Biophysics and Synchrotron Radiation: When the Marriage Fails*

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The damaging effects of synchrotron-derived x-rays on aqueous phospholipid dispersions have been evaluated. The effect of degree of lipid hydration, phospholipid chemical structure, mesophase identity, aqueous medium composition, and incident flux on the severity and progress of damage was quantified using time-resolved low- and wide-angle x-ray diffraction and chromatographic analysis of damage products. Electron-spin resonance measurements of spin-trapped intermediates generated during irradiation suggest a free-radical mediated process. Interestingly, radiation effects revealed by x-ray diffraction were imperceptible when the lipid was prepared at less than full hydration despite the fact that x-ray-induced chemical breakdown of the lipid occurred regardless of hydration level. Of the fully hydrated lipid systems studied, saturated diacyl-phosphatidylcholines (PC) were most sensitive to radiation damage compared to the ester- or ether-linked phosphatidylethanolamines or the ether-linked PCs. The inclusion of HEPES, Tris/HCl, phosphate buffer, or indeed sodium chloride in the aqueous dispersing medium had only a minor effect in reducing x-ray damage development.

A small, inverse dose-rate effect was found when the x-ray beam intensity was changed 15-fold. These results contribute to our understanding of the mechanism of radiation damage, to our appreciation of the importance of monitoring structure and composition when evaluating biomaterials radiation sensitivity, and to the development of strategies for eliminating or reducing the severity of damage due to synchrotron x-radiation. Since damage is shown to be free-radical mediated, these results also have a bearing on age-related accumulation of free radicals in cells and how these might compromise membrane integrity culminating in cell death.

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*Work supported by grants from the National Institutes of Health (DK 36849, DK 46295, GM56969).