A New Evaluation Method for LCD Panel Anti-Smudge Treatment

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Abstract

We suggest a new method to evaluate the anti-smudge performance of LCD panels. The anti-smudge performance is characterized by oleic acid contact angle. This method shows accurate and reproducible result and overcomes the difficulty of quantitative evaluation for the anti-smudge characteristic and low reliability in several proposed measurements.

1. Introduction

Touch screen panel (TSP) is widely used on LCDs, especially for mobile display application. Since in most case TSP works under directly finger or pen contact, its readability may be easily decreased by environmental contaminations. Due to this problem, optical film anti-smudge techniques are developed to protect panel surface. Therefore the evaluation method is necessary to characterize the anti-smudge performance.

Several methods have been used for this purpose. A simple one is pen mark removal test. The ink pen is used to draw on the sample surface, then wipe the surface and compare remaining marks, as shown in FIGURE 1. The result of pen mark removal test is easy to see, but hard to quantitatively compare. Its qualitative result strongly depends on the observer. Different result may be obtained for the same sample due to individual variance.

Another method is color difference (△Ea*b*) test. Artificial fingerprint is stamped on the sample surface, and then wiped off. The color difference △Ea*b* values before and after stamp is wiped are measured for comparison. In this method, the color result is influenced by film essential color, and using of artificial fingerprint is too complicated. Water contact angle is also used to characterize the anti-smudge performance. However, the water contact angle of anti-smudge treated surface and low reflection treated surface is similar, which cause the result is hard to analyze. TABLE 1 is typical results of color difference test and water contact angle test. The results show that these two methods are also not very suitable for evaluating anti-smudge characteristic.

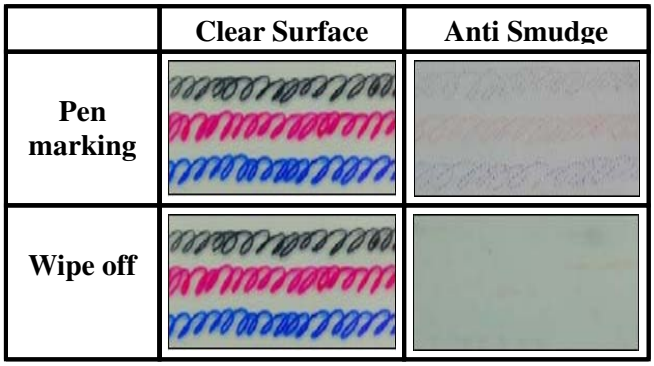


Fig. 1. Pen mark removal test example

TABLE 1. Example for color differences test and water contact angle test

Film Surface Treatment	△Ea*b*		Water contact angle
	Stamp	Wipe off	
Clear Surface	2.6	1.4	47.29°
Anti Smudge	0.9	0.6	100.28°
Low Reflective	1.2	1.4	102.36°

Here we describe a new anti-smudge performance evaluation method by measuring the contact angle with oleic acid ($C_{18}H_{34}O_2$). This method is quantitative, and gives satisfied result.

2. Principle of New Evaluation Method

Generally smudge free LCD panels are made by modifying surface layer of polarizer. Fig. 2. shows a schematic diagram of anti-smudge surface treatment. Anti-smudge groups chemically combine on the surface of optical films.

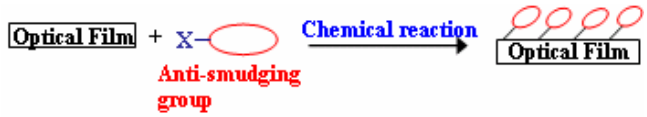


Fig. 2. Anti-smudge treatment of optical film for LCD panel

When anti-smudge groups have formed strong chemical bonds with functional group on substrate surface, surface energy is significantly changed. Considering this property, we could suggest an evaluation method using contact angle measurement which depends on the surface energy, and oleic acid as standard liquid.

The contact angle measurement (Fig. 3.) shows either the physical properties of a liquid against different solid surfaces or a solid surface against different liquids. The contact angle could be sustained by the equilibrium among vapor, liquid and solid. Therefore we could select contact angle as the criterion for judging anti-smudge characteristic, which can be theoretically formulated by Young's equation as following.

$$\cos\theta = (\gamma_S - \gamma_{SL}) / \gamma_L \quad (1)$$

where:
(L: surface tension of liquid
γ_S: surface tension of solid
γ_{SL}: surface tension between liquid and solid
θ: liquid contact angle on solid surface

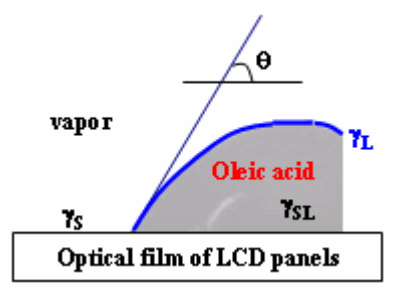
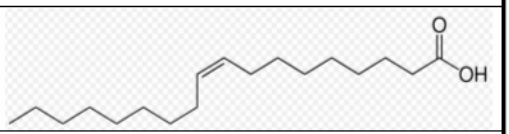


Fig. 3. Thermodynamic equilibrium at the interface between liquid and solid

Water has relative large surface tension. According to Young's equation (1), large surface tension decreases the variance of contact angle. That will make the results no big difference and difficult to analyze. If using a liquid with lower surface tension, the variance will be easy to find. In this paper, we use oleic acid (a monounsaturated omega-9 fatty acid) as standard liquid for contact angle measurement, the chemical structure and properties are shown in TABLE 2.

Contact angle measurement is very simple and reliable. In this test a sessile drop and tangent method are used in measuring for anti smudge panel and a circular segment method is used measuring for no-treatment panel. The thermal influence is not considered (assuming that the loss of steam pressure is not exist) and one drop volume of oleic acid is 3 $\mu\ell$.

TABLE 2. Structure and properties of oleic acid

	Oleic acid ($C_{18}H_{34}O_2$)
Structure	
Properties	- IUPAC name : (9Z)-octadec-9-enoic acid - Molar mass : 282.4614 g/mol - Density : 0.895 g/ml - Melting point : 13 ~ 14℃ (286K) - boiling point : 360℃ (633K) (760mmHg) - Solubility : Insoluble in water; soluble in Methanol

3. Results and Discussion

An evaluation measurement is done using above method and water contact angle method. The clear surface without treatment, low reflection surface treatment and anti smudge treatment samples are tested.

TABLE 3. Results of anti-smudge characteristic evaluation (sampling with optical films for LCD panels)

Samples	Water contact angle	Oleic acid contact angle
Clear Surface	47.29°	17.54°
Low Reflection	102.36°	48.24°
Anti Smudge -1	102.58°	58.18°
Anti Smudge -2	101.48°	56.51°
Anti Smudge -3	100.28°	57.67°

TABLE 3. shows that the evaluation method of contact angle using oleic acid is accurate and reliable. In contrast, the contact angle distinction of samples using water is small between low reflection treatment sample (102.36°) and smudge free treatment ones (~100°).

The standard derivation of test data is shown in TABLE 4. The standard deviation of oleic acid contact angle values was very small (under 0.5°), while water test data is about 1°.

TABLE 4. Standard deviation of data in Table 3 measurement

Samples	Water test	Oleic acid test
Clear Surface	0.78°	0.39°
Low Reflection	1.02°	0.21°
Anti Smudge -1	0.98°	0.34°
Anti Smudge -2	0.54°	0.49°
Anti Smudge -3	1.35°	0.28°

4. Summary

This paper describes accurate and reproducible anti-smudging characteristic evaluation method using the contact angle measurement with standard liquid-Oleic acid ($\mathbf{C_{18}H_{34}O_2}$).

This quantitative evaluation method for the anti-smudge characteristic has very simple measurement methods, low measurement errors and high distinctions about the anti-smudge characteristic. This evaluation method also guarantees high reliability, accuracy and reproducibility, and overcomes the difficulty of quantitative evaluation for the anti-smudge characteristic and low reliability in several proposed methods.

5. References

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