Induced transparency in polythiophene bearing azobenzene moieties

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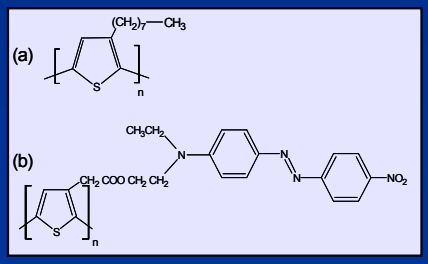
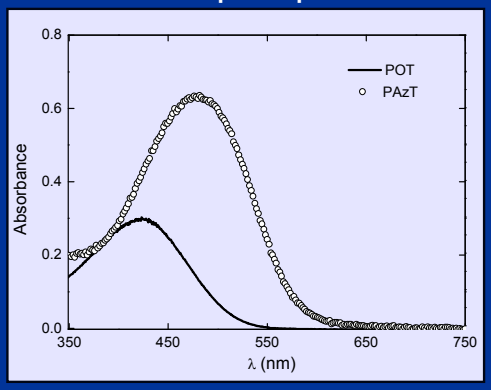
The nonlinear absorption of Poly[2-[ethyl-[4-(4-nitro-phenylazo)-phenyl]-amino]-ethane (3-thienyl)ethanoate], PAzT, was investigated through single pulse and pulse train open aperture Z-scan techniques, which allowed the discrimination between fast and accumulative nonlinearities. We observed an induced transparency for excitation with picosecond laser pulses at resonant conditions, which was attributed to the azobenzene moieties attached to the polymer backbone. We believe that the process observed here makes PAzT an attractive polymer for photonics applications, such as optical switches and storage devices.

•PAzT and POT molecular structures



•Linear absorption spectrum

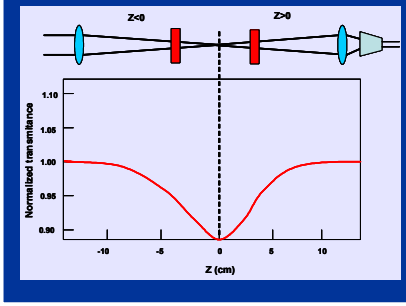


$$\sigma_c = (6.0 \pm 0.2) \times 10^{-17} \text{ molecule/cm}^3$$

Z-scan technique

Normalized transmittance (NT)

$$TN(z) = \frac{T(z)}{TL} = \frac{1}{\sqrt{\pi} q_0(z,0)} \int_{-\infty}^{\infty} \ln\left[1 + q_0(z,0) e^{-\tau^2}\right] d\tau$$

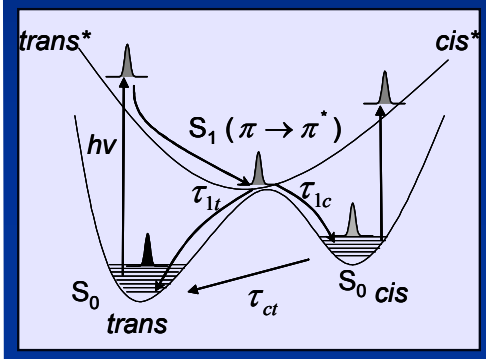


where

$$q_0(z,t) = \frac{\beta I_0(t) L}{\left(1 + z^2 / z_0^2\right)}$$

$$\delta = h\nu\beta / N$$

3 energy-level diagram

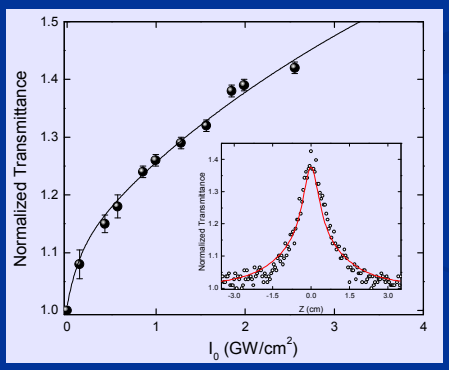


$$\frac{dn_{tS_0}}{dt} = -n_{tS_0} W_{tS_1} + \frac{n_{S_1}}{\tau_{tS_1}} + \frac{n_{cS_0}}{\tau_{ct}}$$

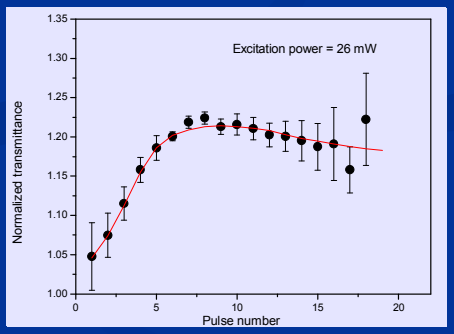
$$\frac{dn_{cS_0}}{dt} = -n_{cS_0} W_{cS_1} + \frac{n_{S_1}}{\tau_{cS_1}} - \frac{n_{cS_0}}{\tau_{ct}}$$

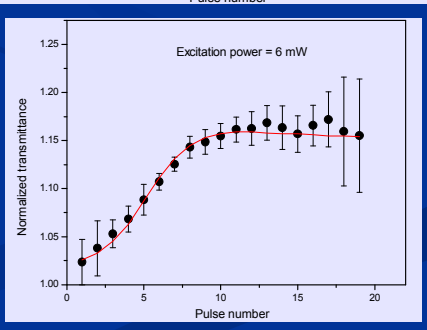
$$\frac{dn_{S_1}}{dt} = n_{tS_0} W_{tS_1} + n_{cS_0} W_{cS_1} - \frac{n_{S_1}}{\tau_{cS_1}} - \frac{n_{S_1}}{\tau_{tS_1}}$$

Single pulses Z-scan data



Pulse train Z-scan data





Parameters obtained from the fitting

$$\sigma_c = (4.5 \pm 0.2) \times 10^{-17} \text{ molecule/cm}^3$$

$$\tau_{ct} \approx 100\,\mu s$$

Conclusions

The change of population from the ground state S_0 to the excited state S_1 was found to be the main contribution for the fast transparency presented by this polymer. The ground state population change from *trans* to *cis* configuration plays only a minor contribution to the nonlinear absorption, since we found both states present similar cross-section values. The induced transparency presented by this material suggests novel possible applications for this polythiophene derivative, such as optical switches and image storage devices.

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