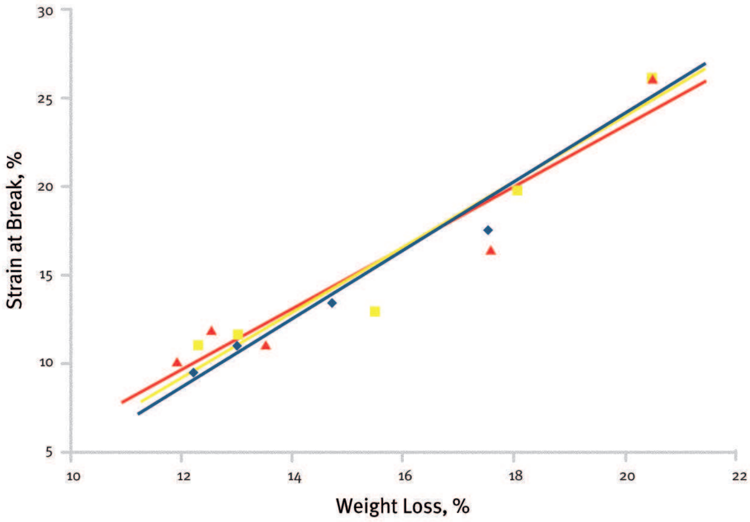

Figure a. Percentage weight loss versus the strain at break for the samples aged at 70°C and 30%, 50% and 70% RH. Tensile tests carried out using a 500 N load cell, gauge length of 50mm and a crosshead speed of 5 mm.min^{-1}. Thermogravimetric analysis on samples weighing in the region of 5mg over a temperature range of 30 to 450°C at a heating rate of 5°C.min^{-1}

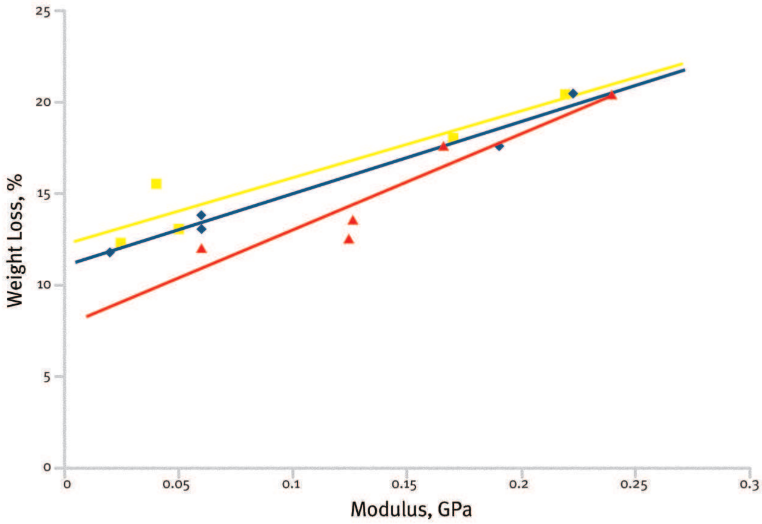

Figure b. Difference in flexural modulus between 5 minutes and 120 minutes versus percentage weight loss for the samples aged at 70°C and 30%, 50% and 70% RH. Dynamic mechanical analysis carried out using a three-point bend at constant temperature of 24°C, performed over a period of 120 minutes at a frequency of 1.0 Hz. Thermogravimetric analysis on samples weighing in the region of 5mg over a temperature range of 30 to 450°C at a heating rate of 5°C.min^{-1}

Physical effects of plasticiser loss on cellulose acetate film

Plasticisers are added in order to lower the glass transition temperature (Tg) of thermoplastics. Their presence reduces this secondary transition, accompanied by a reduction in the brittle point and improving the working properties of a polymer. The corollary of this is that the loss of plasticiser with age will have a corresponding negative effect on mechanical properties, increasing the Tg and resulting in embrittlement.

Commercially available cellulose acetate film of a thickness of 0.25 mm, plasticised with diethyl phthalate (DEP) and triacetin was subjected to an artificial ageing regime of 70°C, and relative humidities of 30, 50 and 70%, over a period of three months. Subsequent to ageing, the samples were studied using thermogravimetric analysis, uniaxial and three-point bend analysis, to determine the dependence of the room temperature working properties relative to migration of plasticiser. The three-point bending tests were aimed at determining the time dependent working properties of the cellulose acetate at ambient conditions. Particular focus was given to the flexibility of the film as a function of time.

Progressive degradation of the cellulose acetate results in a decrease in the strain at break (Figure a), corresponding to a positive correlation with the percentage loss of plasticiser. The flexural modulus also has a positive correlation with plasticiser content (data not shown).

It is shown that the samples with greater plasticiser content exhibit an increase in flexural modulus over the duration of the experiment, up until termination at 120 minutes. Calculating the difference in modulus (ΔE) between 5 minutes into the experiment and 120 minutes, it is found that there is a degree of strain hardening in the less degraded samples. This leads to a positive correlation with plasticiser loss (Figure b).

This behavior is attributed to the degree of free volume present in the cellulose acetate film. For samples with greater plasticiser content there is greater molecular rearrangement as the film is placed under stress. As free volume decreases there is a restriction in movement of the polymer chains. This lower molecular motion and increased flexural modulus prevents dissipation of the applied stress. The material is closer to failure than those samples capable of re-arrangement under deformation.

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