Figure 3 and 4 show the corresponding time-dependent grayscale curve corresponding to penetration of water and undiluted alcohol through the silicone membrane. Again, the results confirm that water penetrates through the membrane faster than undiluted alcohol.

Theoretical Analysis

For solvent penetration through a thin film membrane, a time-lag method was used to analyse the time-dependent curve and to determine the permeability and diffusion coefficient of the film. If the solvent concentration is assumed to be a constant \( C_0 \) at one side of the membrane, at the surface of the other side of the membrane, the solute concentration \( C(t) \) at time \( t \) can be expressed as: \[ C(t) = C_0 \left(1 - \frac{1}{2n+1} \right) \left(1 - \frac{1}{2n+1} \right) \left(1 - \frac{1}{2n+1} \right) \frac{D(2n+1)^2 \pi^2}{4L^2} t \]

Where \( D \) is the diffusion coefficient of the membrane, and \( L \) is the thickness of the membrane. Using Eq 1 to fit the Figure 3 and 4 data with least squares, it is possible to determine the permeability of the membrane. The diffusion coefficient of the membrane may also be calculated assuming that the thickness of the membrane is \( 0.1 \) mm.

Figure 5 shows the least squares fitting results for water penetration data shown in Figure 3. The results show that the diffusion coefficient of the membrane for water is \( D = 2.56 \times 10^{-11} \) cm\(^2\)/s, and \( DL^2 = 0.019 \) cm\(^2\).

Figure 6 shows the least squares fitting results for undiluted alcohol penetration data shown in Figure 4. The results show that the diffusion coefficient of the membrane for undiluted alcohol is \( D = 3.01 \times 10^{-11} \) cm\(^2\)/s, and \( DL^2 = 0.026 \) cm\(^2\).

Conclusions

This study shows that the capacitive fingerprint sensor is a powerful tool for studying solvent penetration through membranes. Fingerprint sensors are not only sensitive to water, but also sensitive to solvents with relatively large dielectric constants. By calculating the grayscale values of the images, it is possible to estimate the quantity of solvent that has penetrated through the membrane and from the time-dependent diffusion coefficients may be calculated. The results have considerable implications for advancing our understanding of excipients in model membranes and ultimately in skin.

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References