INCOMPLETE WETTING OF THE OCULAR SURFACE
The Most Common Problem in Dry Eye

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FreshKote Lubricant Eye Drops
What is Wetting?

Wetting basically means the behavior of a fluid when it is brought in contact with an insoluble solid.

The degree of wetting is defined by the contact angle of a sessile drop of a fluid placed on the solid surface. Complete wetting implies a zero contact or wetting angle.

A sessile drop of water placed on a solid surface immersed in n-octane (preferential wetting) provides basic information on the hydrogen-bonding capability of the solid.

Wetting can also be defined in terms of capillary rise of fluid in a small diameter tube made of the solid.

Wetting of a Solid Surface

When a liquid is placed on a solid surface there are two possibilities:

• the liquid beads up and forms a sessile drop (partial wetting)
• the liquid spreads over the surface (complete wetting)

If the solid is immersed in the liquid and then slowly raised, then either

• the fluid film will rupture at a critical thickness (incomplete wetting)
• the solid will remain wet even at very small thicknesses (complete wetting)

The first case comprises a more rigorous condition of complete wetting and the wetting angle of the sessile drop will be larger (advancing contact angle). In the second case, the wetting angle of the fluid at the rupture (dry spot) will be smaller (receding contact angle).

The reason for this anomaly is that the solid is rarely inert. When in contact with a liquid (e.g. water) the following interactions may take place:

• morphological (i.e. due to roughness)
• physical (e.g. hydration)
• chemical (e.g. hydrolysis)
• stereo-chemical (e.g. molecular rotation)

All these tend to lessen the energy of the solid-water interface.

Complete wetting of the solid is only possible if the liquid molecules are attracted to the solid surface more than to each other:

adhesion > cohesion

Basic Tenets of Wetting
Applied to Tear Film

The tear film is basically a fluid film coating a solid (ocular) surface. After a blink the tears completely wet the ocular surface provided the tear film energy is less than the bare ocular surface energy.

The tear layer is coated with an even thinner lipid layer which is confined between the lids. This coat lowers the energy of the tear film. Two other factors involve the adsorption of high molecular weight glycoprotein both at
the epithelium-tear interface and at the lipid layer-tear layer interface. These interactions also contribute to the lowering of film energy (cf. below).

**What Stabilizes the Tear Film?**

The tear film must have a specific energy (sum of surface and interfacial tensions) that is lower than the energy of the bare ocular surface exposed to air at 100% humidity. The energy of the thus hydrated ocular surface is estimated to be 38 mJ/m².

If coated with a water layer the energy increases to 90 mJ/m².

\[ 90 > 38 \text{ unstable} \]

If also coated with a lipid layer, the energy decreases to 78 mJ/m².

\[ 78 > 38 \text{ still unstable} \]

Due to lipid-mucin interaction the energy decreases to 54 mJ/m².

\[ 54 > 38 \text{ still unstable} \]

Due to mucin-water interaction, energy decreases to 35 mJ/m².

\[ 35 < 38 \text{ finally stable} \]

Since 35 < 38, in a healthy eye the tear film is stable!

**What Destabilizes the Tear Film?**

Anything that increases its film energy.

Such a problem can arise at the lipid/tear interface when the insufficient polar lipids are unable to saturate the interface.

Often the problem is at the cornea/tear interface due to lipid contamination of the mucin layer.

**How Can Wettability be Re-established?**

By the adsorption of hydrophilic polymer chains that have some hydrophobic side groups that will stick to the problematic areas via hydrophobic bonding.

The hydrophilic sites on the polymeric chains then will attract the tears and bind the water molecules to the ocular surface via hydrogen bonding.

**Synergistic Mixture of Two Types of Polyvinyl Alcohol**

In such a mixture, one polymer has 13% hydrophobic side chains, the other almost none.

At a certain ratio, the mixture lays down a molecular layer of tangled polymer chains with the proper density of hydrophobic sites for bonding to the surface.

These will attach to the hydrophobic spots of the solid surface and the absorbed polymeric layer will present a new, entirely hydrophilic surface to the aqueous tears.

**Tear Film Break-up Time (TBUT)**

Tear film rapidly deteriorates in the human eye with the lids open.

The time interval between the previous blink and appearance of dry spots is measured in
seconds and called the TBUT. Less than 10 seconds is indicative of a dry eye.

**Why is Complete Wetting Important in the Eye?**

Only a stable (continuous) tear layer under the lid ensures hydrodynamic lubrication during blinking thereby protecting the global and interior palpebral epithelial layers.

A stable tear film between the lids also protects the underlying tissue and ensures visual acuity by providing an optically smooth surface for the cornea, the most powerful lens in the eye.

**Which Eye Drops Address the Wettability Problem?**

Most artificial tears, unlike FreshKote, are unable to make a hydrophobic ocular surface wettable by tears! Unlike FreshKote.

FreshKote® is a unique formulation which assures complete wetting of the eye surface, provides polar lipids to stabilize the lipid layer, and has high oncotic pressure to restore epithelial integrity.