2018 Time Temp Testing
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3

THE UNIVERSITY OF TEXAS AT AUSTIN
DEPARTMENT OF CHEMICAL ENGINEERING
CHE 395E

EFFECTS OF TIME AND TEMPERATURE ON THE MECHANICAL PROPERTIES OF POLYETHYLENE

I.Object

Unlike metals, polymers at modest temperatures exhibit both elastic and viscous or fluid-like behavior. This feature complicates the description of their mechanical behavior and their use in load bearing applications. This experiment explores the effects of temperature and time or rate of strain on the tensile properties of a semi-crystalline polymer at temperatures above its Tg.

II. References

1. E. Baer, "Engineering Design for Plastics", Polymer Science and Engineering Series, Reinhold, New York, 1964. Chapts. 3- 5.

2. J. D. Ferry, "Viscoelastic Properties of Polymers", J. Wiley & Sons, New York, 1961.

3. T. Alfrey, "Mechanical Behavior of High Polymers", Interscience, New York, 1948.

4. E. Baer, J. R. Knox, T. J. Linton, and R. E. Maier, SPE Journal, 16, 396 (1960).

5. M. L. Williams, R. F. Landel, and J. D. Ferry, J. Am. Chem. Soc., 77, 3701 (1955).

6. K. Nagamatsu, T. Takamura, T. Yoshitomi, and T. Takemoto, J. Polym. Sci., 33, 515 (1958).

III. Equipment and Supplies

I. Instron Model 1137 Tensile Tester with Environmental Chamber. (or equivalent)

2. Molding machine capable of producing ASTM D638 tensile bars without weld lines; or, equivalently, a source of tensile bars.

3. Polyethylene molding material.

IV. Testing Procedure

I. Prepare at least 20 molded tensile bars. Your instructor will help you find suitable molding conditions. BE SURE THAT NO WELD LINES ARE PRESENT IN THE MOLDED SPECIMENS.

2. Calibrate the Instron Tensile tester. Use the chart output to obtain complete stress-strain curves. Your instructor may also demonstrate the use of the data acquisition computer for conventional testing.

3. Obtain force versus deflection diagrams at room temperature using cross head rates of .02, .1, .5, 2, 10, and 20 in./min. Convert these measurements to stress vs strain and calculate the resulting elastic moduli, yield stresses, and, where possible, stresses and strains at break. Plot these values as a function of strain rate.

4. Install the Instron Environmental Chamber. Stack remaining samples to be tested in the chamber so that they may attain the chamber temperature. From the measurements at low test rates above, estimate a strain at which the stress vs strain curves are linear; this might be of the order of 10%. Calibrate and install a strain gauge which will measure this value. Put the chart recorder in the strain gauge mode, use the manual cross-head positioner to set the desired strain, then switch the recorder to the time sweep mode to watch the reduction in force with time at room temperature. This experiment is called a stress relaxation experiment. Convert force to stress and calculate the modulus as a function of time.

5. Repeat the stress relaxation experiment at 35, 55, 75, and 95 oc. Use a new specimen each time. Allow samples to equilibrate for at least 15 minutes after the chamber has reached desired temperature before mounting. Wait another 5 minutes after closing chamber door before beginning the test.

6. Construct elastic modulus vs time plots on log-log paper. Try to use the WLF equation to construct a master curve using the time-temperature superposition principle (see references 1-6).

V. Report

I. Why does ASTM D638 call out two different testing rates, 2 in./min for polyolefines and 0.2 in./min for glassy polymers?

2. Qualitatively explain the results observed when doing room temperature tensile testing at different testing rates. Can a simple Maxwell model be used to correlate these results?

3. Does the WLF equation do a reasonable job of correlating the results from stress relaxation at various temperatures? Plot log(aT) vs 1/T to obtain the mechanical activation energy.

4. Discuss some applications where one would need to obtain master curves by WLF or other methods to provide the information necessary for a safe design.