PHONON ASSISTED EXCITON TRANSFER IN BIOLOGICAL MOLECULES

Zhengli Cai, Xinyi Zhang and Shuyan Tang
Changchun Institute of Physics, Academia Sinica, China

By using the exciton diffusion theory, we have investigated the phonon assisted energy transfer process, the values of some parameters are obtained.

1. INTRODUCTION

Recent years, there are many studies of primary reaction of photosynthesis such as spinach, bacteria with modern techniques. The fluorescence and energy transfer process of soybean chloroplast at different excitation densities and various temperatures were studied.

2. EXPERIMENTAL

The chloroplast of the wild soybean leaves which consist of plenty of proteins was prepared following Amor's method.

A XeCl laser (308nm) and an excimer molecule lasers were used. The photoluminescence spectra of chloroplast were measured in the temperature range from 10K to 150K and different excitation densities (10^{10}–10^{27} photons/cm²·s), as shown in Figs. 1–4. The spectra were deconvoluted by a micro-computer.

At low excitation density (cw, below 10^{18} photons/cm²·s), we have observed three subbands in the emission spectrum, which are centered at 685nm, 695nm and 735nm respectively (noted as F_{685}, F_{695} and F_{735}). F_{685} comes from the luminescence of pigment molecule C_{680}, F_{695} from C_{685} and C_{720}, F_{695} from C_{720}. F_{685} and F_{695} decrease with the increase of the temperature. The decrease rate of F_{685} is faster than that of F_{695} and the integrated intensity of F_{685} and F_{695} has a linear relationship with the excitation density.

At high excitation density (over 10^{25} photons/cm²·s), the decrease rate of F_{685} is faster than that of F_{695} with the increase of the temperature and both F_{685} and F_{695} have a nonlinear relationship with the excitation density.

3. DISCUSSION AND CONCLUSION

At low excitation density, a part of ground states of C_{680} and C_{685} are excited, so the exciton density is small and the exciton annihilation can be neglected. There is a nonresonance energy transfer between C_{680} and C_{685}. On the basis of the kinetic analysis, we have obtained the formula describing the temperature or excitation density dependence on the emission intensity. The fitting of above calculated relationship to the experimental results yields the following parameters:

number of phonon involved in energy trasfer

\[ n, \]

phonon energy \[ h\nu = 26 \text{ meV}. \]

Considering the energy mismatch between F_{685} and F_{695}, these values are reasonable.

When the exciton annihilation can be neglected, the kinetic analysis tells us that F_{685} and F_{695} have a linear relationship with the excitation density, that accords with the experimental results.

Under high density excitation, most of the ground states are excited, and the exciton annihila-
The phenomenon of exciton annihilation process should be considered. Consequently, there exists the resonance energy transfer among the same kind of centers C\textsubscript{680} or C\textsubscript{685}. So, the temperature dependence of F\textsubscript{685} and F\textsubscript{695} is different from those at low density excitation.

In the case of exciton annihilation being considered, we can obtain the following relations from the kinetic analysis:

\[ I_{685} = K_1 I_{\text{ex}}^{1/2}, \quad I_{695} = K_2 I_{\text{ex}}^{1/2}, \]

where, \( I_{685} \) and \( I_{695} \) are the fluorescence intensity of F\textsubscript{685} and F\textsubscript{695} respectively, \( K_1 \) and \( K_2 \) are constants which have no dependence on excitation intensity, and \( I_{\text{ex}} \) is the excitation intensity. These relations are in good agreement with the experimental results.

REFERENCES