Femtosecond pump-probe studies of zinc phthalocynine in DMSO

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INTRODUCTION

Phthalocyanines are new class of photosensitiser used for photodynamic therapy. These drugs are used to treat small and superficial tumours. In recent years, a particular attention has been given to phthalocyanine in order to search suitable photosensitisers that can be clinically used as photodynamic cancer drug. The zinc phthalocyanine (ZnPc) has been reported to have suitable photophysical properties in photodynamic therapy. Recent work done on zinc phthalocyanine dynamic has proven that the energy transfer from singlet state to triplet state occurs on ultrafast timescale and the determination of the ultrafast component remains a challenge.

MECHANISM OF PHOTODYNAMIC THERAPY

The processes of light absorption and energy transfer are at the heart of the photodynamic therapy. It is based on introducing a tumour localising photosentiser and then excites the photosentisers with an appropriate wavelength. There be an energy transfer from singlet to triplet via inter-system crossing. By quenching of the triplet state of the photosensitiser, there will be an energy transfer which will generate an electronically-excited state of the singlet state of the oxygen. The excited state of the oxygen will lead to the destruction of the tumour.

$$P + h\upsilon \rightarrow {}^1P^* \xrightarrow{ISC} {}^3P^*$$

$${}^3P^* + {}^3O_2 \rightarrow {}^0P + {}^1O_2^*$$

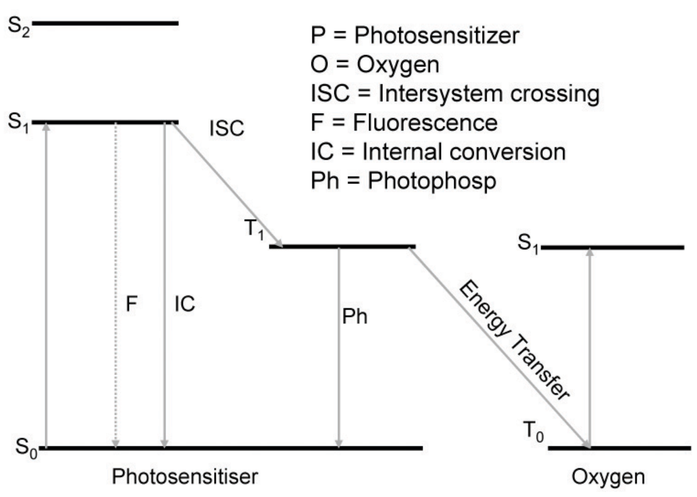


Figure 1: Energy transfer and energy level diagram of zinc phthalocyanine

PUMP-PROBE TECHNIQUE

Figure 2 indicates the Femtosecond pump-probe technique used to investigate the ultrafast dynamics ZnPc.

- Start process with an intense ultrashort pump pulse.
- Probe process after t_D with a weaker ultrashort probe pulse. Slow detector.
- Repeat experiment with different delay times t_D.
- Follow the transient concentration.

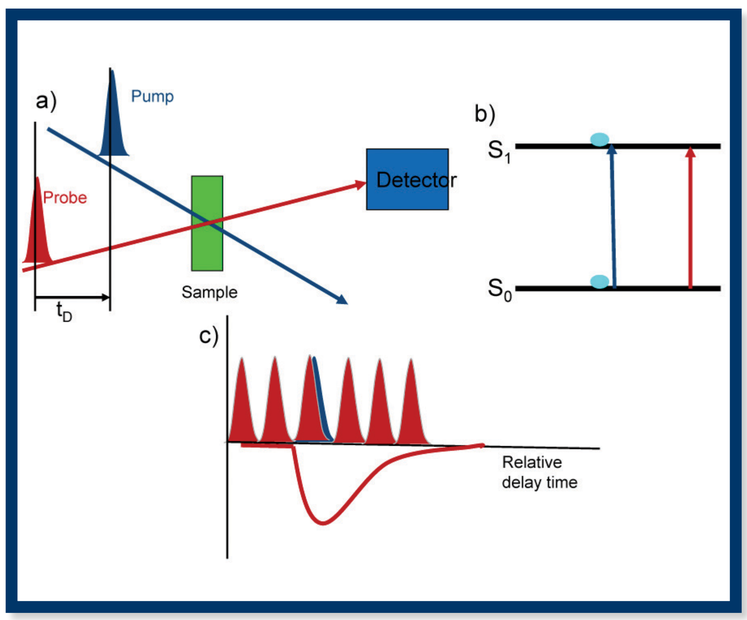


Figure 2: Femtosecond pump-probe technique : a) The overlap of pump and probe beams, b) Energy level diagram showing the pump beam exciting molecules from ground state to the first excited state and the probe. c) kinetics of the sample

EXPERIMENTAL SETUP

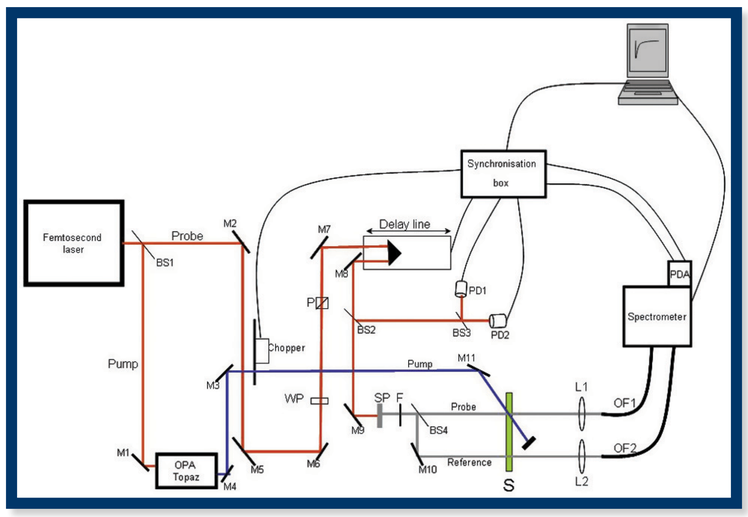


Figure 3: Experimental setup used to investigate the energy transfer in ZnPc

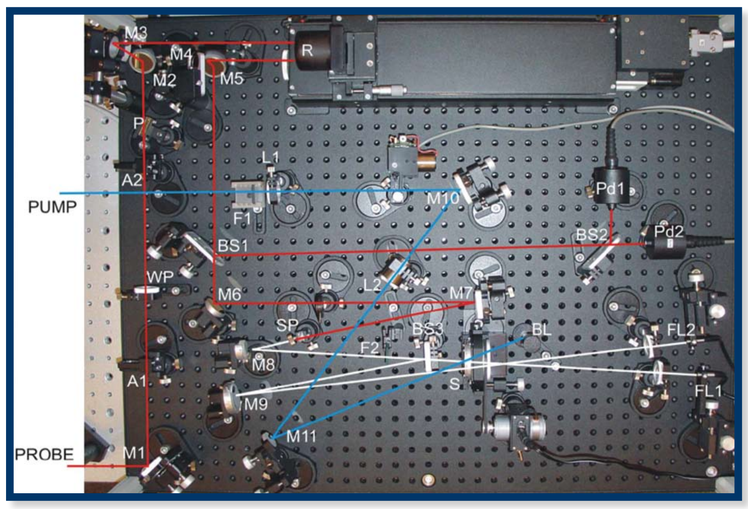


Figure 4: Image of the pump-probe setup

RESULTS

The zinc phthalocyanine sample was pumped at wavelength 625 nm and probed by a white light continuum. The results obtained in our experiment show a good fit to a bi-exponential decay at the 675 nm band peak, comprising a fast process with a time constant of 1.82 ± 0.06 ps and a slower process with a time constant of about 38.9 ± 2.6 ps.

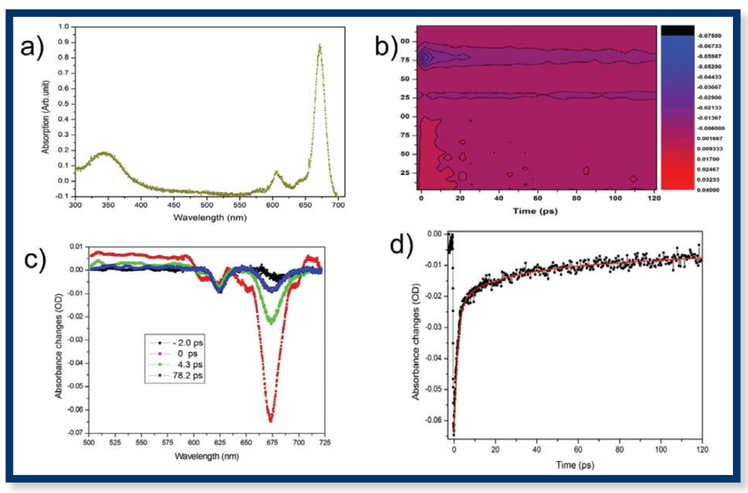
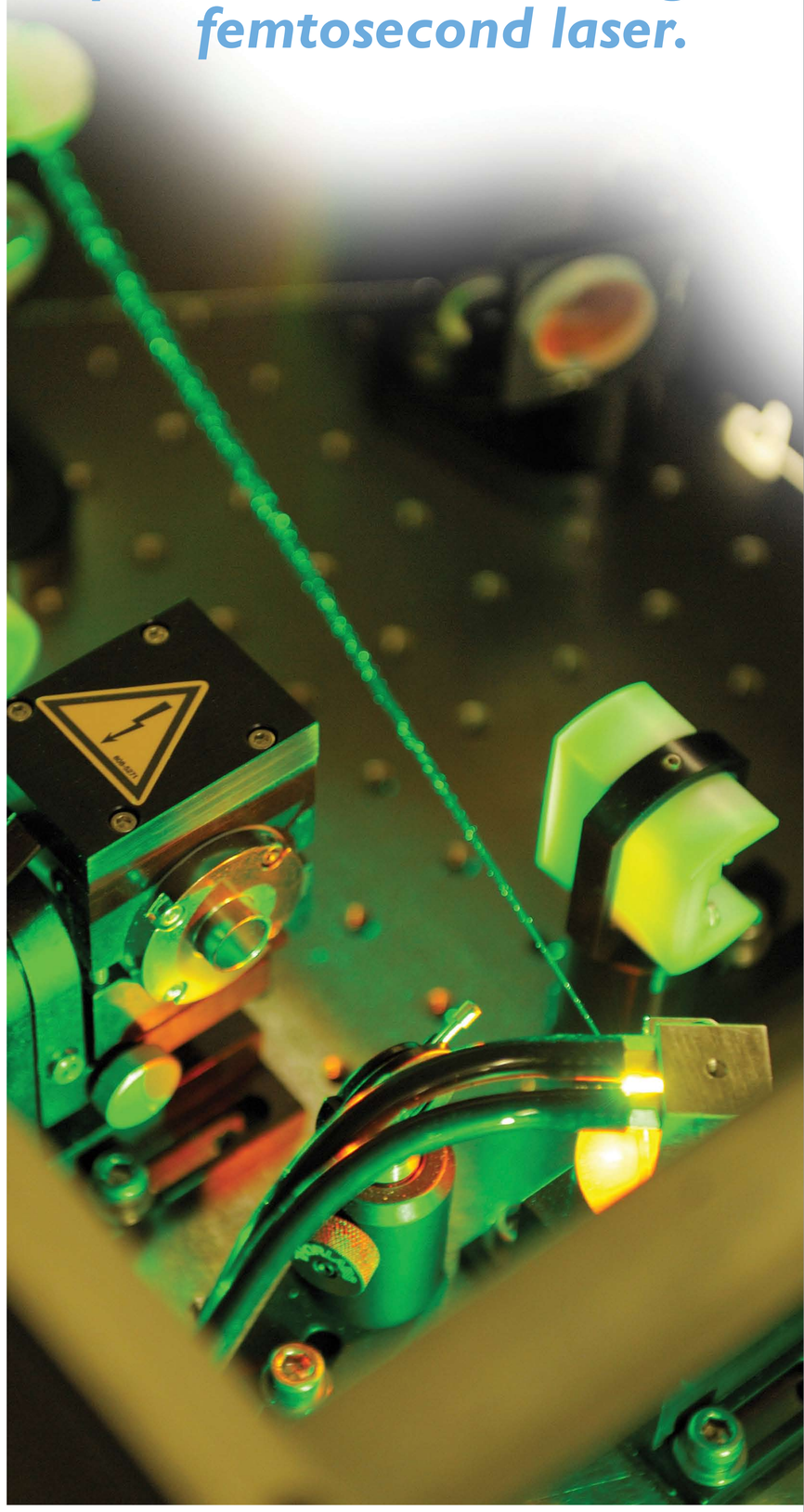


Figure 5: a) A steady state absorption spectrum of ZnPc in DMSO at a concentration of 10 µM acquired using a Xe-Kr lamp combined with USB2000 ocean optics spectrometer Image of the pump-probe setup. b) Transient absorption contour graph indicating measured absorbance spectra for a range of delay times between pump and probe pulses. Pump was set at 625nm and probe was a white light continuum. c) Transient absorption spectra of ZnPc in the indicated wavelength interval and time delays with the pump wavelength set at 625 nm. d) Absorbance change kinetics as a function of relative delay time between pump and probe pulses for ZnPc at 675 nm

CONCLUSION

We were able to measure the transient absorption of Zinc Phthalocyanine in DMSO and bi-exponential fit on the kinetics data allow us to extract time constants for a fast and slow processes. However, a difference between our results and those reported literature was noticed. This could be attributed to the fact that in our setup we could not resolve time constants below 300 fs.

CSIR researchers are investigating drugs that can treat small and superficial tumours using femtosecond laser.



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