Permeability of mouse skin for propylene glycol

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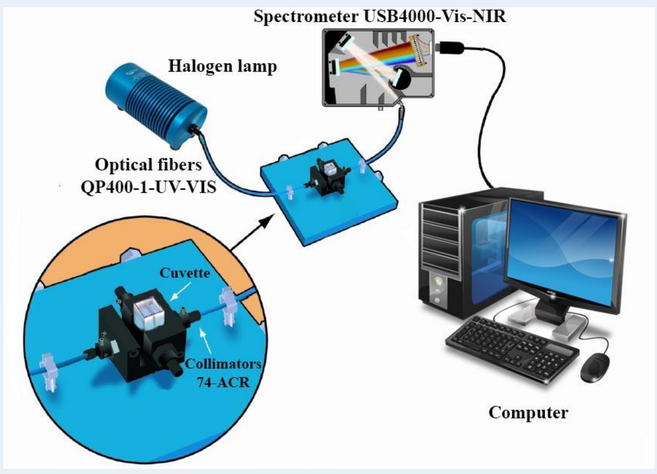
Measurement of the diffusion coefficient of propylene glycol (PG) was conducted by collimated transmission spectroscopy. Since the collimated transmittance of the skin increased with time during immersion in the PG due to the diffusion of PG and tissue water, providing optical clearing of the skin, it is possible to quantify the diffusion process. The diffusion coefficient of PG in the skin, the permeability of the skin for PG, and the efficiency of optical clearing of skin samples at different wavelengths were obtained.

MATERIALS AND METHODS



Measurement of collimated transmittance

Samples were immersed in propylene glycol (NevaReaktiv, Russia) (n=1.4318 at 589 nm).

The kinetics of collimated transmittance of samples was measured in the spectral range of 450-950 nm using USB4000-Vis-NIR spectrometer (Ocean Optics, USA).

Optical clearing of skin sample

Estimation of tissue permeability for PG

Estimation of PG diffusion coefficient in tissue is based on measuring of collimated transmittance kinetics of tissue samples and minimization of the target function:

$$f(D)=\sum_{i=1}^{N_t}\left(T_c^{teor}(D,t_i)-T_c^{\exp}(t_i)\right)^2$$

N_t is the number of time points; $T_c^{teor}(D,t_i)$ and $T_c^{\exp}(t_i)$ are the calculated and experimental values of the time-dependent collimated transmittance, D is the diffusion coefficient, t is time.

Collimated transmittance is estimated as: $T_c^{teor}(t)=\exp\left[-\left(\mu_a(t)+\mu_S(t)\right)\times l(t)\right]$, $\mu_a(t)$ and $\mu_S(t)$ are absorption and scattering coefficients, $l(t)$ is the sample thickness.

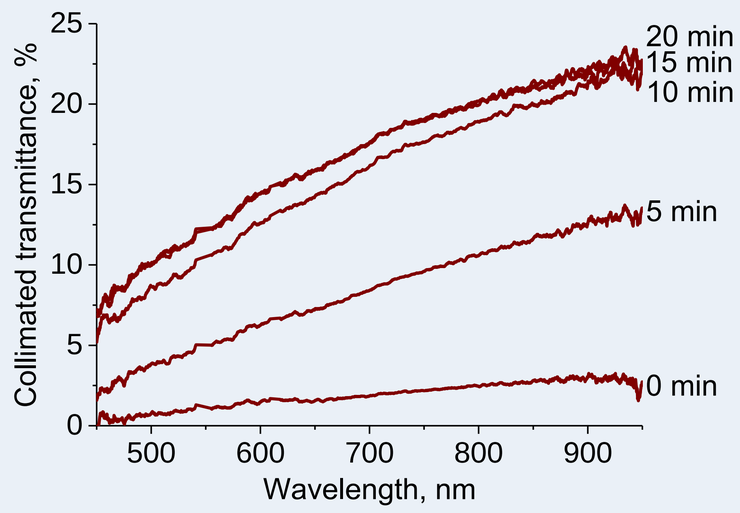
The skin permeability coefficient for PG (one-side diffusion) was estimated from: $P=\frac{D}{l}$.

The efficiency of skin optical clearing OC_{eff} was estimated as:

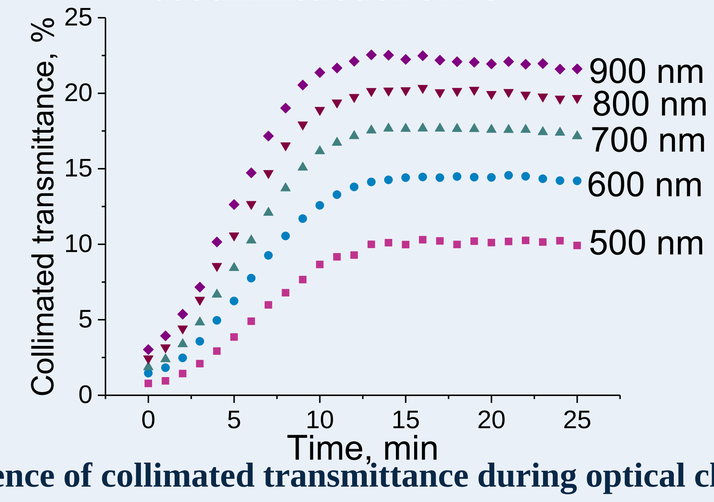
$$OC_{eff}=\frac{\mu_t(t=0)-\mu_{t\_min}(t)}{\mu_t(t=0)}\cdot 100\%,$$

where $\mu_{t\_min}(t)$ is the minimal attenuation coefficient.

RESULTS



Spectra of collimated transmittance of the skin sample measured at different time at administration of PG



The time dependence of collimated transmittance during optical clearing of the skin sample placed in PG

Thickness and weight of samples before (l_0 and W_0) and after (l and W) immersion in PG, the diffusion coefficient of PG in skin (D_{pg}), the permeability (P) of skin for PG, the efficiency of optical clearing of skin samples (OC_{eff}) at different wavelengths

l_0/l, mm		0.31±0.06/0.31±0.06
W_0/W, mg		97±27/57±14
D_{pg}, cm²/sec		(8.8±2.4)×10⁻⁷
P, см/с		(3.1±1.1) ×10⁻⁵
OC_{eff}, %	500 nm	57±12
	600 nm	57±13
	700 nm	61±12
	800 nm	59±13
	900 nm	61±12

CONCLUSION

The collimated transmittance of the skin increased with time in the studied spectral range during immersion in the PG due to the diffusion of PG and tissue water, providing optical clearing of the skin.

Significant effect of optical clearing of the skin in the studied wavelength range was obtained after immersion of skin samples in PG. On average, this is a 59% decrease in the scattering coefficient of tissue, which corresponds to a change in the transmission intensity of samples at a wavelength of 900 nm from 3% for untreated tissue to 22% for fully cleared tissue, i.e. the increase in the transmitted light intensity increases by 7.3. The thickness of the samples did not change after immersion in PG, the weight of the samples decreased by approximately 40%, which indicates their dehydration and longitudinal compression of the collagen and elastin fibers of the dermis due to the osmotic pressure created by the agent.

These data can be used in a wide area of biology and medicine, including in solving the problem of biodegradable smart implants.

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