24	25	273	313

<sup>a</sup> At 65% R.H. and 70°F.

The drained water contents of the styrene grafted wools are presented in Table II together with the amount of polystyrene grafted, the conditions of grafting, and the total radiation dose. It is apparent that the latter can affect the results greatly. Unfortunately, there is no consistent pattern in the results; however, the samples prepared at low degrees of swelling gave, in general, lower values. This is consistent with the presumed relationship between nature of the surface and drainage properties. A knowledge of the location of the graft polymer in the fiber could be of great value in interpreting the results obtained. Work on this problem is in progress.

TABLE II  
Drained Water Content of Styrene-Grafted Wool\*

Graft, %	Swelling agent	% swelling agent in soln.	Dose, Mrad	Drained water content, %	
				Total	Wool
	Control			511	511
1.0	H <sub>2</sub> O	1	0.5	516	521
6.7	CH <sub>3</sub> OH	18	0.3	414	442
6.7	CH <sub>3</sub> OH	7	5	299	319
7.2	CH <sub>3</sub> OH	10	1	527	565
7.4	H <sub>2</sub> O	1.1	5	285	306
9.0	CH <sub>3</sub> OH	10	1	543	595
9.7 <sup>b</sup>	CH <sub>3</sub> OH	12	1	467	512
10.5 <sup>c</sup>	H <sub>2</sub> O	4	1	542	600
10.6	CH <sub>3</sub> OH	12	1	408	451
10.9	H <sub>2</sub> O	7.5	0.3	259	274
11.1	H <sub>2</sub> O	1.1	5	293	325
11.8 <sup>d</sup>	CH <sub>3</sub> OH	12	1	465	520
15.0	CH <sub>3</sub> OH	10	1	550	633
20.9	CH <sub>3</sub> OH	7	5	228	276
23.1	CH <sub>3</sub> OH	18.5	1	492	606
25.0	H <sub>2</sub> O	2	0.5	460	561
25.7	H <sub>2</sub> O	1.6	5	209	338
33.5	CH <sub>3</sub> OH	18.5	2	364	487
36.4	H <sub>2</sub> O	4.1	0.5	275	375
40.5	CH <sub>3</sub> OH	18.5	5	416	584
45.4	H <sub>2</sub> O	6	0.5	194	282
60.6 <sup>c</sup>	H <sub>2</sub> O	4	10	311	500
165.8	H <sub>2</sub> O	4.1	2	136	362
242.4	H <sub>2</sub> O	7.5	5	134	460
6.0 <sup>e</sup>	Mechanical			713	756

\* Samples grafted with 3.06*M* styrene in dioxane; dose rate, 0.3 Mrad/hr.

<sup>b</sup> No contact time.

<sup>c</sup> Van de Graaff.

<sup>d</sup> Contact time 6 days.

<sup>e</sup> Polystyrene applied by soaking fabric in 1% polystyrene solution in wet dioxane, centrifuging, and drying.

The results obtained with a number of other monomers are shown in Table III and are not too encouraging except for 2-ethylhexyl acrylate, for which substantial reductions in the drained water content were found. It is interesting that this monomer was grafted by a simple padding process in methanol solution which might tend to keep the grafting to the surfaces of the wool fibers.

### Water Vapor Sorptions

The water vapor sorption isotherms were measured on a selected number of chemically treated and grafted wool samples. The results obtained with the chemically treated wools calculated on the total weight are presented in Figures 2 and 3 and for the grafted samples in Figure 4. The data based

TABLE III  
Drained Water Content of Miscellaneous Grafted Wool

Monomer	Graft, %	Method	Dose, Mrad	MeOH, %	H <sub>2</sub> O, %	Drained water content, %	
						Total	Wool
Control						511	511
Stearyl methacrylate	6.6	Mutual	0.5	2		454	483
"	9.7	Pre-irrad.	5	6		421	462
"	10.1	Pre-irrad.	2	6		381	419
$\alpha$ -Methylstyrene <sup>a</sup>	-6.3	Mutual	1		3	522	489
"	0.2	"	5		1	496	497
"	0.4	"	5		2	528	530
"	0.8	"	5		3	514	515
Allyl acetate <sup>a</sup>	4.7	"	5		2	527	552
"	6.0	"	5		6	572	606
Allyl benzoate <sup>a</sup>	10.6	"	5		6	509	563
"	11.6	"	5		2	511	570
Acrylonitrile	9.0	Vapor phase	0.6			443	484
"	17.0	Vapor phase	1.2			446	527
Acrylonitrile <sup>b</sup>	17.4	Mutual	5	0.5		750	881
"	22.0	Vapor phase	1.8			447	544
Acrylonitrile <sup>b</sup>	34.0	Mutual	5	2.5		514	688
"	46.4	"	5	4.5		585	856
2-Ethylhexyl acrylate <sup>c</sup>	15.0	Padded	0.3			238	274
2-Ethylhexyl acrylate <sup>d</sup>	37.0	Padded	0.3			297	407

<sup>a</sup> 3.06M in dioxane.

<sup>b</sup> 3.06M in dimethylformamide.

<sup>c</sup> 15% monomer in methanol.

<sup>d</sup> 30% monomer in methanol.

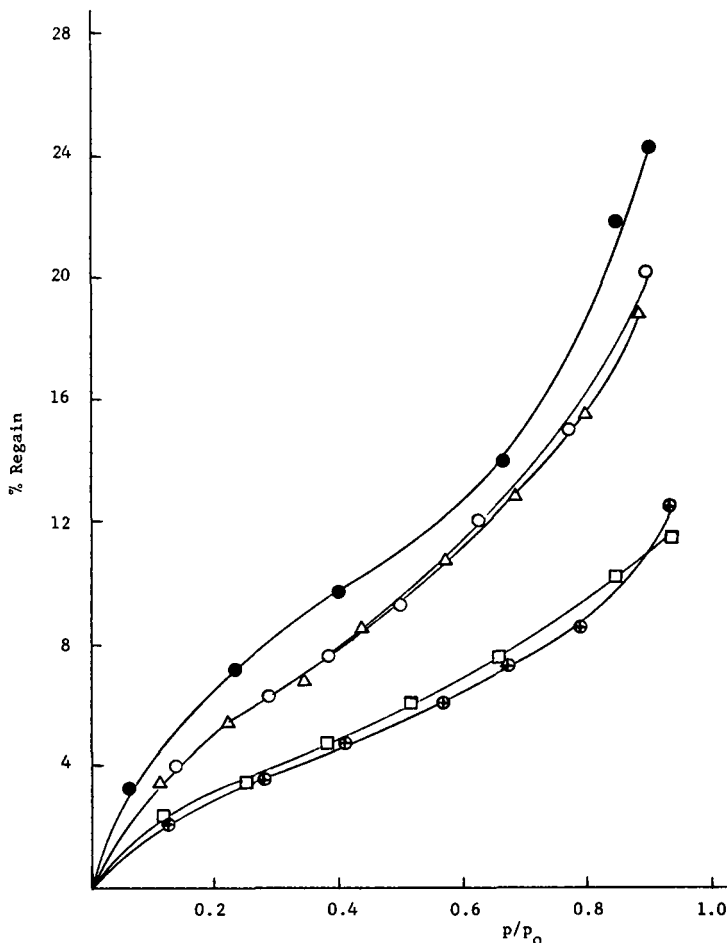


Fig. 2. Water vapor sorption isotherms at 25°C. for benzoyl chloride-treated wool (calculated on total weight): (●) untreated wool; (○) 8.5% weight increase; (Δ) 13.1% weight increase; (□) 18.9% weight increase; (⊕) 27.7% weight increase.

on the wool content only have been plotted for all the isotherms according to the simplified B.E.T. treatment;<sup>4,5</sup> reasonable linear plots were obtained up to about 40% R.H. Typical curves are shown in Figure 5. The B.E.T. temperature factors<sup>4,5</sup> and monolayer water concentration are given in Table IV for all the samples studied. The region at 90% R.H. and the differences between this value and the monolayer regains, i.e., the concentrations of a nonbonded dissolved water, are also included in Table IV. These are presented on a simple relative scale to facilitate comparison.

The values for the untreated wool are similar to those reported by Bull.<sup>5</sup> Considering the grafted wools, the overall water sorption is considerably reduced even when calculated on the wool content only. The first layer sorption figures are somewhat reduced for two of the samples. The non-



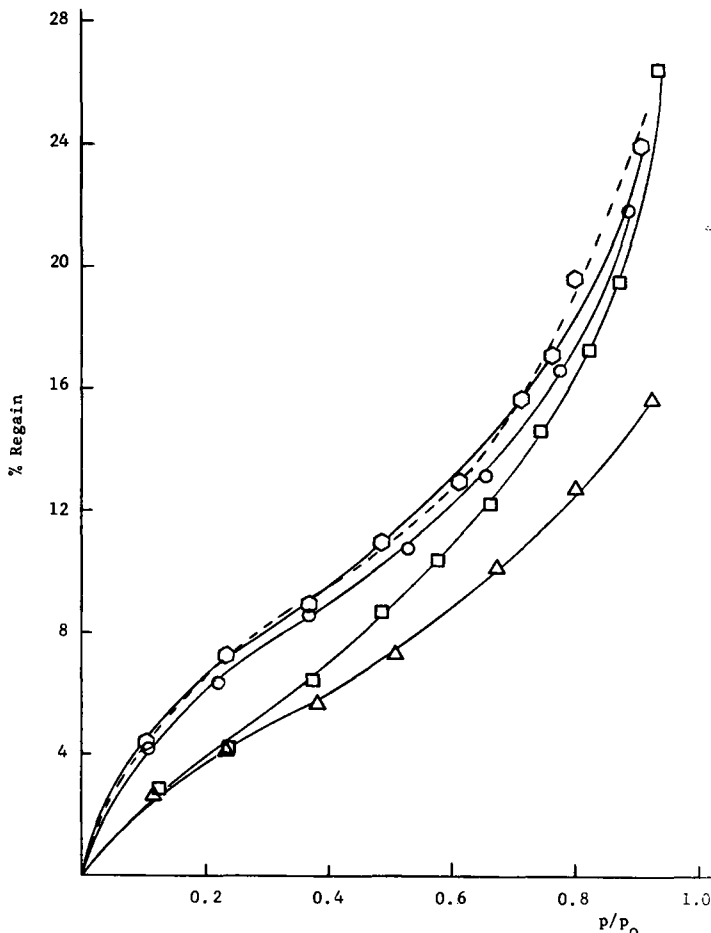


Fig. 3. Water vapor sorption isotherms at 25°C. for chemically treated wools (calculated on total weight): (---) untreated wool; (○) dodecyl chloride-treated, 5.3% weight increase; (○) dodecyl chloride-treated, 14.5% weight increase; (□) dodecyl chloride-treated, 25.4% weight increase; (△) trifluoroacetic anhydride-treated, 14.6% weight increase.

bonded water contents are systematically decreased showing the reduced swelling brought about perhaps by the bulking action of the grafted polymer. The two samples of styrene-grafted wools (6.7% and 25%) prepared under low swelling conditions gave much less change in both the first layer and nonbonded water than the two prepared under high swelling conditions, as would be expected. The 2-ethylhexyl acrylate sample was padded on with a methanol solution of the monomer and shows results characteristic for high swelling preparations, although the drainage properties were also good. Considerable information regarding the location of the graft polymer could be gained by a systematic study of the sorption isotherm, and such work is in progress at this time.

TABLE IV  
B.E.T. Constant, Weight of Water in the Monolayer  $a_1$ , and  
Regain at 90% R.H. for the Sorption of Water Vapor

Sample	$h$ (B.E.T. constant)	$a_1$ , g./100 g. dry wool	Sorption at 90% on wool basis	Differ- ence on rel. scale <sup>a</sup>
Untreated	14.1	6.9	25.2	1.00
Grafted				
6.7% Polystyrene <sup>b</sup>	9.3	7.8	24.9	0.93
13.1% Polystyrene <sup>c</sup>	9.4	5.6	18.0	0.68
25.0% Polystyrene <sup>b</sup>	9.3	7.8	22.7	0.81
143.0% Polystyrene <sup>c</sup>	5.4	4.8	13.6	0.48
37% 2-Ethylhexyl acrylate	14.1	6.9	18.8	0.65
Chemically treated				
8.5% Benzoyl chloride	7.8	6.8	22.4	0.85
13.1% " "	7.9	7.0	21.9	0.81
18.9% " "	8.0	4.7	15.0	0.56
27.7% " "	5.5	5.2	13.3	0.44
5.3% Dodecyl chloride	15.6	5.5	24.3	1.03
14.5% " "	6.8	5.1	24.6	1.06
25.4% " "	5.3	6.2	26.8	1.12
14.6% Trifluoroacetic anhydride	6.1	5.1	17.0	0.65

<sup>a</sup> Nonbonded sorbed water.

<sup>b</sup> Prepared under low swelling conditions.

<sup>c</sup> Prepared under high swelling conditions.

TABLE V  
Effect of Chemical Modification of Wool on the Change in Regain  
and Heat Evolved with Increase in Relative Humidity from 50% to 75%

Treatment	Regain, %			Heat evolved, cal./g. fiber <sup>a</sup>
	50% R.H.	75% R.H.	Difference	
None	15.7	21.1	5.4	3240
25% grafted polystyrene	9.3	13.6	4.3	2580
143% " "	2.8	4.2	1.4	840
18.9% benzoyl chloride	5.9	8.7	2.8	1680

<sup>a</sup> The average heat evolved from 50 to 75% R.H. was found to be 600 cal./g. water sorbed.

The chemically treated samples also showed marked reductions in both the first layer and bulk water sorptions, except for the dodecyl chloride-treated samples. These tended to have lower first layer sorptions but to give increased free water sorption, perhaps indicating some quaternization or excessive rupture of the wool structure. The regains of wools modified in various ways at different humidities have recently been discussed in considerable detail by Watt and Leeder.<sup>6</sup>

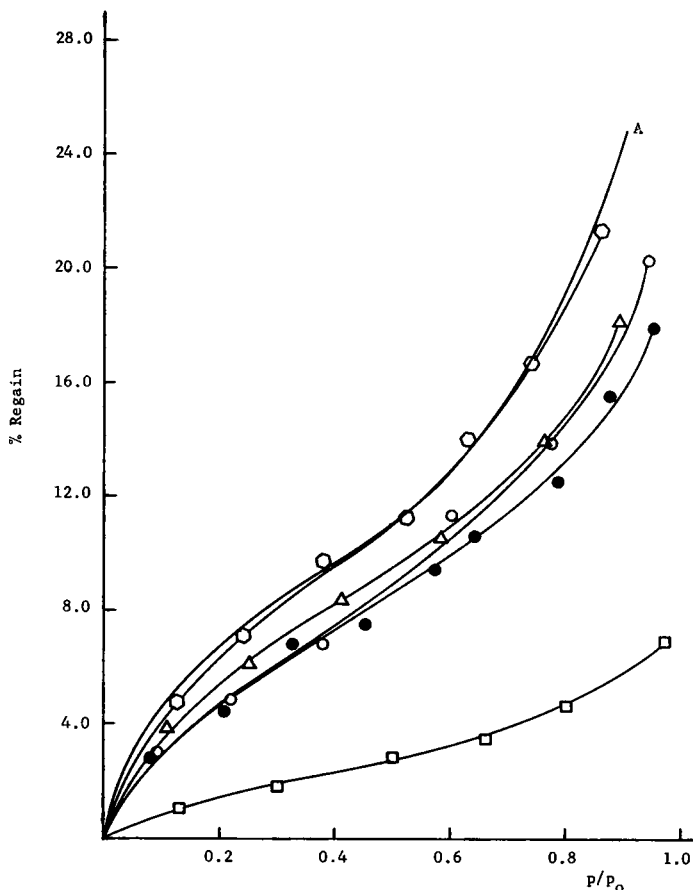


Fig. 4. Water vapor sorption isotherms at 25°C. (calculated on total weight): (A) untreated wool; (○) 6.7% grafted polystyrene; (●) 13.1% grafted polystyrene; (△) 25% grafted polystyrene; (□) 143% grafted polystyrene; (○) 37% grafted poly(2-ethylhexyl acrylate).

The heats of sorption have also been calculated in the case of the untreated wool and three modified samples by using the method described by Treybal<sup>7</sup> based on the original papers of Othmer and Sawyer,<sup>8</sup> and the results are presented in Figure 6 as a function of regain. Most of the heat of sorption is clearly the heat of condensation of water. This value is known and has been computed and subtracted from the total heat of sorption, hence the heats of mixing can be obtained, and these are presented in Figure 7. At low regains, i.e., in the specific site sorption regain, there is considerable heat of mixing, especially with the untreated wool; the results are in line with the B.E.T. heat terms given in Table IV, which are also a measure of the heat of "mixing" of the first layer of adsorbed water molecules.

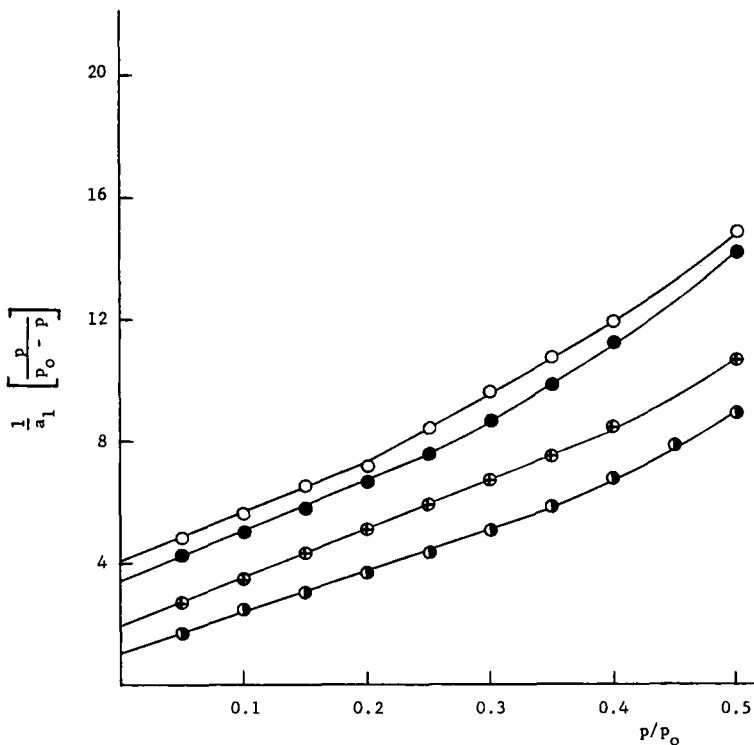


Fig. 5. Typical simplified B.E.T. plots: (●) untreated wool; (+) 13.1% grafted polystyrene; (●) 27.7% benzoyl chloride; (○) 143% grafted polystyrene.

The modifications of the wool lead to changes in the heats of sorption for a given change in relative humidity, mainly due to the change in the amount of water sorbed. In Table V the changes in regain and the consequent differences in the heats evolved are given for the untreated wool and three modified samples on increasing the relative humidity from 50% to 75%. There is a substantial reduction in both quantities for the highly modified samples. This is in contrast to the less highly modified samples, where considerable decreases in the drained water content were achieved with almost no change in the sorption isotherms.

### Diffusion of Water Vapor

The sorption-desorption method of measuring diffusion constants for water in polymers is often complicated by the accompanying heat effects. This is particularly true in the case of wool and other protein fibers because of the large heats of sorption. The actual magnitudes of the temperature changes during sorption and desorption have been measured; typical results are shown in Figure 8. It can be seen that a rise in temperature of more than 10°C. occurs during the sorption process. This effect has been reported by Cassie et al.,<sup>9</sup> who assumed that the water vapor was taken up to equilibrium essentially instantaneously and the rate of sorption was en-

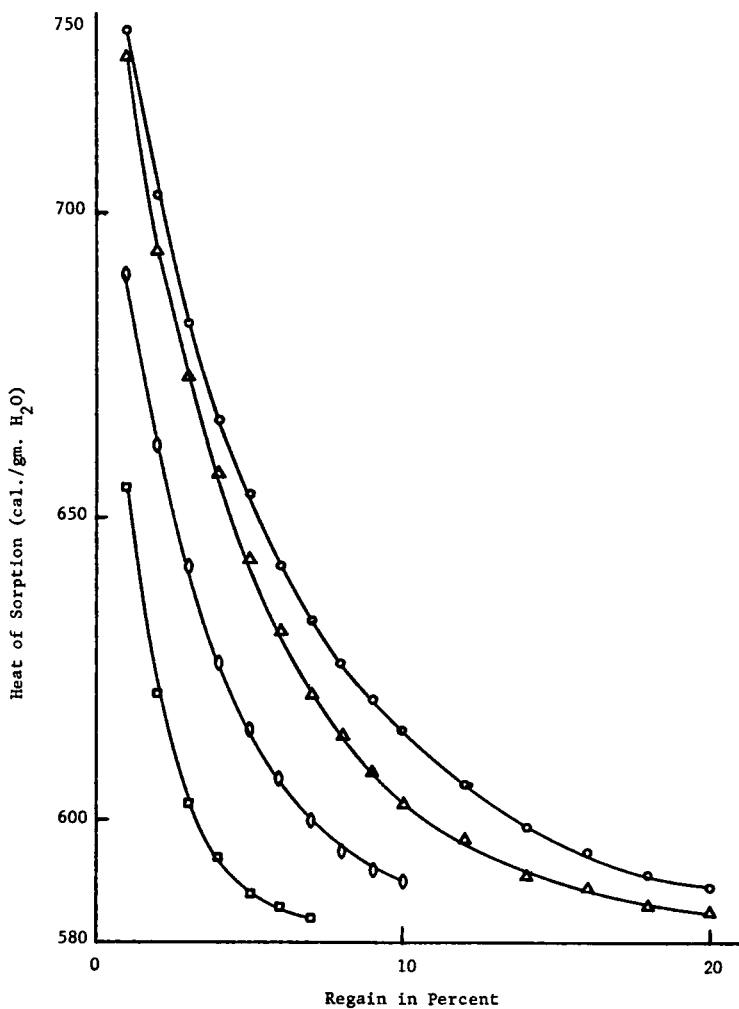


Fig. 6. Heats of sorption vs. regain: (O) untreated wool; ( $\Delta$ ) 25% grafted polystyrene; ( $\square$ ) 143% grafted polystyrene; ( $\circ$ ) 18.9% benzoyl chloride.

tirely a heat effect. Experiments by Armstrong and Stannett<sup>3</sup> have demonstrated, in the case of wool fabric, that the diffusivity must also be taken into account.

A model was set up to include both the diffusivity and heat effects, and a mathematical solution was obtained for this model. The necessary parameters were determined experimentally for wool fabric, and corrections were made for the heat effects. The correction factors increased with increasing water content and rapidly rose to several hundred per cent. At high water contents the correction factors became so large that the equation became too sensitive for accurate corrections to be made. A full account of the calculations and the correction factors may be found elsewhere.<sup>3</sup>

The diffusion coefficients were measured by the sorption-desorption

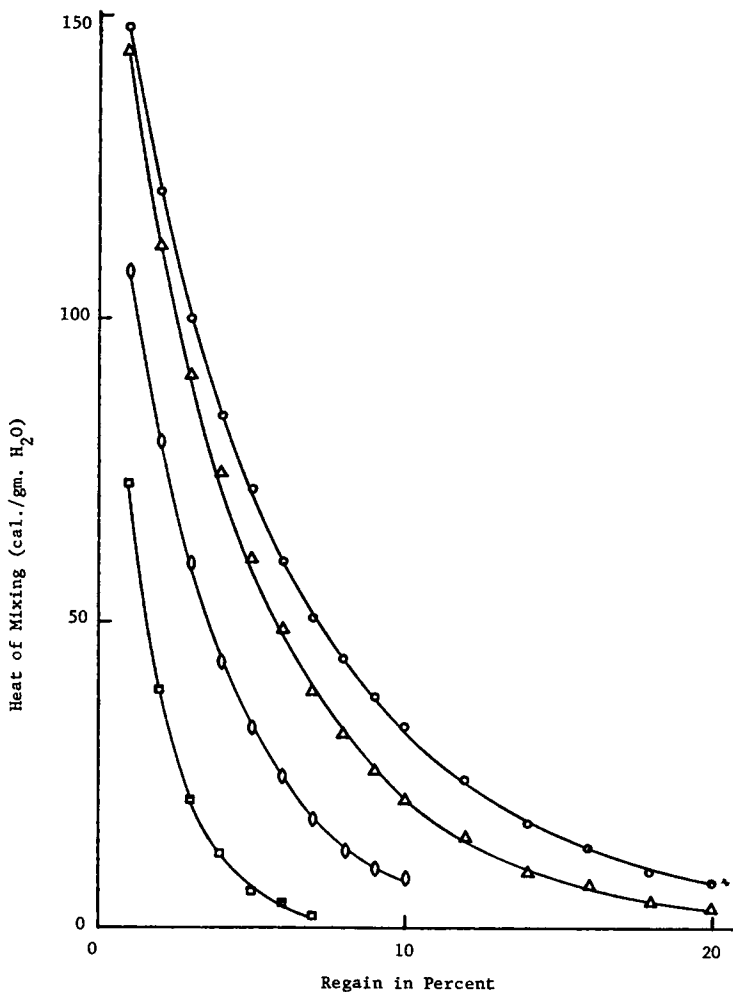


Fig. 7. Heats of mixing vs. regain: (O) untreated wool; ( $\Delta$ ) 25% grafted polystyrene; ( $\square$ ) 143% grafted polystyrene; (o) 18.9% benzoyl chloride.

method for untreated wool and wool grafted with 25% polystyrene, 143% polystyrene, and treated with 18.9% benzoyl chloride. Corrections were made for the heat effects, and the values are shown in Figure 9.

The results are quite interesting; in the case of the untreated wool the diffusion constants can be seen to increase rapidly with the concentration of water in the fiber. This is in agreement with the published results of King,<sup>10</sup> Nordon et al.,<sup>11</sup> and Watt,<sup>12</sup> as are the actual orders of magnitude of the diffusion constants in the range of concentrations where the correction factors are valid. The modified wools, however, show a quite different pattern of behavior. The least modified wool, with 25% of grafted polystyrene, shows also an increasing diffusivity with concentration. However, there is a longer concentration interval with essentially no concentration

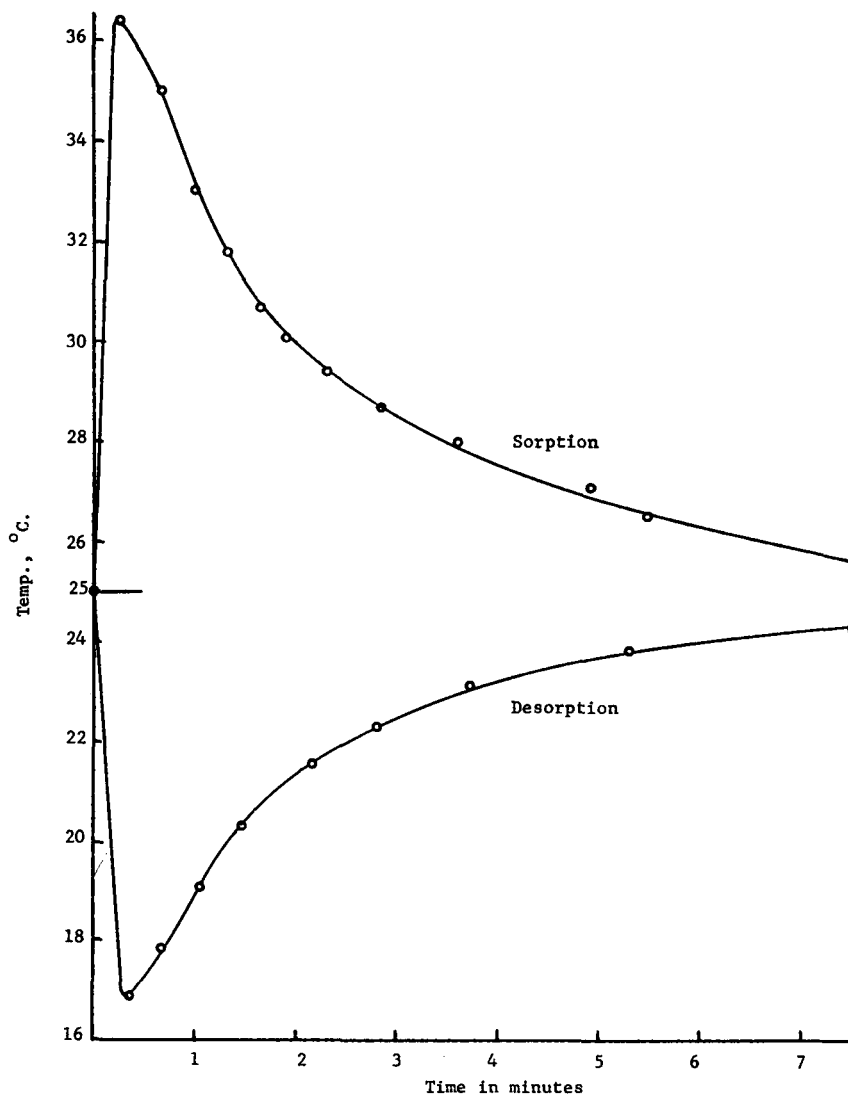


Fig. 8. Typical temperature changes in wool during sorption and desorption experiments; 0-6.0% regain at 25°C.

dependence before the diffusion constants begin to increase. The highly modified samples (as shown by the sorption isotherms) have a slightly larger diffusion constant at very low regains which, instead of increasing with increasing concentration, can be seen to decrease. This pattern of behavior has recently been found<sup>13,14</sup> with ethyl cellulose and has been ascribed to the clustering of water in the polymer. It is possible that with the increasing hydrophobicity of the fiber a similar phenomenon begins to occur with the modified wools. In any case, it is clear that within the humidity ranges important in the drying process itself, say, from 100% to

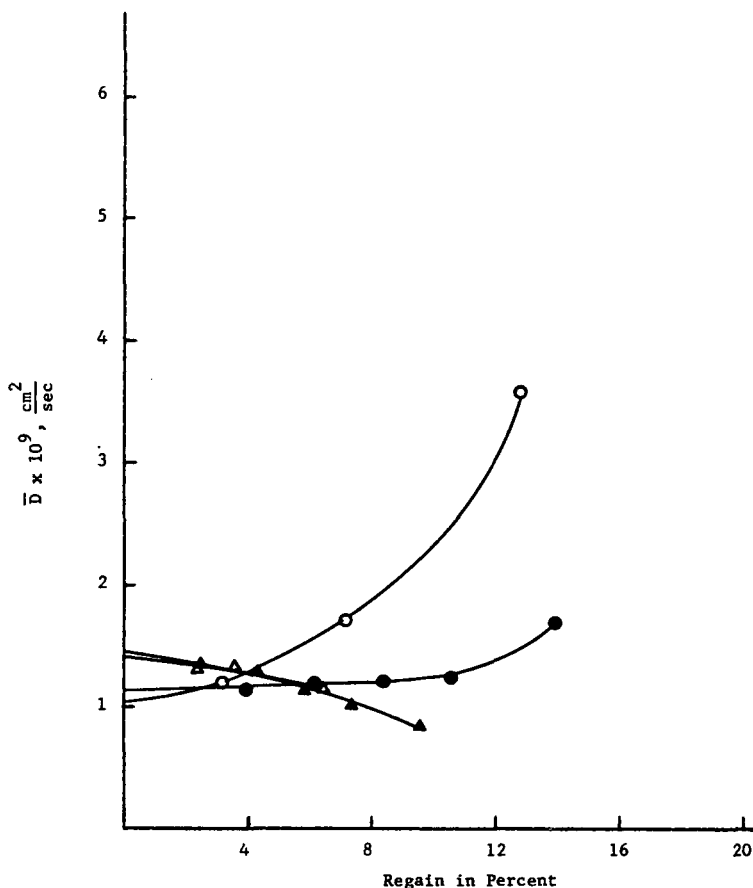


Fig. 9. Integral diffusion constants for water at 25°C. (corrected for heat effects): (O) untreated wool; (●) 25% grafted polystyrene; (Δ) 143% grafted polystyrene; (▲) 18.9% benzoyl chloride.

65% R.H., the modified, more hydrophobic, wools have considerably smaller diffusion constants for water vapor when corrected for the temperature effects. The magnitude of these differences will be reduced when the temperature effects in air are also taken into account.

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### Résumé

Les rapports laine-eau d'échantillons de laine modifiées, préparés comme décrit dans la partie I de cette série ont été étudiés. On a mesuré la teneur d'eau absorbée par le tissu et des isothermes de sorption et des constantes de diffusion de vapeurs d'eau de la laine non traitée et modifiée ont été mesurées. La plupart des tissus à base de laine traité ont une considérable diminution de teneur en eau absorbée comparée à la laine non traitée. Toutefois, le degré d'amélioration dépend de façon notoire des conditions ou de modification particulièrement pour les matériaux greffés avec du styrène. Dans certains cas des valeurs voisines de celles des tissus à base de polypropylène ont été trouvées. Les isothermes de sorption également montraient que les modifications réduisaient substantiellement dans certains cas, les regains, mêmes lorsque ceux-ci sont calculés sur la teneur en laine uniquement. Les constantes de diffusion étaient difficiles à mesure à cause des chaleurs de sorption qui causent des variations de température en cours de sorption, toutefois, aux regains plus faibles cet effet peut être corrigé. On a trouvé que, à la fois les modifications chimiques directes et les greffages manifestaient un comportement à la diffusion qui était plutôt caractéristique des matériaux hydrophobes, en ce sens que les constantes de diffusion tendaient à décroître avec une concentration croissante. Aux faibles humidités les constantes de diffusion étaient plus grandes que dans la laine non traitées; à humidité plus élevée des diffusivités plus faibles ont été trouvées pour les laines modifiées.

### Zusammenfassung

Die Wasseraufnahme von Wolle wurde an den entsprechend der Beschreibung im Teil I dieser Reihe dargestellten modifizierten Wollen untersucht. Der Gehalt des Gewebes an entfernbar Wasser sowie die Sorptionsisotherme und die Diffusionskonstante von Wasserdampf in unbehandelten und modifizierten Wollen wurde gemessen. Die meisten behandelten Wollgewebe zeigten im Vergleich zur unbehandelten Wolle eine beträchtliche Abnahme des Gehalts an entfernbar Wasser. Der Grad der Verbesserung hing aber merklich von den Modifizierungsbedingungen ab, besonders bei den mit Styrol aufgepfropften Stoffen. In einigen Fällen wurden Werte gefunden, welche denjenigen eines vergleichbaren Polypropylengewebes nahe waren. Auch die Sorptionsisothermen zeigten, dass die Modifizierung, in einigen Fällen sogar wesentlich, auch die für den Wollgehalt allein berechnete Aufnahme herabsetzten. Die Diffusionskonstanten waren wegen der durch die Sorptionswärme während der Sorption bedingten Temperaturänderung schwierig zu messen; bei geringeren Aufnahmen konnte aber für diesen Effekt korrigiert werden. Es wurde gefunden, dass sowohl die direkte chemische Modifizierung als auch die aufgepfropfte Wolle ein Diffusionsverhalten zeigte, welches mehr für ein hydrophobes Material charakteristisch war, da die Diffusionskonstanten eine Neigung zur Abnahme mit zunehmender Konzentration zeigten. Bei niedriger Feuchtigkeit waren die Diffusionskonstanten grösser als bei der unbehandelten Wolle, bei höherer Feuchtigkeit wurde aber bei der modifizierten Wolle eine geringere Diffusionsfähigkeit gefunden.

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