Phospholipid Delivery from a Silicone Hydrogel Contact Lens

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Statement of Purpose: Recent studies have correlated dryness in the eye with disruption of the lipid layer of the tear film, sometimes attributed to lack of phospholipids. (1,2) Without sufficient phospholipid, the oily lipid layer cannot spread evenly over the aqueous layer, leading to tear film disruption. We present a novel approach to replenish phospholipid in the tear film by using the contact lens itself as the depot for phospholipid delivery.

Methods: Silicone hydrogel contact lenses were supplied by CIBA VISION (Duluth, GA). ^{14}C-labeled dimyristoylphosphatidylcholine (DMPC New England Nuclear) was used along with "cold" DMPC to produce a 0.15% w/v of DMPC in n-propanol of desired ^{14}C activity. The artificial tear solution (ATF) was kindly provided by CIBA VISION. A lens was removed from a blister pack and immersed in 5 mL of DMPC-propanol solution for 60 seconds. The lens was removed and rinsed with distilled deionized water (DD H_2O) and then placed in a glass vial (with plastic snap cap) containing 3.00 mL of elution fluid. The capped vial was placed on a rotary shaker (60 rpm) in a 35°C incubator. The elution fluid was either DD H_2O or ATF. Samples from the vial were collected at 0, 2, 4, 10, 24, 48 and 72 hrs by pipetting 0.1 mL from the vial into scintillation fluid for elution quantitation by scintillation counting. In other experiments the time of loading was varied and the elution solutions were spiked with ^{14}C-DMPC. To quantify the amount of DMPC loaded into the lenses, non-eluted lenses were extracted with *n*-propanol and the ^{14}C-activity measured by scintillation counting.

Results: The average amount of DMPC loaded in 60 seconds was 33 µg/lens. The amount loaded increased linearly with loading time up to 120 sec. The loading did not decrease the wettability or clarity of the lenses. Figure 1 shows the mean and 95% C.I. amounts of DMPC eluted for repeat experiments of elution in ATF and in H_2O for 72 hrs. Elution is much greater in ATF. In ATF there was a small burst effect, and a total of about 1 µg was released in the first 10 hours of elution.

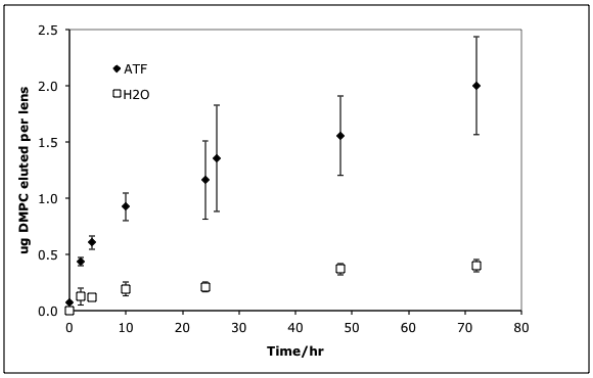

Figure 1. Elution of DMPC (mean & 95% CI, n≥4) in ATF (◆) and water (□).

Elution during the first 10 hrs was proportional to the square root of time (Figure 2), suggesting that elution might be diffusion controlled. Subsequent loading and elution of varying amounts of DMPC showed that the rate and amount of elution was proportional to the amount loaded. These experiments allowed us to estimate a diffusion coefficient for DMPC within the silicone hydrogel matrix on the order of about 10^{-12} cm^2/s.
In experiments in which the ATF was spiked with varying amounts of ^{14}C-DMPC, the elution rate was slowed, showing some kind of mass transfer effect on elution.

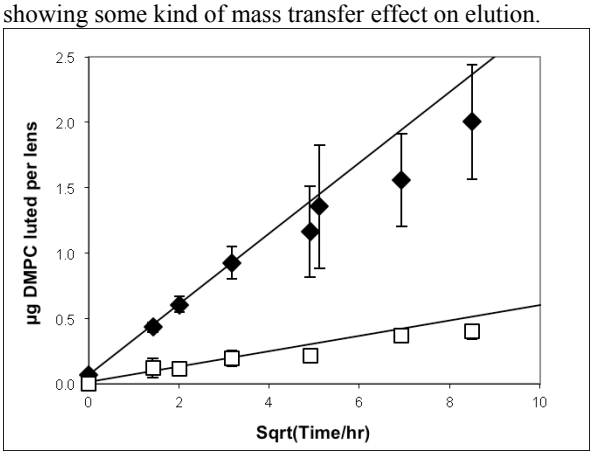

Figure 2. Elution of DMPC (mean & 95% CI, n≥4) in ATF (◆) and water (□) plotted against the square root of time, showing diffusion controlled release. The line is a fit of the first 10 hors of data.

Conclusions: We can vary the loading of DMPC into silicone hydrogel contact lenses by varying the sorption time in an n-propanol solution of DMPC. The subsequent rate of elution into ATF appears to be proportional to the amount loaded, as one would expect based on Fickian diffusion of DMPC within the contact lens. As DMPC in the eluent increases, the rate of release from the lens appears to decrease somewhat, but the rate appears also to be strongly influenced by the composition of the elution solution. Increasing the DMPC loading did not appear to decrease the optical transmission of the lens. It may be possible to load the lens even further for faster release or more extended release. These data support the proposition of designing a contact lens that can deliver a phospholipid over several hours, and of producing a lens that may provide relief of eye irritation associated with the lack of phospholipids in the tears.

Conflict of Interest: This research was supported by financial support and materials from CIBA VISION Corporation. Two of the authors are employees of CIBA VISION, and none of the authors have any direct financial interest in commercial products from this research.

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