Application Report

Surface free energy of skin

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Drop Shape Analyzer – DSA100

Method: 

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Measuring the surface free energy of human skin

Abstract

Previously the wetting properties of cosmetic products could only be determined when sufficient "helping hands" were available. Tests were carried out which in the product was applied to the skin and the result then assessed. It would be helpful if a prediction about the wettability on the skin could be made in advance, particularly as interactions between the various additives make the behavior more complicated. This gap in our knowledge can now be closed by making contact angle measurements with the DSA100.

Method

Human skin, just like any other surface, has a specific energy that can be measured. And it is just this physical property that, in combination with the surface tension of the cosmetic product, is responsible for its wettability.

However, a single energy value for the human skin is not enough. Various skin types must also be taken into account: skin can be dry, greasy, normal or even mixed. If the energy profiles of all these skin types are known then the wetting behavior with various liquids can be predicted. This ensures that different cosmetics can be perfectly matched to the particular user.

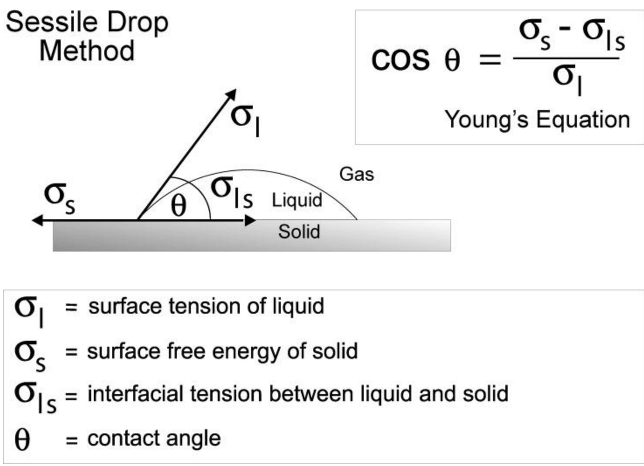

Fig. 1: Schematic diagram of a sessile drop

Experimental part

Both Owens/Wendt and Fowkes describe the relationship between the contact angle on a solid surface and the polar and disperse fractions σ^D and σ^P of the surface tensions of the two phases:

$$\sqrt{\sigma_s^D \cdot \sigma_l^D} + \sqrt{\sigma_s^P \cdot \sigma_l^P} = \sigma_l (\cos\theta + 1)/2.$$

With the aid of a drop shape analysis system contact angles are determined on the skin for different liquids. The surface free energy can then be determined directly from these values, provided that the polar and disperse fractions of the liquids are known.

Fig. 2: Drop shape analysis system DSA100

A collection of data for all skin types drawn up in this way makes it possible to selectively alter the formulation of cosmetics by making use of molecular parameters such as polar behavior. This means that the number of measurements that have to be carried out on volunteers can be dramatically reduced.

Result

The following table shows the differences in energy resulting from different degrees of greasiness of the skin:

	Skin not degreased	Skin degreased
Surface free energy (mN/m)	43.7	32.9
Polar fraction (mN/m)	8.0	1.6
Disperse fraction (mN/m)	35.7	31.3

Tab. 1: Surface free energies of two skin types

If the polar fractions of the surface tension are plotted against the disperse fractions then the result is the “wetting envelope”, which is shown here using non-degreased skin as an example. (see Figure 3). All liquids whose data lie beneath the curve will provide complete wetting.

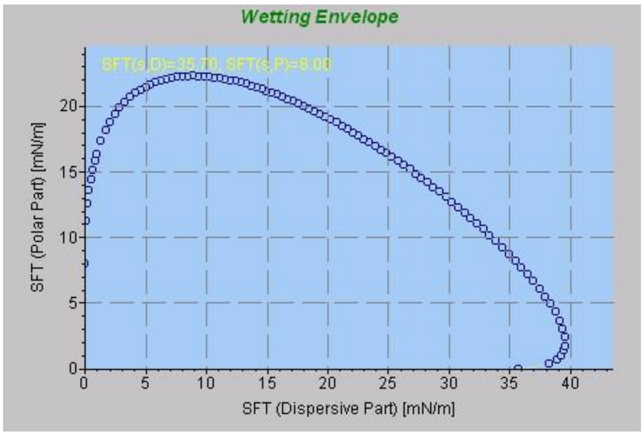

Fig. 3: Wetting envelope for non-degreased forehead skin

Summary

With the determination of the surface free energy of human skin only the surface tension components of the liquids involved are required to permit reliable statements to be made about the wetting behavior for various types of skin.

Literature

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