Journal of Thermal Analysis, Vol. 32 (9987) 901–908

COMPARATIVE TESTING OF THE FLAMMABILITY OF UPHOLSTERY TEXTILES*

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(Received June 10, 1986)

Flash ignition temperatures of upholstery textiles were measured with a modified derivatograph, and the TG, DTG, DTA and T curves were also recorded. The results obtained with the newly-developed system were compared with those of the ASTM D 1929 test procedure and with the simultaneously recorded thermal analysis curves.

The level and the speed of flame propagation depend primarily on the place where the fire starts and on the features of the materials located close to the flames. Flammable subjects such as curtains, furniture covers, carpets and floor-coverongs help fire in its propagation. If we make textiles flame-retardant by special finishing or we make a correct choice materials, quick flame propagation can be prevented.

The following parameters are used to define the flammability of textiles:

— the ease of ignition,
— flame propagation,
— the heat produced by the combustion,
— smoke evaluation,
— and the toxicity of the gaseous products of fire.

It is especially important to know these factors in the case of public buildings containing large numbers of people, when we should take into account not only the threat to human life, but also the high value concentrated there. However, if these buildings are planned with the internal decoration, including textiles, taken into consideration at the very beginning of the planning, it is possible to limit the danger caused by textiles.

Ignition itself can be characterized as a chance for the material in question or its pyrolysis products to ignite under certain condition of temperature, pressure and

* Paper presented at the World Conference on Thermal Analysis, Madeira (Portugal), 1986.

John Wiley & Sons, Limited, Chichester
Akadémiai Kiadó, Budapest

oxygen concentration. Measures of ignition include the flash-ignition temperature, the autoignition temperature and the oxygen index.

In this report we deal in details with determination of the flash-ignition temperature.

Experimental

Our aim was to determine the flash-ignition temperature exactly, and if possible quickly. We performed our experiments in two ways: in a hot-air furnace heated by a hot air stream, and in a modified derivatograph [1]. As the modified derivatograph is a newly-developed instrument, the optimum experimental conditions for textile investigations were not known. For this reason, we first had to establish the correlations between the flash-ignition temperature and the conditions of the experiments, i.e. the weight and division of the material, the heating rate and the air supply. We compared the flash-ignition temperature obtained with the derivatograph with the results we had found with a standard method. The results of thermal analysis were extremely useful, as, besides the flash-ignition temperature, they provided certain additional information.

Equipment and methods

The flash-ignition temperatures of solid materials, including textiles, are determined with the ASTM D 1929 test procedure [2]. The principle of the measurements is as follows:

The material is placed into an electrically heated, vertical furnace, in which air with a predetermined temperature and speed is flowing upwards. At the upper opening of the furnace, a pilot flame ignites the mixture of air and the degradation products of the material under experiment. The quantity of material is 3 g. The air temperature is gradually changed until ignition can be observed. The flash-ignition temperature is taken as the lowest temperature of the air at which enough flammable gas is formed to be ignited by a small pilot flame.

This investigation is rather long and its exactness can be questioned. Further, the quantity of material used is rather high.

In the standard test method, the sample quantity was in all cases 3 g. The air stream speed was 1.5 m/min at all temperature levels. The measuring time varied between 10 and 30 min. This does not include the time needed for heating to the temperature of the measurement, nor the time needed for the temperature to become constant. If we take into account these time limits too, the measuring time is about 1 hour. If the ignition temperature is known approximately, the time needed for one determination is about 2 hours.

The above complications can be avoided if the flash-ignition temperature is tested with a derivatograph. For this, the MOM Q 1500 D derivatograph was fitted with an ignition temperature measuring unit. In this way the equipment can be used for the measurement of flash-ignition temperatures and autoignition temperatures, and simultaneously TG, DTG, DTA and T curves. The vapour and gases evolved from the tested material are ignited by means of an electric spark source built into the inner space of the furnace of the derivatograph, and the ignition temperature is measured with an additional Pt–Pt/Rh thermocouple.

The new construction is fixed to the ceramic base under the furnace, which holds the two spark peak rods and the thermocouple connected to them. The whole unit can be lifted or lowered by means of a screw. The two spark peak rods can be regulated separately and can be turned over their own axis. The thermocouple measuring the flash-ignition temperature, which is placed between them, can be regulated independently into the desired position. The whole unit, including the inlet and outlet gas pipes and the sample holder containing the material and inert material, is covered by a quartz bell. With a small pump, air can be transmitted through the inlet gas pipe under the bell, if necessary. The air flow can be varied. In

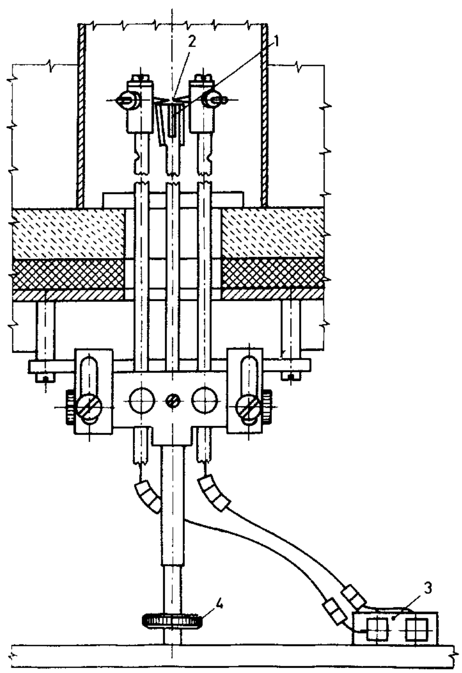

Fig. 1 Modified furnace space of the derivatograph. 1 Sample holder; 2 Spark source; 3 Spark-producing unit; 4 Lifting screw

Table 1 Experimental conditions

Hot-air furnace		MOM Q 1500 D derivatograph
Sample: 3 g		heating rate: 10 deg/min
Air flow speed: 1.5 m/min		T (maximum): 500 °C
Measuring time	max: 30 min	TG: 100–500 mg
	min: 10 min	DTA sensitivity: 500 V
		DTG sensitivity: 1 mV
		Sample holder: 16 mm high
		Atmosphere: static air
		Spark distance: 2 mm
		Distance between sample holder and spark: 2 mm
		Sparking interval: 20 s
		Min. sparking voltage: 10 kV

the measuring room, there should be no intensive air currents which can disturb the measurements (Fig. 1). The test conditions can be observed in Table 1.

The ranges for the experimental parameters are as follows: spark distance: 0–10 mm; distance between the upper part of the sample holder and the spark: 0–15 mm; time between two sparkings: 2–30 seconds; sparking voltage: 10–22 kV. From preliminary measurements, we found the values in Table 1 to be optimum.

This method yields not only the ignition temperature, but also complex information about the thermal behaviour of the material. The modified derivatograph is suitable for the determination of flash-ignition temperatures.

Materials

The tested materials are listed in Table 2.

Table 2 Tested materials

Material	Fabric weight, g/m²	Fabric construction	Finishing
Cotton	120	plain weave	bleached
Viscose rayon	138	plain weave	bleached
Wool	140	plain	bleached
Polyester	140	plain	bleached

Figure 2 depicts the thermoanalytical curves of viscose rayon. The sample weight of the material is 360 mg. The T_1 (flash-ignition temperature) curve reflects the reading of the thermocouple placed above the crucible. At the flash-ignition temperature, a high peak can be observed in the curve. The readings depends on the

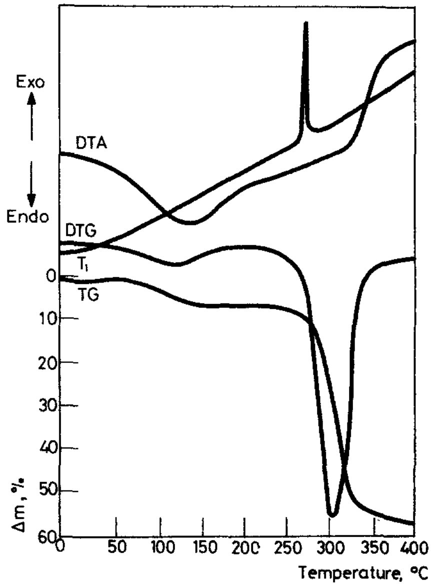

Fig. 2 TG, DTG, DTA and T_i curves of viscose rayon sample. Sample weight: 360 mg

weight of the sample. In Fig. 3, viscose rayon thermoanalytical curves are shown for a smaller sample weight, where the ignition temperature is much lower.

Table 2 gives data on the above 4 kinds of textiles, concerning the correlation between the flash-ignition temperature and the weight of the sample. The results are presented in Fig. 4. For cotton and viscose rayon, it can be seen that the flash-ignition temperature becomes lower when we increase the sample weight.

The upper limit of the sample weight (500 mg) was limited by the capacity of the crucible. For sample weights above 400 mg, the flash-ignition temperature is almost constant. However, for sample weights of 100–150 mg the flash-ignition temperature may rise by up to 15% relative to those for bigger samples. At a sample weight of 50 mg, the ignition temperature is very changeable. If we want to characterize the above materials from a fire danger aspect, it is more reasonable to work with bigger sample weights, of 400–500 mg, which give the lowest flash-ignition temperature. In the case of wool, we could measure such low ignition temperatures with 150 or 200 mg of material. These temperature levels are practically the same.

For polyester, we found a curve very similar to those for viscose rayon and cotton. With a sample weight over 350 mg, measurements cannot be made properly because of the capacity of the crucible and the foaming of the material.

In Table 3 compare the flash-ignition results found with the derivatograph with those obtained with the standard method. It is clear that, except for wool, the intervals of flash-ignition temperatures measured with the derivatograph include those with the standard method.

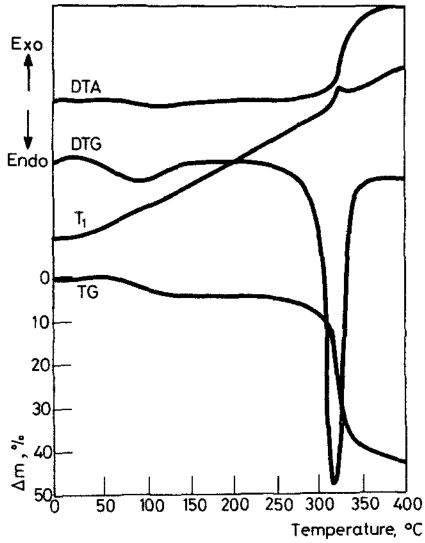

Fig. 3 TG, DTG, DTA and T_i curves of viscose rayon sample. Sample weight: 50 mg

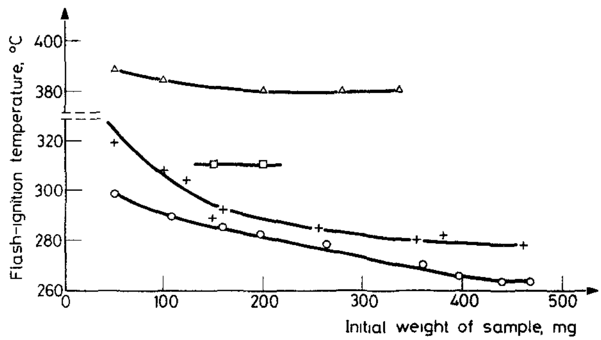

Fig. 4 Flash-ignition temperature *vs.* initial sample weight; + cotton, ○ viscose rayon, □ wool, △ polyester

Table 3

Material	Flash-ignition temperature, °C	
	MOM D 1500 Q derivatograph	MSZ 40042–77, ASTM D 1929
Cotton	278–318	280
Viscose rayon	263–298	275
Wool	310	350
Polyester	379–390	385

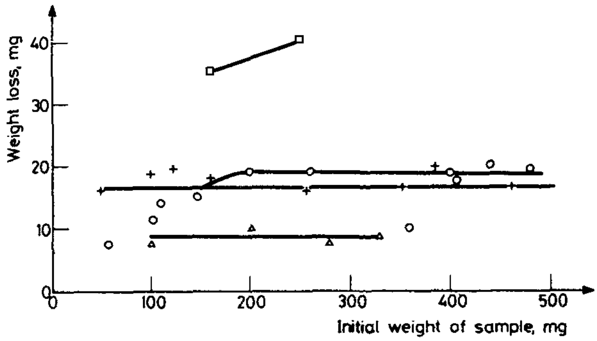

Fig. 5 Weight loss *vs.* initial weight of sample; + cotton; ○ viscose; □ wool; △ polyester

The data from the TG curves in Fig. 4 show the weight losses up to the flash-ignition temperature (excluding adsorption humidity). These weight losses are practically constant for a given material. For cotton the weight loss is 10–21 mg, for viscose 18–20 mg, for polyester 7.5–10 mg, and for wool 35–40 mg. We believe that the fluctuations are due to the relatively high heating rate and to the relatively long sparking interval of 20 s.

The comparatively constant weight loss indicates that flash-ignition always needs the same concentration of the flammable material in the gas phase, independently of the initial sample weight. However, it is more correct to use absolute weight units instead of relative values expressed in percent, and to refer them to the volume of air.

In conclusion, the MOM Q 1500 D derivatograph modified with a flash-ignition temperature measuring unit can be advantageously used to measure the flash-ignition temperatures of textiles. In comparison with the standard test method, it has the advantages that it requires smaller samples, the determination time is shorter and the TG, DTG and DTA curves give additional information. Under strict test conditions, it gives the possibility to examine the relative fire dangers of different textiles and to determine the effectivity of flame retardency. We are now carrying out further experiments in this direction.

References

1 J. Simon and A. Androsits, Hung, Sci. Instr., 48 (1980) 1.

2 C. J. Hilado, Flammability Test Methods Handbook, Technomic Publ. Co. Inc., Wesport Conn. 1973.

Zusammenfassung — Der Flammpunkt von Upholstery-Textilien wurde mittels eines modifizierten Derivatographen gemessen. TG-, DTG-, DTA- und T-Kurven wurden registriert. Die mit diesem neuentwickelten System erhaltenen Ergebnisse wurden mit den nach dem ASTM D 1929 Testverfahren erhaltenen und mit den simultan registrierten thermoanalytischen Kurven verglichen.

Резюме — С помощью модифицированного дериватографа измерены температуры воспламенения обивочных текстильных материалов, а также их ТГ-, ДТГ-, ДТА- и Т-кривые. Полученные при этом результаты сопоставлены с таковыми, полученными на основе тестового метода ASTM Д 1929 и с содновременно измеренными термоаналитическими кривыми.