Disruption of Liposomes in Water by Neutron Recoil

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Abstract

We seek to measure the disruption of liposome membranes by shockwaves emanating from passing neutrons.

It has been shown both experimentally [1] and theoretically [2] that the passage of a heavy charged particle through a fluid can cause an extremely rapid deposit of thermal energy along its trajectory. This energy disperses as a shockwave, where initially very intense packets of pressure and temperature quickly propagate and decay. It has been widely suggested that this may cause damage to nearby cells, simply by mechanical disruption of the cell membrane. This could be an issue in radiotherapy, and would be in addition to the damage caused by direct ionization of moleculecular bonds in the cell.

Liposomes, which are basically closed cell membranes, could be useful in measuring the described disruption, since their preparation in a solution yields liposomes containing the solvent. If concentration of the solvent in a neutron irradiated sample of liposomes is measured, it should return a higher result than a control sample, if indeed liposomes have been broken by the radiation. Breaking due to shockwaves can be distinguished from direct ionization by the temperature dependence of water's acoustic properties (and hence of the shockwave effect). However, it should also be noted that the cross section of a liposome is far smaller than the area impinged on by a typical neutron shockwave. Hence the relative probability of direct ionization is very small, and observation of a temperature-dependent effect may not be necessary for a convincing (but not conclusive) result.

We report on progress towards the observation of this effect: namely, the consistent production of liposomes in solution and first results of their irradiation.

To continue the abstract would require actual results.

1 Introduction

1.1 Relevance of the Effect

1.2 Review of Theoretical Predictions

In particular, a review (and adaptation) of the theoretical treatment of fiber optic neutron recoil in [3].

2 Making Liposomes

2.1 Account of Experimental Process

I will be making the liposomes in solution myself under supervision of a postdoc in Ka Yee Lee's group, in the Chemistry Department. They have been developing the ability to produce liposomes which do not leak significantly and have a relatively long shelf-life, and I will be seeking to reproduce such results. I am waiting for Professor Collar to set up a meeting with this postdoc.

Contrary to my original abstract, we may not necessarily encapsulate ATP in the liposomes - it is possible some dye will instead be used, for more direct detection.

2.2 Results

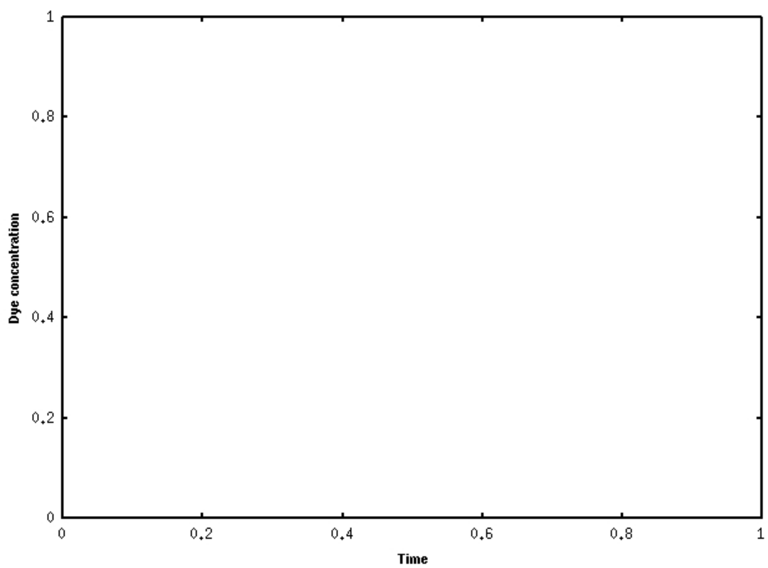

Figure 1: Decay of liposomes over days (hopefully weeks).

3 Irradiation

3.1 Account of Experimental Process

3.2 Results

Results will include plots of the observed change in dye concentration after irradiation (Fig. 2), and the dependence of this change on irradiation time (Fig. 3).

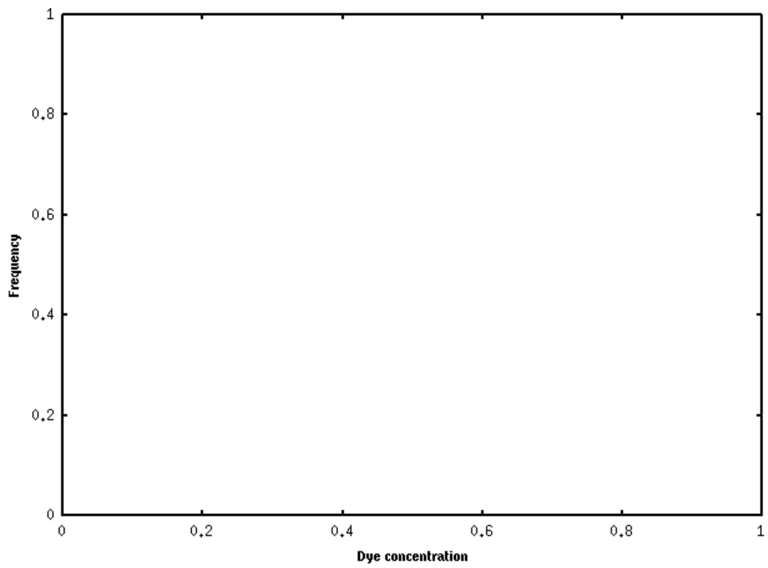

Figure 2: Increase in dye concentration after irradiation, for a fixed irradiation time.

If things go particularly well, a plot of the temperature dependence of the effect may also be included.

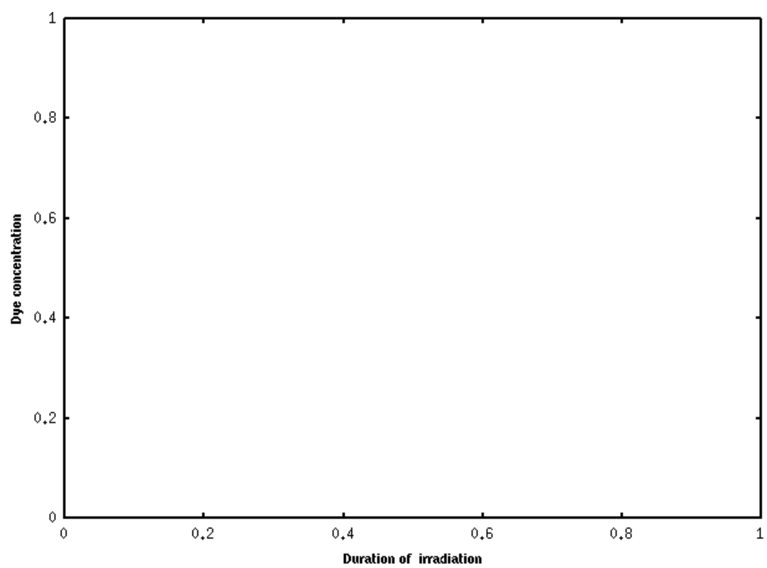

Figure 3: Dependence on irradiation time of increase in dye concentration.

4 Conclusions

A previous student of Professor Collar's did not manage to produce lisposomes reliable enough for experimentation [4]. A realistic conclusion for this project would be to have produced sufficiently reliable liposomes, figured out how to do the irradiation and take measurements in a consistent fashion, and found results warranting further investigation. To have conclusively observed a temperature-dependent breaking of liposomes would be a bonus.

References

[1] L. Sulak, "Experimental studies of the acoustic signature of proton beams traversing fluid media," *J. Acoust. Soc. Am.*, vol. 64, p. S106, 1978.

[2] Y. Sun and R. Nath, "Pressure generated by the passage of a heavy charged particle in water," *Med. Phys.*, vol. 20, p. 030633, 1993.

[3] X. Würms, "Study on fiber optic neutron detection by means of optical frequency-domain reflectometry," Master's thesis, Universität Zürich, 2005.

[4] "Report on liposome preparation by summer student, attached.".