SUMMARY

The stresses (tensions) built-up within fibers during processing are important because they determine many of the ultimate properties of the fiber. Thermomechanical Analysis (TMA) provides a rapid method for measuring those stresses particularly in an R&D laboratory where only limited amounts of fiber may be available.

INTRODUCTION

There are numerous physical and chemical properties which are used to classify the usefulness of fibers for various situations. These include softening point, tensile strength, solubility or meltability for spinning, modulus or stiffness, and textile qualities such as wrinkle resistance, dyeability, moisture regain, etc. Thus, it is important that the fiber quality control chemist have some methods whereby these various fiber properties can be evaluated. One such method of evaluation is examination of the tension generated by the fiber as a function of temperature, after it has been processed under a given set of conditions or has been made to certain specifications.

Numerous instrumental techniques have been devised for studying the tension exerted by fibers under either constant load or constant elongation (1, 2). Most of these methods, however, suffer from the disadvantages of requiring large samples, rather elaborate equipment and operator manipulation. Furthermore, such methods often are rather limited in their adaptability.

An alternative method of tension measurement is provided by Thermomechanical Analysis (TMA). TMA normally measures the change in dimension of a material as a function of temperature; i.e., it is a displacement sensing technique. The TA Instruments TMA 943, however, can be converted from strictly a displacement sensing instrument to a force measuring transducer by adapting a totally passive mechanical fiber tension accessory to the sample clamping device. The fiber tension accessory and the LVDT displacement sensor of the TMA work in conjunction to provide the needed force transducing capability, and no excitation or additional signal processing is needed. The heart of this accessory is a load cell with its spring positioned in parallel with the sample, which can also be considered as a spring. The load cell spring has a force gradient chosen such that the shrinkage tensions of monofilament or multifilament fibers are measured at approximately constant elongation (<1% strain) as a function of temperature. The flexibility, small sample size, and ease of measurement make the modified TMA a viable alternative to currently used fiber tension measuring techniques.

**EXPERIMENTAL**

In TMA, a fiber of suitable length (typically 4-5 mm) is mounted in cleaved aluminum balls or stainless steel mini-clamps so that all filaments of the fiber are held with equal tension. The mounted sample is then placed in the TMA between the movable and fixed portions of the probe. A fiber tension load cell is brought into contact with the TMA probe (Figure 1) so that the tension exerted by the fiber can be calculated from the displacement curve using the equation:

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\text{Load Cell Schematic}
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*The EXPERIMENTAL section describes the procedure when using the TMA 943. TA Instruments offers another TMA (the TMA 2940) which contains more automated features. In that unit, force can be varied electronically automatically during the measurement. Hence, results such as those described later in the RESULTS section can also be obtained with the TMA 2940, and they can be obtained directly without the use of a load cell.*
In some cases, the derivative of the parent tension scan is useful in observing subtle differences in the parent scan or in adding further information which when combined with that from the parent scan provides a means of differentiating fibers of approximately the same tension. Figure 3 is a composite of the negative derivative scans for textured and untextured PET. Both of these pieces of information (parent scan and its negative derivative) are obtained simultaneously from the initial experimental scan.

Similar information on the tension generated by film or sheet samples can be obtained using the same load cell arrangement, a tension probe, and clamps. Other related measurements including stress relaxation can also be made using this modified TMA arrangement.

**REFERENCES**