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DEFENCE RESEARCH ESTABLISHMENT OTTAWA
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Abstract

This study examined how fibre and fabric properties affect the drying time of a wide range of textile materials. It was found that the drying time of a fabric is independent of its fibre type and thus regain, but dependent on the amount of water initially in the fabric which depends to a great extent on the thickness of the fabric.

Résumé

Cette étude a eu pour but d'examiner comment les propriétés des fibres et des tissus affectent le temps de séchage d'une gamme étendue de matières textiles. Il est apparu que le temps de séchage d'un tissu ne dépendait pas du type de fibre dont il est fait et, par conséquent, de sa teneur en humidité, mais dépendait plutôt de la quantité d'eau initialement contenue par le tissu, ce qui est relié en grande partie à l'épaisseur du tissu.

EXECUTIVE SUMMARY

The purpose of this study was to examine how fibre and fabric properties affect the drying times of a wide range of textile materials. The drying times of a wide range of fabrics made from various fibres were measured. The drying time of a comparable amount of water from a flat surface was compared to these results.

It was concluded that the amount of water freely held by a fabric is independent of fibre content and thus regain. The main fabric property which does determine the amount of water a fabric freely picks up is thickness. Further, the time that it takes a fabric to dry is directly related to the amount of water which is in the fabric initially, the more water it holds initially, the longer it takes to dry. Finally, water evaporates more rapidly from a fabric than from a water drop of equivalent volume. This is because a fabric has a greater surface area from which the water can evaporate.

INTRODUCTION

Over the years, some researchers (1 - 6) have attempted to relate the water retention of textile fabrics to their fibre content, claiming that fibres with high regains should hold more water than those with low regains. Other researchers (7,8) have concluded that it is selected **fabric** properties rather than **fibre** properties which determine the total amount of liquid a fabric absorbs, but none have demonstrated this experimentally. Rampant throughout the popular outdoor magazines are both articles and advertisements that state or imply that the higher the fibre's regain, the more water the fabric absorbs and so the longer it takes to dry.

The purpose of our study was to examine how fibre and fabric properties affect the drying time of a wide range of textile materials. This paper will show that the drying time of a fabric is dependent on the amount of water initially in the fabric which depends to a great extent on the thickness of the fabric.

METHOD

A range of fabrics varying in construction, mass per unit area and fibre type were selected. Their pertinent physical properties are given in Table 1.

The masses of the fabric specimens were measured after conditioning in an atmosphere of 20°C and 65% relative humidity and after drying at 105°C. The regains of the fabrics were calculated according to the Canadian Standard, CAN/CGSB-4.2 "Determination of Moisture in Textiles" Method No 3 (9).

The specimens, die-cut to identical area, were uniformly wetted out in distilled water to which detergent had been added and left overnight between damp sponges. The next day, the mass of the water freely absorbed each specimen was recorded. This method agrees suitably with other methods (10). The specimens were again placed in the atmosphere of 20°C and 65% relative humidity to dry. The mass of each specimen was automatically recorded at appropriate intervals in the drying cycle. The time to dry was recorded when the mass of the specimen reached 105% of its dry mass. The 5% reflects the accuracy of the balance used. Three specimens of each fabric were wetted and dried.

Table 1. Pertinent Physical Properties of the Fabrics Used.

Fabric	Mass (g/m^2)	Thickness (mm)	Count (yarns/cm)
Cotton duck*	362	0.66	21x17
Cotton sheeting*	155	0.41	22x17
Cotton lawn*	100	0.28	32x32
Polyester plain weave A*	159	0.41	20x16
Polyester plain weave B*	121	0.30	25x21
Polyester batiste*	71	0.20	40x25
Wool plain weave*	124	0.46	22x28
Wool single knit*	213	0.81	23x28
Acrylic plain weave*	144	0.38	20x15
Acrylic knit*	124	0.69	19x22
Nylon knit*	215	1.02	12x14
Nylon tricot knit*	84	0.25	18x18
Cotton/polyester knit	162	0.64	13x13
Polypropylene plain weave*	160	0.64	16x13
Polypropylene knit	221	1.24	9x11
Nylon/tricot Goretex	175	0.43	40x25
Dermoflex**	201	0.23	27x20

* Obtained from Testfabrics Incorporated, New Jersey
** A water-vapour permeable waterproof coated nylon

We also measured the rate of evaporation of equivalent amounts of water from a free surface. The tests were done in a conditioning room (20°C, 65% relative humidity). A plastic petri dish 85 mm in diameter, was placed on the balance pan and the balance tared. Water, with a very small amount of surfactant to promote spreading, was added to the petri dish with a hypodermic syringe. At the beginning of the test, the mass of water was set at 1.25 g and the dish was grasped with tweezers and moved in such a way as to spread the water over the bottom surface. The mass of water was recorded at half hour intervals until it neared zero. This experiment was repeated six times.

RESULTS

The percent regain, the amount of water picked up by the fabric and the time to dry are given in Table 2.

Table 2. Results of the Drying Experiments.

Fabric	Regain (%)	Mass of water per specimen (g)	Time to dry (h)
Cotton duck	7.5	1.25	5.5
Cotton sheeting	7.2	0.96	5
Cotton lawn	7.1	0.58	2.25
Polyester plain weave A	0.8	0.73	3
Polyester plain weave B	0.5	0.58	2.5
Polyester batiste	0.6	0.32	1
Wool plain weave	13.4	0.58	3
Wool knit	13.8	1.64	7
Acrylic plain weave	1.0	0.50	2
Acrylic knit	1.1	1.45	5
Nylon doubleknit	4.1	2.52	10.5
Nylon tricot knit	4.1	0.25	1.1
Cotton/polyester knit	3.8	1.97	8.75
Polypropylene plain weave	0.08	0.80	3
Polypropylene knit	0.14	2.26	8.75
Nylon/tricot Goretex	3.4	0.63	2
Dermoflex	2.7	0.16	1

REGAIN AND WATER ABSORBED

Table 2 and Figure 1 show that the amount of water picked up by the fabric is independent of fibre type and regain. The most diverse are the two nylons which, in standard conditions, have identical percent regains but one initially has ten times the amount of water in it. We believe the confusion of equating fibres with high regain with high water retention arises when "regain", which involves water vapour, is applied to liquid water. When a fabric is wetted, the fibres in the yarns in the fabrics are surrounded by liquid water. The hydrophillic sites on the high regain fibres which attracted water molecules from the atmosphere are now under many layers of water molecules. The low regain fibres are also covered with water. The regain property is no longer relevant.

CORRELATION OF WATER ABSORBED WITH PHYSICAL PROPERTIES

In a previous study (11), the amount of water which should be held in the yarns of a totally-wet fabric was calculated and was found to be insufficient to account for all the water held by the fabric. We concluded that obviously the water was being held elsewhere and the most obvious place was at the yarn interstices. This was shown to be true by the fact that we found a good correlation between the fabric thickness and the amount of water held by it. This was considered logical since the degree of contact at a yarn interstice is greater for thick yarns than for thin ones and so thick fabrics would hold more water at their yarn interstices than thin ones. As shown in Figure 2, this study confirms the results of our previous work, namely that there is a good correlation between the amount of water held by a fabric and its thickness.

A paper by Maejima (12) contains detailed descriptions of fabrics varying in fabric and fibre type. We used varying combinations of his values of fibre diameter, yarn diameter, count and fabric volume to calculate detailed fabric parameters and plotted the results against total amount of liquid (n-dodecane) the fabrics took up per unit area. The plot of thickness versus amount of liquid in the fabric (Figure 3) produced the least scatter of all combinations of variables considered. Therefore, we concluded that, for all practical purposes, the amount of liquid, including water, a fabric takes up is simply correlated with thickness; the thicker the fabric, the more liquid it holds.

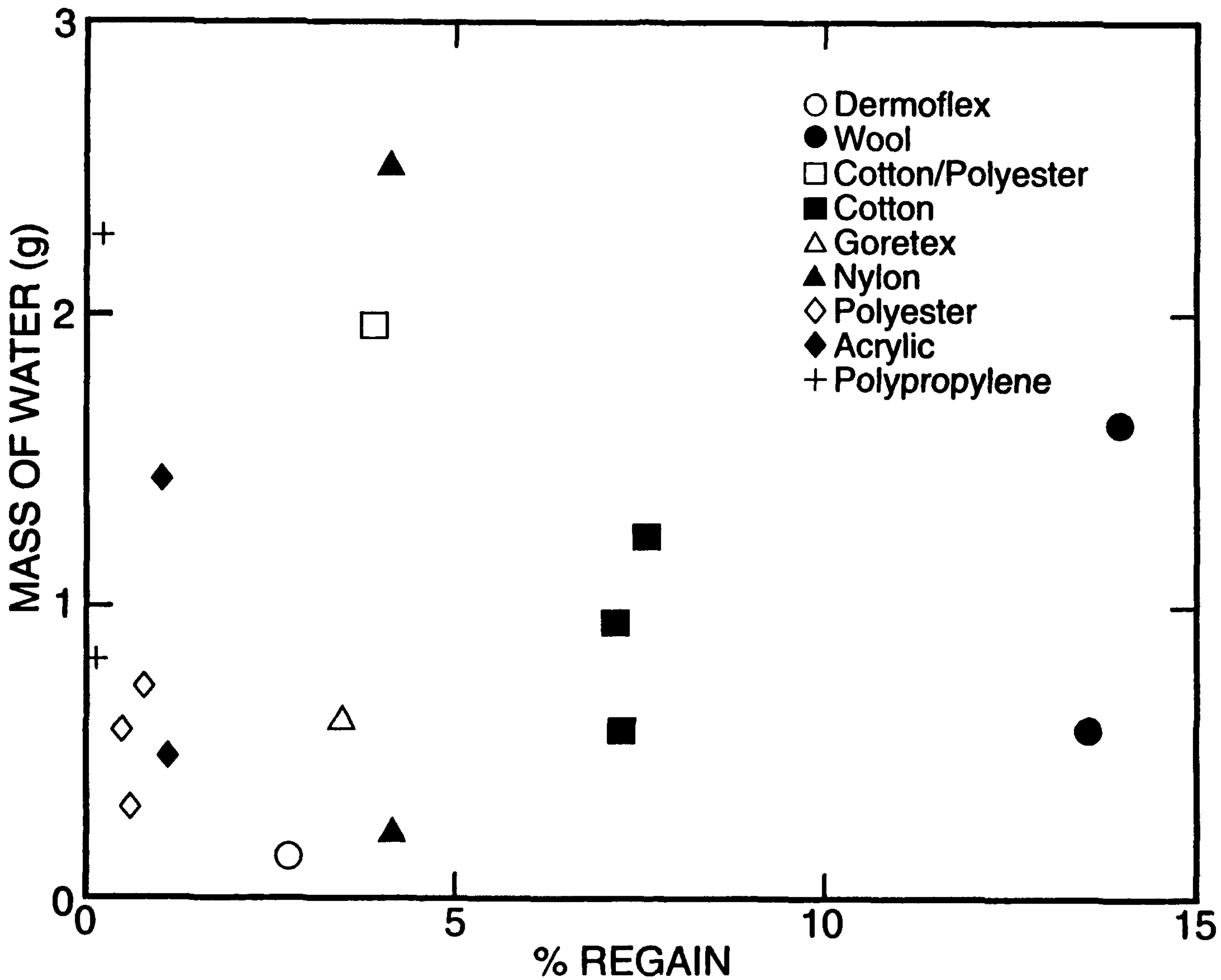

Figure 1. This shows no relationship between the % regain of the fibre and the mass of water initially in the fabric.

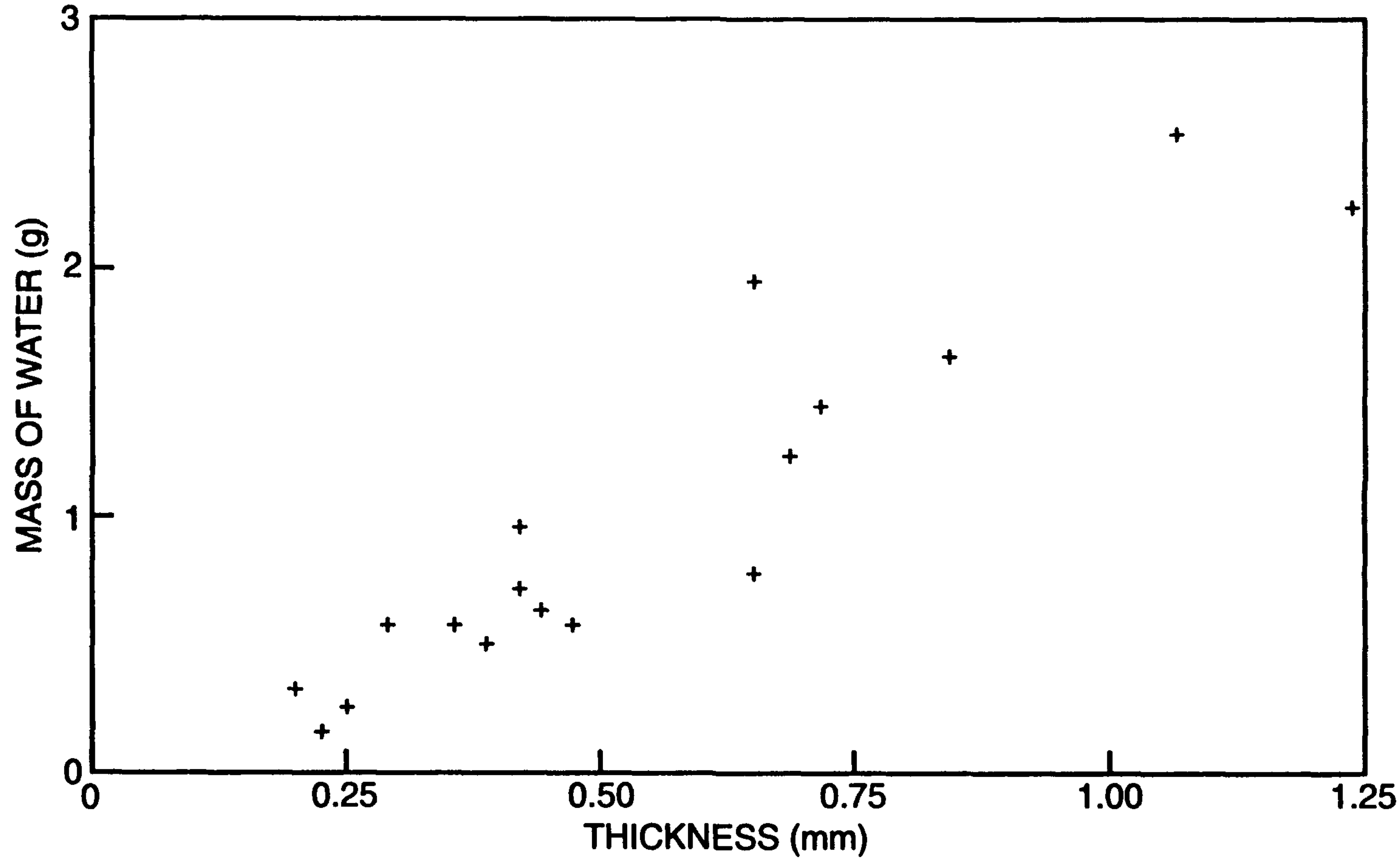

Figure 2. There is a good correlation between Mass of Water held by the fabric and its thickness.

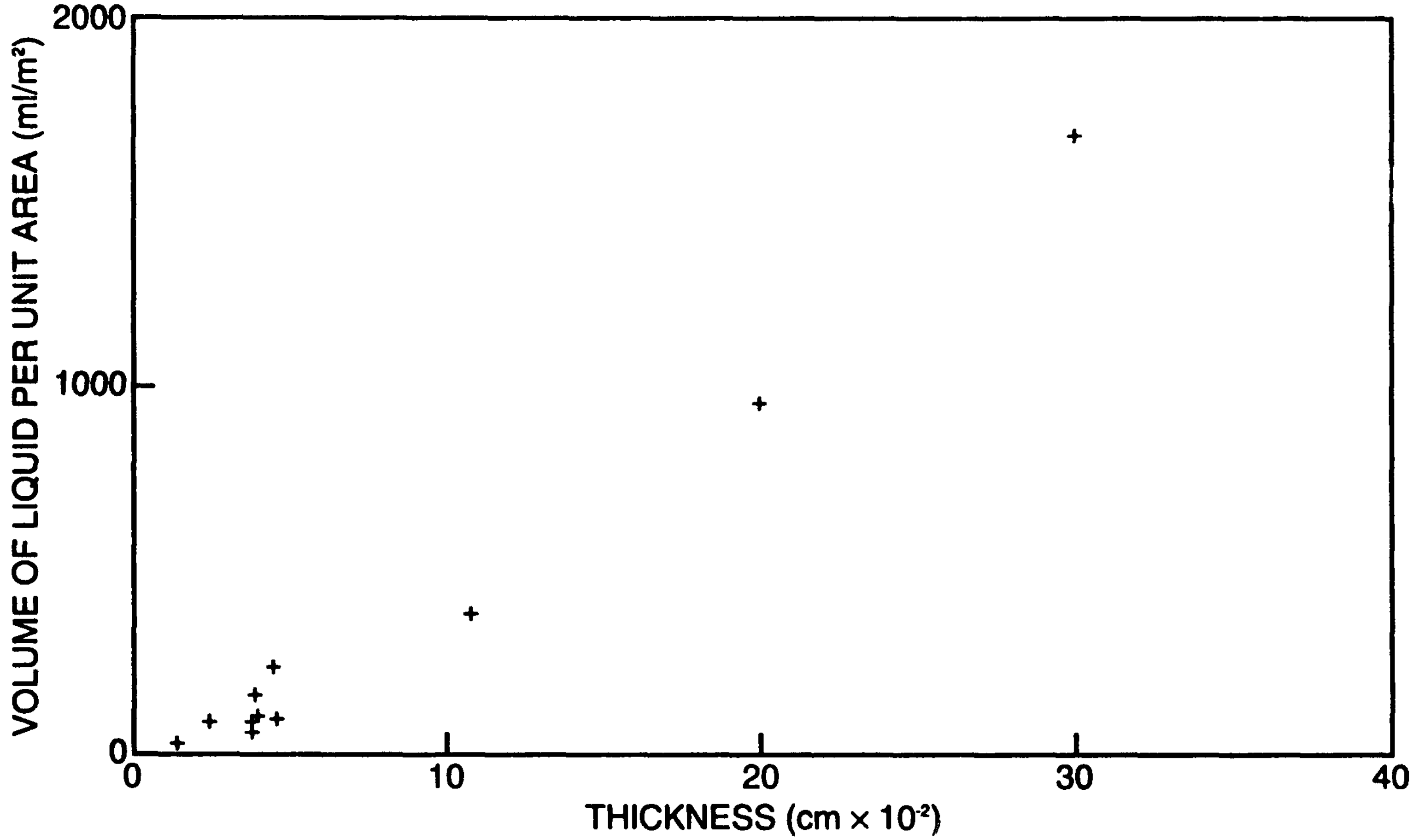

Figure 3. A plot of thickness versus volume of liquid held by Maejima's fabrics.

WATER ABSORBED AND DRYING TIME

Figure 4 shows that there is a linear relationship between the time to dry and the initial mass of water in the specimen. In other words, the more water there is in the fabric to begin with, the longer it takes the fabric to dry. Since the amount of water held by a fabric is independent of fibre type, the time to dry is not fibre dependent. A cotton, a wool and a synthetic nylon all held the same amount of water initially and all took about the same time to dry. As mentioned earlier, our experiments were terminated when the mass of the specimen was within 5% of its original conditioned mass. Therefore, there may well be differences in the drying times for fibres of varying regains during this final, but unmeasured, drying period.

The results of the times to dry for fabrics and for the free-standing water are given in Figure 5. Only the results of the fabrics which had initially 1.25 g of water or less in them are included. The water in the fabric takes a shorter time to dry than an equivalent amount of free-standing water. This can be explained by the fact that there is a greater surface area in the fabrics from which the water can evaporate.

CONCLUSIONS

It is concluded that the amount of water freely held by a fabric is independent of fibre content and thus regain. The main fabric property which determined the amount of water a fabric freely picks up is thickness. The time that it takes a fabric to dry is directly related to the amount of water which is in the fabric initially. Water evaporates more rapidly from a fabric than from an equivalent volume of free-standing water.

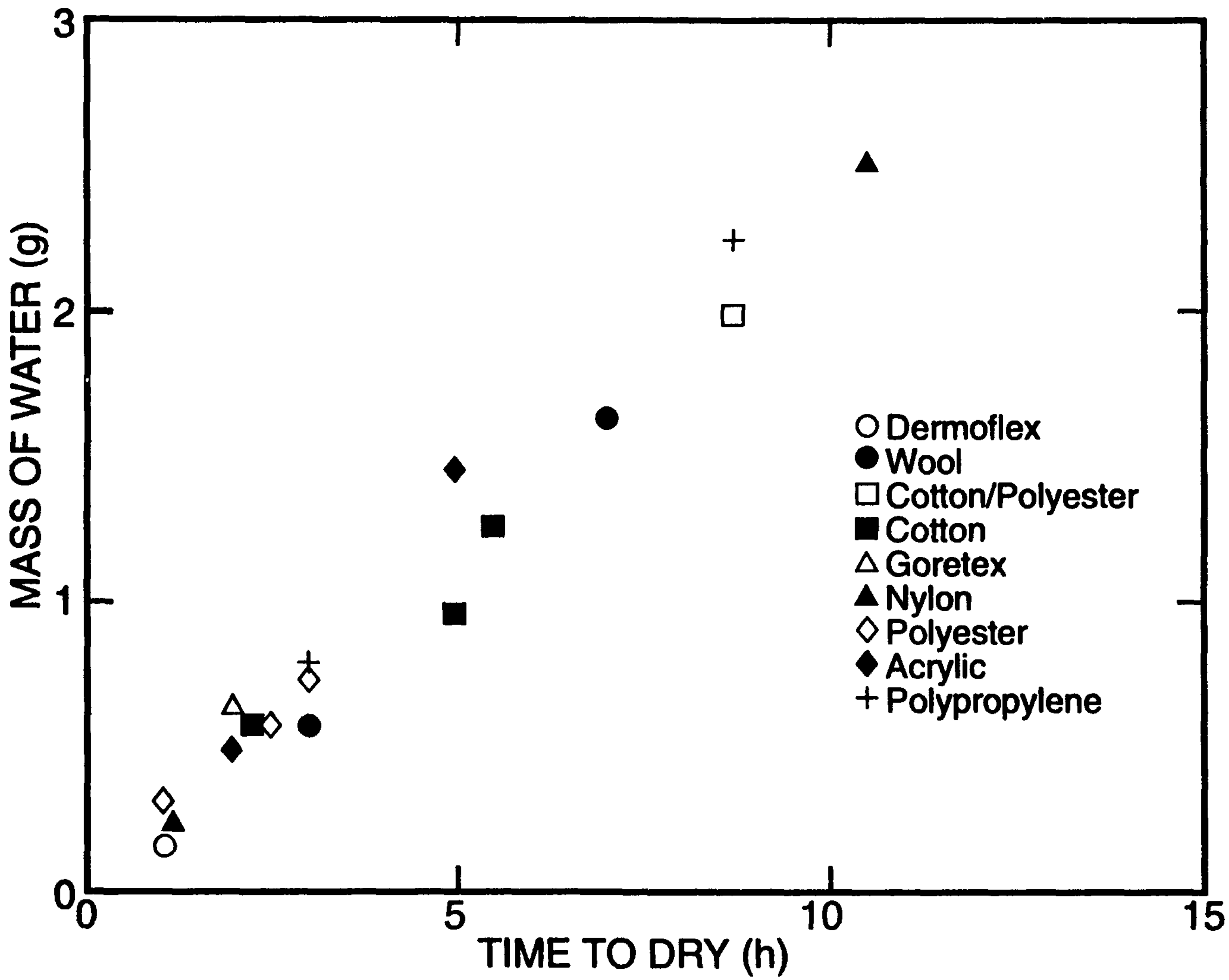

Figure 4. The linear relationship between time to dry and the initial mass of water in the fabric for a range of fabrics made from various fibre types.

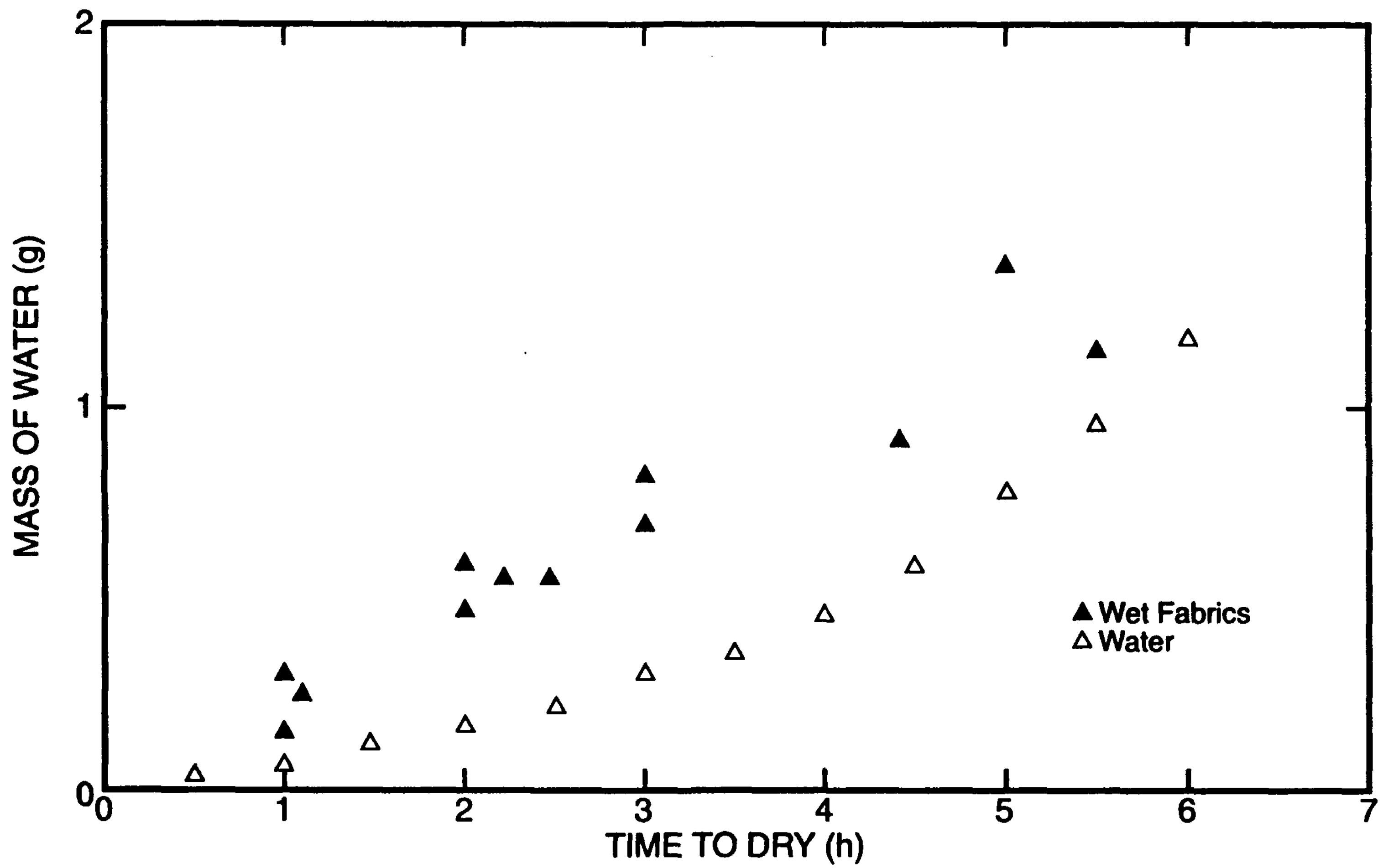

Figure 5. Wet fabrics take less time to dry than equivalent amounts of water.

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