ARTIFICIAL VESICLES WITH INCORPORATED PHOTOSYNTHETIC MATERIALS FOR POTENTIAL SOLAR ENERGY CONVERSION SYSTEMS

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INTRODUCTION

Currently the primary source of energy for industrial and domestic use is based on fossil fuels. The supplies of these fuels are limited and are becoming depleted. Thus there is a search for alternative and more sustainable energy sources. One such source is solar energy, which has many advantages over fossil fuels. Solar energy is:

- Abundant.
- Universally available and not restricted to specific geographical locations.
- Environmentally friendly (non-polluting).
- A more dependable supply and less prone to global political and economic fluctuations.
- More assured long term sustainability.

Thus research into harvesting, transferring, and converting light energy is of great significance. The most abundant and efficient light harvesting, energy transfer and transduction systems are found in nature with the process of photosynthesis. In the photosynthetic system light energy is absorbed by antenna chlorophylls and this energy is then passed onto a reaction centre chlorophyll dimer where charge separation occurs in less than 100 ps [1] and at about 95% efficiency [2]. Also, an organised connective light harvesting system is required for long range energy transfer [3]. As a matrix to stabilize the light harvesting systems we are using a combination of fatty acids and nitrous oxide, rather than conventional phospholipid-based combinations, which enables the production of small, elastic, artificial vesicles, called Pheroid™, of 100 – 300 nm diameters. We have produced stable vesicles, as indicated by their zeta-potentials, of 300 – 800 nm in diameter. Previous work has shown that photosynthetic light harvesting material can be incorporated into Pheroid™ vesicles (Fig.1).

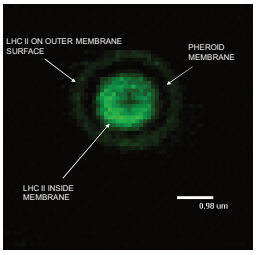

Fig 1: Example of photosynthetic material incorporated into the Pheroid™ vesicles (2.8:2 LHII 5µL). Data collected in collaboration with North-West University (Potchefstroom campus).

In this study we are characterising the level of organisation on the incorporated light harvesting systems using absorption spectroscopy.

MATERIALS AND METHODS

Photosynthetic material were extracted from spinach leaves using the method of Krupa et al. [4] and divided into batches, the first batch consisting of both supernatant and pellet and the second batch having samples consisting of either supernatant or pellet. Absorbance spectra were measured with a UV-VIS spectrophotometer (Shimazdu UV-1650 PC) using standard 1 cm pathlength cuvettes. The samples consisted of different concentrations of photosynthetic light harvesting material added to either a buffer solution or an 0.1% Pheroid™ in aqueous solution. The buffer was 20 mM Tricine pH 7.6 – 7.8. Samples were then stored in the dark individually at room temperature to determine the incorporation ratio of the photosynthetic material into the Pheroid™ vesicles.

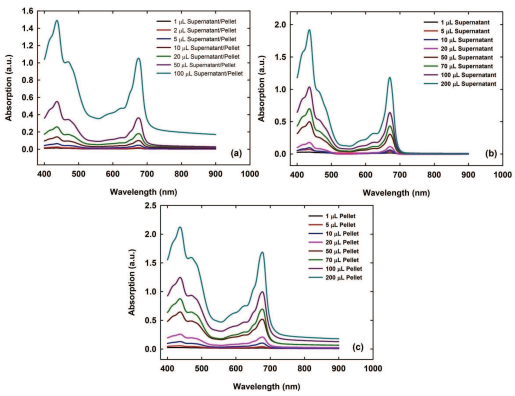

Fig 2: Absorption spectra of different amounts of photosynthetic material incorporated into 3 mL of an 0.1% Pheroid™ vesicle aqueous solution for (a) combined supernatant and pellet, (b) supernatant and (c) pellet.

RESULTS AND DISCUSSION

Fig. 2 shows the absorbance spectra for samples containing increasing amounts of photosynthetic material added to 0.1% Pheroid™ vesicle solutions. Spectra were an amalgamation of chlorophyll *a* (Chla) and *b* (Chlb) with main peaks around 435 nm (Chlb) and 670 nm (Chla) respectively. Spectra of material containing pellet (Figs. 2(a) and (c)) showed a shoulder around 650 nm, possibly attributed to Chlb. Carotenoids attributed a peak around 470 nm, although more pronounced in pellet containing material than in supernatant only material. Shoulders around 590 nm and 620 nm could be attributed to phycoerithrin and Chla respectively.

Peak ratios with respect to the main peaks at 435 nm and 670 nm were calculated for all peaks and shoulders depicted in Fig. 2, as well as for samples of supernatant and pellet added respectively to the buffer. Fig. 3 shows the peak ratios of the 670 nm peak with respect to the 435 nm peak for the three sample sets. For the supernatant / pellet combination the peak ratios were non-linear (Fig. 3(a)), with a minimum around an added amount of 50 µL. For the supernatant and pellet individually, peak ratios prior and after incorporation were more linear for added amounts larger than 20 µL.

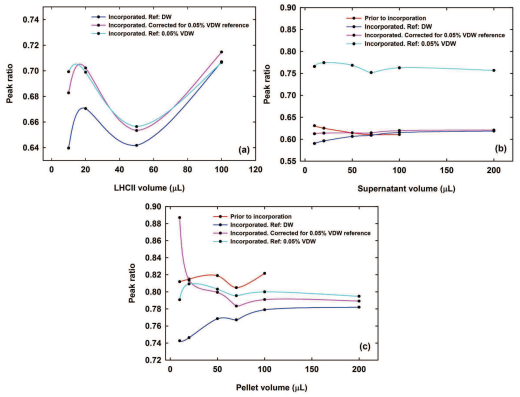

Fig 3: Peak ratios (peak around 670 nm : peak around 435 nm) calculated from Fig 2 for (a) combined supernatant and pellet, (b) supernatant and (c) pellet.

Peak ratios of added photosynthetic material into the Pheroid™ vesicles showed a marked dip at 70 µL added material, while not so for peak ratios of material added to the buffer solution (Figs. 3 and 4). Since the incorporation ratio of photosynthetic material : Pheroid™ was 13.33 : 1 for samples containing either supernatant or pellet respectively (i.e. all added amounts less than or equal to 20 µL were completely incorporated into the Pheroid™ vesicles) and 12 : 1 for the samples containing both supernatant and pellet, the dip cannot be explained in terms hereof.

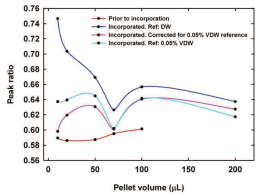

Fig 4: Peak ratios (peak around 650 nm : peak around 670 nm) showing dip in ratios for Pellet volume of 70 µL after incorporation into Pheroid™ vesicles.

CONCLUSIONS

The incorporation ratio of photosynthetic light harvesting material : Pheroid™ has been investigated and preliminary results indicate that the loading capacity of the Pheroid™ differs depending on the photosynthetic membrane fractions used. Peak ratios indicated a possible change in organisation of the light harvesting system after incorporation into the Pheroid™. The next stage will be to further investigate the light harvesting organisation before and after incorporation in more detail using steady state optical techniques such as absorption spectroscopy, fluorescence and CD (Circular Dichroism) measurements, as well as multiphoton multimodal (MPF, SHG, THG) microscopy. SDS-PAGE (Sodium Dodecyl Sulphate PolyAcrylamide Gel Electrophoresis) will also be used for identification of the proteins in order to confirm which light photosynthetic complexes are present. Future work will include assessing the dynamics of the potential energy transfer capabilities using ultra-fast pump-probe transient absorption spectroscopy.

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