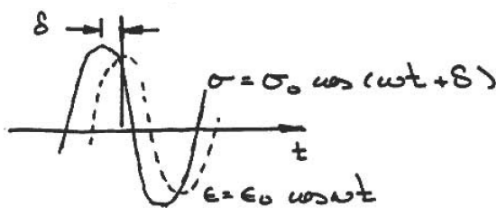
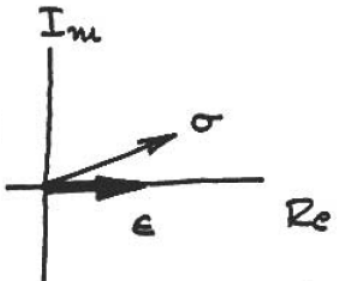
力学松弛

- 应变滞后于应力





$$\sigma = \sigma_0^{'}\cos\omega t + \sigma_0^{''}\sin\omega t = (\sigma_0^{'} + i\sigma_0^{n})e^{i\omega t}$$

- 能量储存和损耗

$$W = \oint \sigma d\varepsilon = \oint \sigma \frac{d\varepsilon}{dt} \bullet dt$$

$$= \int_0^{\frac{2\pi}{\omega}} (\sigma_0^{'}\cos\omega t)(-\varepsilon_0\omega\sin\omega t)dt + \int_0^{\frac{2\pi}{\omega}} (\sigma_0^{''}\sin\omega t)(-\varepsilon_0\omega\sin\omega t)dt$$

$$= 0 + \pi\sigma_0^{''}\varepsilon_0$$

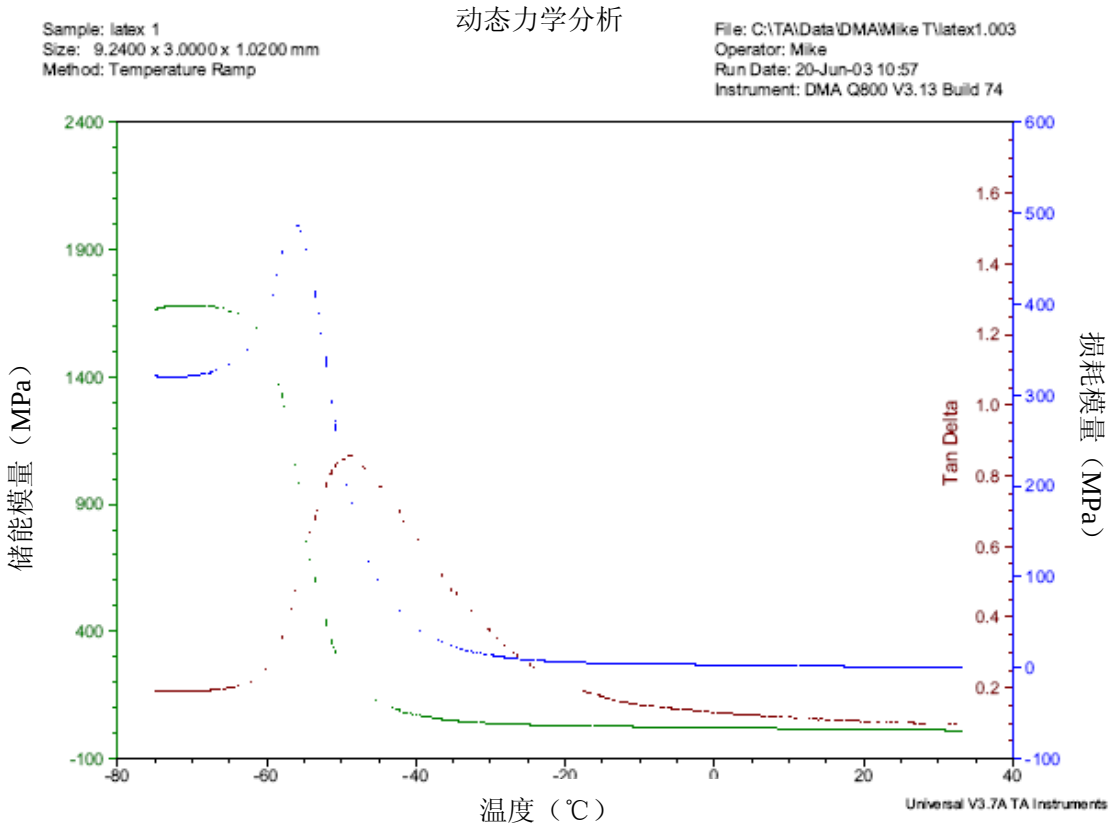
$$W_{st} = \int_0^{\frac{2\pi}{\omega}} (\sigma_0^{'}\cos\omega t)(-\varepsilon_0\omega\sin\omega t) = -\frac{1}{2}\sigma_0^{'}\varepsilon_0$$

$$\frac{W_{dis}}{W_{st}} = \frac{\pi\sigma_0^{''}\varepsilon_0}{\frac{1}{2}\sigma_0^{'}\varepsilon_0} 2\pi\frac{\sigma_0^{''}}{\sigma_0^{'}} = 2\pi\tan\delta$$

- 复数模量

$$E^{*} = E^{'} + iE^{''} = \frac{\sigma_0^{'}}{\varepsilon_0} + i\frac{\sigma_0^{''}}{\varepsilon_0} = \frac{\sigma_0^{*}}{\varepsilon_0^{*}}$$

See Figure 12.1, "Temperature dependence of mechanical loss tangent for nylon," in McCrum, N.G. *Anelastic and Dielectric Effects in Polymeric Solids.* Mineola NY: Dover, 1991.


动态力学分析
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Run Date: 20-Jun-03 10:57
Instrument: DMA Q800 V3.13 Build 74
储能模量（MPa）
Tan Delta
损耗模量（MPa）
温度（℃）
Universal V3.7A TA Instruments