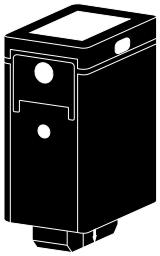
Application Note

PCA 200: Portable contact angle measurements according to ASTM D8597-24

–In cooperation with BECHEM–

Reliable surface preparation is essential for achieving high-quality coating, printing, sealing, and adhesive-bonding results. Even thin residues of lubricants, cleaning agents or other contaminants can significantly alter surface wettability, leading to poor adhesion and coating defects. ***ASTM D8597-24****, '****Standard Test Method for Surface Wettability of Coatings, Substrates, and Pigments by Contact Angle Measurement Using Portable Goniometers****'*[1]*, provides a standardized method for assessing surface wettability with portable contact-angle instruments. Contact-angle measurements offer immediate insight into the interaction between a liquid and a solid surface and can reveal changes caused by contamination, cleaning, surface treatment, or ageing. The* ***PCA 200 portable contact angle goniometer*** *from* ***DataPhysics Instruments fully complies with*** *the measurement requirements of* ***ASTM D8597-24*** *and provides an easy-to-use, reliable, and portable solution for surface-quality control. With* ***just one-click****, the PCA 200 automates dosing, imaging, contact-angle analysis, and surface-energy calculation together with its polar and dispersive components in* ***a few seconds.*** *This application note uses aluminium samples before lubrication, after lubrication, and after cleaning to demonstrate fast, easy, and portable contact-angle and surface energy measurements with the PCA 200 for reliable surface wettability assessment in accordance with ASTM D8597-24.*

Measurement device
Portable Contact Angle Goniometer – PCA 200



Measurement method
Optical contact angle and contour analysis

Measured quantities
Contact angle
Surface energy

Environmental conditions
25 °C

Samples
Aluminium plate

Industries
Coatings
Pre-treatment or cleaning process on a solid surface
Printing

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Theory

The PCA 200 Portable Contact Angle Goniometer (Fig. 1), manufactured by DataPhysics Instruments,[2] is the ideal **hand-held** device for **mobile** measurements of the surface energy of solid surfaces.

It is well established that the surface energy (SFE) of a solid can be determined by contact angle (CA) measurements with at least two different test liquids, for which surface tensions as well as their dispersive and polar parts must be known. The measured CAs as well as the known surface tensions with dispersive and polar parts are then employed in the calculation of the SFE, based on an appropriate theoretical model.[3][4][5] A frequently employed approach is the Owens, Wendt, Rabel, and Kaelble (OWRK) model, which considers the geometric mean of the dispersive and polar parts of the liquid surface tension, and the solid's SFE.

This approach allows to determine the polar and dispersive parts of the solid's SFE from the regression line in a suitable plot (Fig. 2).

Fig. 1: The PCA 200 Portable Contact Angle Goniometer manufactured by DataPhysics Instruments

Main Features

The PCA 200 Portable Contact Angle Goniometer is the perfect instrument for analysing surfaces in production and quality control processes. By dosing up to two different testing liquids onto the surface to be analysed, it ***determines the CAs and SFE within seconds***. In addition to its lightweight design and intuitive user interface, the PCA 200 offers the following key features:

- ***On-Site Companion***

The PCA 200 is a **cable-free, independent system** with a mini-computer and built-in lithium-ion battery. It has an impressive battery runtime of 6 hours, numerous measurement capabilities, and a **highly portable design and low weight (820 g)**.

- ***Quick and Easy***

The PCA 200 can be one-hand controlled and accurately positioned even on small samples. The **live display** clearly shows the test site. By **simply touching** the screen or the measuring button, **the CAs, SFE with dispersive and polar parts, and the image will be displayed in just a few seconds.** The surface quality of the sample can be highlighted by colour (red/green). An integrated barcode scanner can be used to identify the sample.

- ***Reliable***

The PCA 200 is a 'lab-on-the-go' and provides **excellent measurement quality**. It performs optical drop shape analysis and **accurately** determines the surface free energy according to the selected models. It has an **easy-to-use** touch interface and a **web browser interface** for further functionality. It can be connected to a computer to adjust settings, set quality limits, review and organise the measurement data.

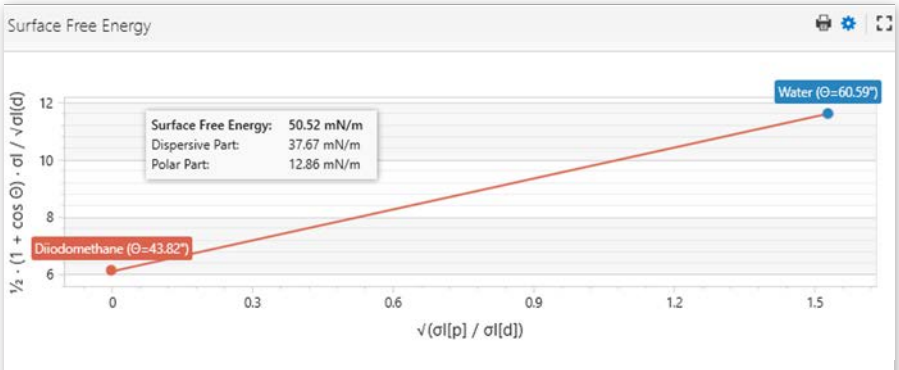

Fig. 2: The polar and the dispersive parts of the solid's surface energy is determined from the contact angles according to the selected model (e.g. OWRK or Wu model).

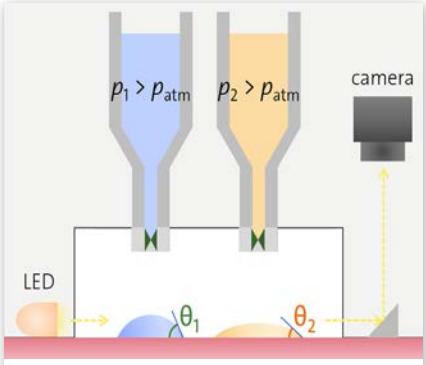

Fig. 3: The measuring principle of the PCA 200

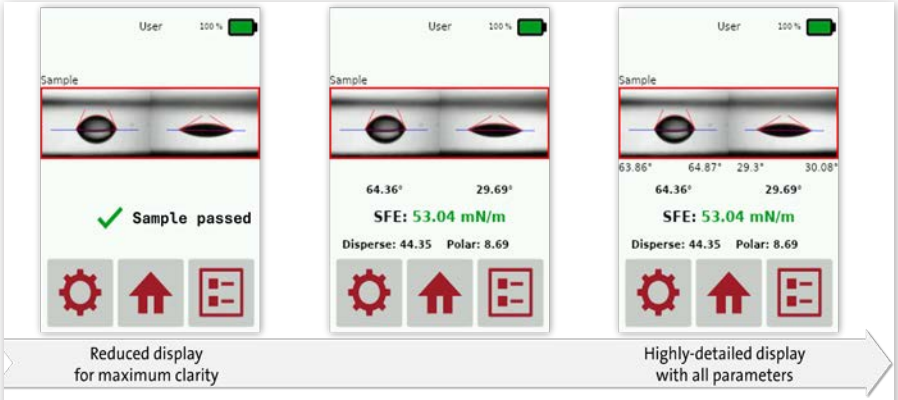

Fig. 4: Users can adjust displayed result detail via the web interface.

Experiment

According to ASTM D8597-24, ultrapure water and diiodomethane were used as test liquids. Water served as the polar probe liquid, while diiodomethane was used as the predominantly dispersive probe liquid. Five (at least three) contact angle measurements were performed for each sample at every treatment stage to ensure reliable and reproducible results. All measurements were conducted at 25 °C and a relative humidity of at least 50%.

The contact angle and surface energy of the aluminium samples were measured using a PCA 200 portable contact angle goniometer. Each surface was evaluated sequentially under the following conditions: (1) as received, (2) treated with the cooling lubricant used in the manufacturing process, (3a) cleaned with Cleaner 1 [6]or (3b) cleaned with Cleaner 2 [6], and (4) rinsed with water.

The PCA 200 initiates and performs a **fully automatic** measurement protocol, as illustrated in the diagram below, **without requiring any manual inputs**.

Step 1: Liquid dosing

The device employs a pressure-based dosing system, whereby both test liquids are simultaneously dosed onto the sample (Fig. 3).

Step 2: Recording the drop image

This is achieved by utilising an optical system incorporating a prism, which enables the camera to capture a profile image of both drops situated upon the sample surface (Fig. 3).

Step 3: Contact angle evaluation

In the image of the drop profile, the software identifies the contours of the drop and the line representing the substrate, and fits the contours with a suitable model. Subsequently, the CAs are determined based on the aforementioned fits.

Step 4: Calculation of surface energy

Following the measurement of the contact angles, the SFE is calculated in accordance with the selected model (OWRK or Wu model).

Step 5: Display of result output

The results are displayed on the device display just within a few seconds, with the desired level of detail (Fig. 4).

Results & Discussion

According to ASTM D859-24, the water contact angle provides a direct indication of surface wettability. As shown in Fig. 5, the as-received aluminium exhibited a high water contact angle of 89.96°, indicating relatively low wettability. After lubrication, the contact angle decreased sharply to 7.76°, showing a strong increase in wettability. This suggests that the lubricant formed a highly hydrophilic surface layer, likely due to polar or surface-active components.

Cleaning with Cleaner 1 increased the contact angle to 73.85°, while Cleaner 2 resulted in a lower value of 64.69°. Both cleaners therefore removed or altered a substantial portion of the lubricant layer. However, Cleaner 1 restored the surface more closely to the as-received condition.

After water rinsing, the contact angles increased further to 88.18° for Cleaner 1 and 89.37° for Cleaner 2. Both values were close to that of the as-received aluminium, indicating that the rinsing step effectively removed residual cleaner or lubricant components.

The standard deviations provide additional information about surface uniformity and measurement repeatability. Low deviations were observed for the as-received, lubricated, and water-rinsed samples, indicating relatively homogeneous surfaces. Cleaner 2 showed the highest standard deviation of 4.94°, suggesting less uniform cleaning or a more heterogeneous distribution of residues. Cleaner 1 showed a lower deviation of 2.16°, indicating a more consistent intermediate surface condition.

The surface energy results shown in Fig. 6 support the contact angle findings. The as-received aluminium

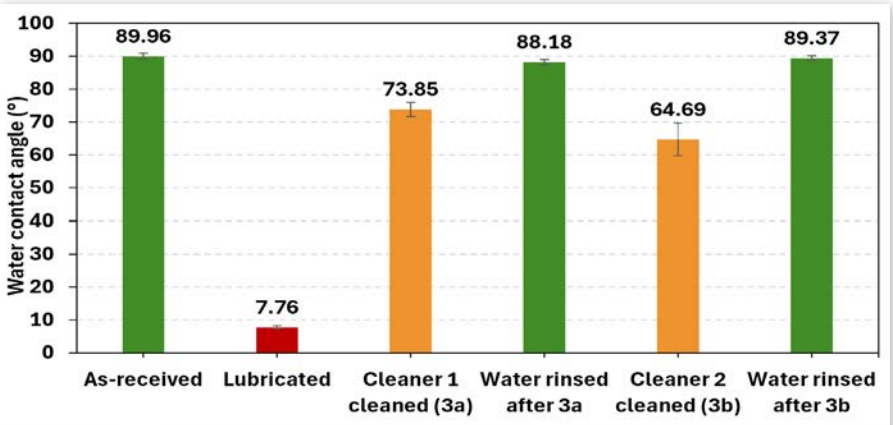

Fig. 5: The water contact angle of the sample aluminium at each treatment stage determined with PCA 200

exhibited predominantly dispersive surface characteristics, with a dispersive component of 38.12 mN/m and a very low polar component of 0.42 mN/m. After lubrication, the polar component increased markedly to 33.31 mN/m. This confirms that the lubricant created a highly polar, water-wettable surface, consistent with the very low water contact angle.

Cleaning with Cleaner 1 reduced the polar component to 1.64 mN/m, bringing the surface much closer to the as-received condition. After water rinsing, the polar component decreased further to 0.60 mN/m, while the dispersive component remained similar at 39.61 mN/m. This indicates that Cleaner 1 removed most of the lubricant and that the rinsing step effectively eliminated remaining residues.

Cleaner 2 also reduced the influence of the lubricant, but the polar component remained comparatively high at 10.31 mN/m after cleaning. This suggests that more polar residue remained on the surface. After water rinsing, however, the polar component decreased to 0.58 mN/m, again approaching the as-received value.

Overall, both cleaning routes successfully restored the aluminium surface after water rinsing. Cleaner 1 was more effective before rinsing, while both final surfaces closely matched the as-received condition. Together, contact-angle and surface-free-energy measurements provide a comprehensive view of surface wettability, cleanliness, and chemical character.

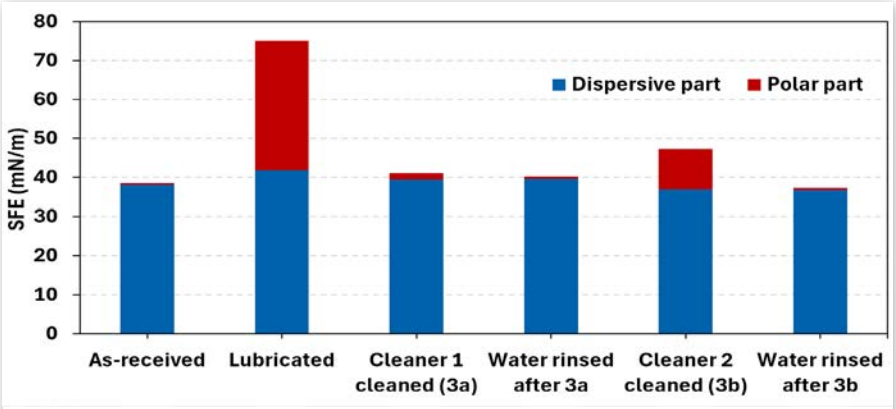

Fig. 6: The surface energy of the sample Aluminium determined with PCA 200

Summary

The results highlight the PCA 200 as a fast, reliable, and portable solution for evaluating aluminium surface cleanliness in full compliance with ASTM D8597-24. By combining water contact angle measurements with surface energy analysis, the instrument clearly differentiates between as-received, lubricated, cleaned, and rinsed surfaces.

With automated liquid dosing, high-resolution imaging, and one-click evaluation, the PCA 200 simplifies cleaner selection, supports process optimization, and enables consistent routine quality control. Its intuitive workflow and standards-compliant measurement capability make it an ideal tool for manufacturers seeking objective, reproducible, and efficient surface treatment assessment according to ASTM D8597-24.

Reference

[1] ASTM D8597-24, Standard Test Method for Surface Wettability of Coatings, Substrates, and Pigments by Contact Angle Measurement Using Portable Goniometers, ASTM International. DOI: 10.1520/D8597-24.

[2] www.dataphysics-instruments.com/

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