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DCA400

Digital Contact Angle Tensiometer

60.50.493 Ed. 3 – 11/2017

All the information given in this manual is what available at the time of printing.
The manufacturer reserves the right to make changes to the product at any time without notice.
It is advisable to verify if there are any updates.

INDEX

1. GENERAL FEATURES – DCA400

- Power source: 230 V -15% +10% by external power supply, 50 Hz
- Power consumption: 10 VA

1.1 DIGITAL TENSIOMETER

- Display of surface tension value expressed in mN/m (dyne/cm) measured with the Wilhelmy method
- Precision: ± 0.02 mN/m (dyne/cm)
- Capacity: 1-1000 mN/m resolution 0.01 mN/m
- Max capacity: 110 g
- Autocalibration with internal mass
- Contact angle 0-180 degrees

1.2 EQUIPMENT

- Glass plates (dimensions 24×24×0.15 mm)
- Suspended system for the arrangement of glass plate
- Glass container for liquid sample
- manual adjustable lab jack

☐ **Software with the following performances:**

a- contemporaneous display on PC:
- force changes during the measurements
- past time
- surface tension value

b- data recording (useful for other elaborations)

c- changing value of perimeter plate (if different from the standard)

d- selection of manual or automatic system for the end of measurement determination

☐ **Automatic jack with programmable speed (from 21 to 1000 μm/sec)**

☐ **Platinum Wilhelmy plate**

☐ **Platinum Du Nouy ring**

☐ **Floater calibrated in weight and in volume and double wall cylinder for relative density measurement:**

- range of measure for the density: 0.5 ÷ 2.25
- readability: 0.00005
- precision and reproducibility: ± 0.00005

} g/cm^3

☐ **Specific container for sample thermostatation**

☐ **Special pan for metrological control**

☐ **Thermometric probe PT 100 1/3 DIN:**

- Range of measure: 0-50 °C
- Accuracy: 0.05 °C
- Readability: 0,1 °C

2. INSTALLATION

DCA400 had been designed and manufactured to withstand and work even in severe environmental conditions.
Nevertheless it is advisable to install DCA400 as follows :

- **on a sturdy support free from vibrations**
- **in a place where the temperature is constant and free from excessive air draughts**
- **electrically connected to a preferential mains line**

Unlock the instrument by rotating the knob on the right side clock-wise until the stop is reached (Fig. 1).

Fig. 1

Put on level with adjustable feets.
Picture of upper balance with bubble (fig. 2)

Fig. 2

3. DESCRIPTION

The DCA400 (Fig. 3) is a tensiometer that follows to have the static measure of the surface tension of liquid samples with the Wilhelmy plate method.
The functions of the instrument can be increased (measure of surface tension with DuNouy ring, dynamic measure with Wilhelmy plate, contact angle measure, data memorization) by connecting it to a PC and using a supplied software.

1 - Hang down
2 - Suspended system for arrangement of glass plate or ring
3 - Sample container
4 - Automatic jack with programmable speed
5 - Thermo probe
6 - Locking device for transport

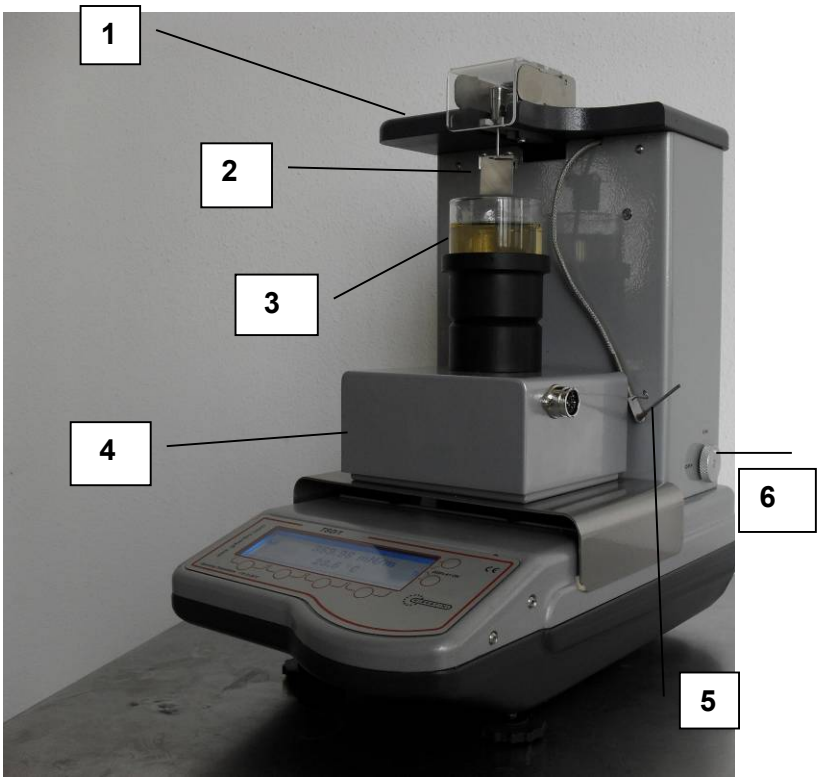

Fig. 3

WARNING: the suspension must be free when the instrument is not in use to allows the automatic calibration.

4. OPERATING INSTRUCTIONS

4.1 GENERAL CONSIDERATIONS

The values of the parameters, surface tension, temperature, weight and volumic mass, are showed on displays (Fig. 4 - 5).

UNIT FOR CHANGING (g / mg)

Fig. 4

Fig. 5

KEYBOARD FUNCTIONS

Briefly press any key to follow on the covering function

Held down longer the "MENU" key to enable the configuration menu

5. LIQUIDS SURFACE TENSION MEASUREMENT

The DCA400 allows to have the static measure of the surface tension of liquid samples with the Wilhelmy plate method. Proceed as follows:

- place the plate in the support;
- clean the plate with the oxidizing flame of Bunsen burner
- wait the cooling of the plate;
- suspend the support with the plate on the hang down;
  place on the lab jack the container with the liquid in examination and lift it until the surface is close to the lower side of the plate (Fig. 6);

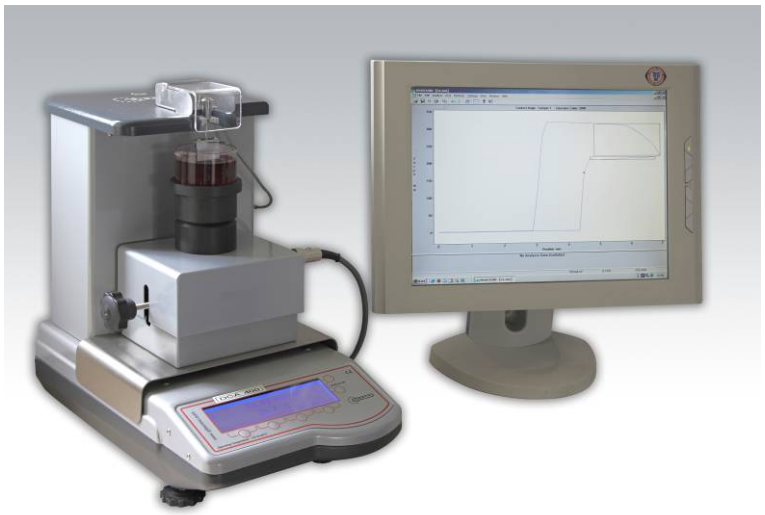

Fig. 6

- press the **UNIT** key; till appear 0,00mN/m
- at this moment the tensiometer is ready to execute the measure:
- lift very slowly the sample and stop when the surface touches the lower side of the plate.
  This moment is very visible because the liquid suddenly go up on the plate walls and then a meniscus is formed (Fig.7)

  <u>The value showed on the display is the surface tension of the sample.</u>

  At the end of the test, remove the support from the hangdown.

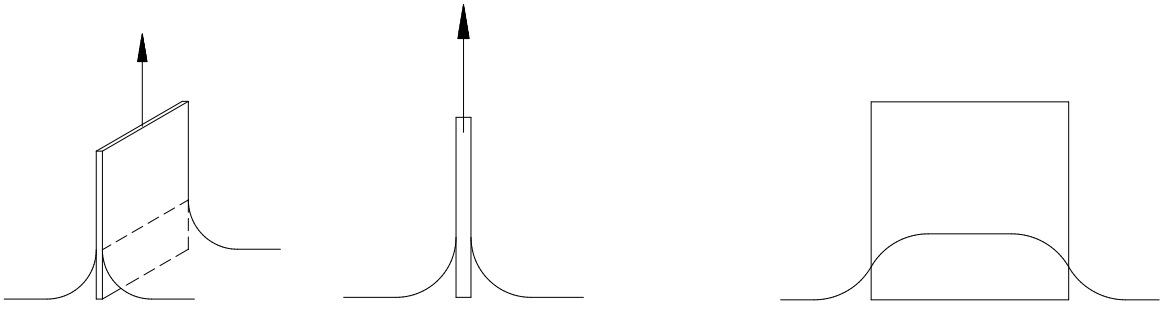

Fig. 7

6. SURFACE TENSION AND TEMPERATURE

Surface tension and temperature are inversely proportioned: when the temperature increases, the surface tension decreases. For example:

Standard Liquids 100%	***Surface tension***					
	5°C	***10°C***	***15°C***	***20°C***	***25°C***	***30°C***
Water	74.9	74.2	73.6	72.9	72.1	71.4
Ethanol	23.6	23.2	22.8	22.4	22.0	21.6
Heptane	21.6	21.1	20.6	20.1	19.7	19.2

It is advisable to know the temperature of the sample.
The thermo probe, must be plunged in the sample at the end of the test, to avoid contamination.

7. CLEANING

Glass plates and sample containers must be carefully cleaned.
The container can be cleaned with plasma or chromic mixture (better if warm).

8. MENU OPTION

SET UP PARAMETERS

- **Serial port**
  - Baudrate
    - 38400
    - 19200
    - 9600
    - 4800
    - 2400
    - 1200
  - Byte Format
    - 7-E-1
    - 7-O-1
    - 7-N-2
    - 7-E-2
    - 7-0-2
    - 8-N-1
    - 8-E-1
    - 8-O-1
    - 8-N-2
  - Protocol
    - Crystal
    - Printer
    - Europe
  - Transmit optino
    - Request
    - Continue
  - Stable Optino
    - Stable mode OFF
    - Stable mode ON
- **Calibration**
  - Calibration AUTO
  - Calibration ON
  - Calibration OFF
- **Autozero**
  - Zero On
  - Zero Off
- **Filtering**
  - Slow Filtering
  - Average filtering
  - Fast filtering (Dosage)
- **Idle Setting**
  - Idle on
  - Idle off
- **Set Default**
  - Exit without saving
  - Store parameter & Exit

- **External calibration**
- **Internal calibration**
- **Floater correction**

9. APPENDIX A - Measurement of the volumic mass

1. Select the function. Press Unit key till appear the value 2.49551 g/cm^3.
2. Fill the cylinder with the sample until the level (about 70 ml) and proceed with the volumic mass determination.
3. Introduce the floater and the thermoprobe in the liquid (Fig. 9)
4. Stir for few seconds to homogenizing the temperature. Control that no air bubbles are present on the floater (Fig. 10).
5. Hook the floater the hang down (figure 1) and verify that it doesn't touch the internal walls of the cylinder or the thermo probe.

   The volumic mass will appear on the display: this value is requested for the surface tension measurement with the Du Nouy ring method.

   At the end of the test, remove **always** the floater from the hang down.

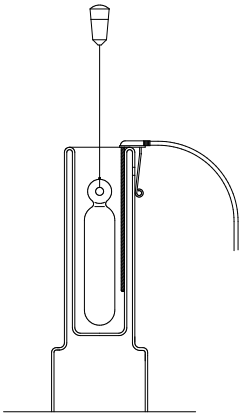

Fig. 9

Fig. 10

Fig. 11

10. SOFTWARE DCA GIBERTINI

The Wilhelmy plate technique provides the most accurate and repeatable measurements. In the Wilhelmy plate technique, the solid sample is hanged perpendicular to the liquid's surface. When the solid is partially immersed in the liquid, the equilibrated force can be expressed as:

$$F \times g = F(\text{liquid-solid interaction}) - F(\text{buoyancy})$$

Or

$$\mathbf{F \times g = \gamma \times PR \times \cos\theta - \rho \times V} \qquad \mathbf{(1)}$$

Where F is the interaction force between solid and liquid, g is the gravitational constant, γ is the surface tension of the liquid, PR is the wetted perimeter of the solid, θ is the contact angle between the solid and liquid, ρ is the density of the liquid, and V is the volume of solid immersed underneath the liquid.

When the solid is right at the liquid's surface, the F(buoyancy) term, $\rho \times V$, equals to zero. Then, the final equation for calculation will be:

$$\mathbf{F \times g = \gamma \times PR \times \cos\theta} \qquad \mathbf{(2)}$$

Since the equation involves in force measurement, with a high-precision balance, the measurement can then be done with high accuracy and repeatability.

By using the Wilhelmy technique it is possible to measure the surface tension of a liquid or the contact angle between a liquid and a solid.
Measurement of surface tension: $\cos\theta$ must be equal to 1. We can have this condition if the contact angle is 0. The cleanliness of the plate is very important to have this value.
Measurement of contact angle: the surface tension must be known and this value must be used to calculate the contact angles (advancing and receding).
Since each sampling technique serves a different purpose, there are different experimental steps involved. To perform an experiment it is necessary to prepare an analysis method.

10.1 Surface Tension

To measure the surface tension of liquid, there are two different types of solid probes that can be used. One is a Wilhelmy Plate, made of glass or platinum. Another is the Du Nouy ring, made of platinum-iridium.

When using a Wilhelmy plate, the Wilhelmy equation, $F \times g = \gamma \times PR \times \cos\theta$, is used again. However, it's necessary to use standard solid probes which will provide known contact angle values. This standard solid probes can be clean glass plate or platinum plate, which will give a 0° contact angle, or $\cos\theta = 1$, because of the very high surface energies of these two materials when they are clean. This turns the Wilhelmy equation into:

$$F \times g = \gamma \times PR$$

Or

$$\gamma = F \times g / PR$$

Another commonly used surface tension measurement method is using a Du Nouy ring. In this method, a Platinum-Iridium ring is immersed into the testing liquid, and pulled out of the surface. (*insert figures to show the ring, and the process.*) The force needed to bring the ring out of the liquid is directly related to the surface tension value of the liquid. The equation used to calculate the surface tension of the liquid is expressed as follow:

$$\gamma = \gamma^* \times cF$$

Where γ^* is the raw surface tension reading from the measurement, and cF is the correction factor, which is used to correct for the amount of liquid attached to the bottom of the ring during the pulling process of the experiment.

$$cF = 0.7250 + \sqrt{\frac{1.452\gamma^*}{C^2(D-d)} + 0.04534 - \frac{1.679}{R/r}}$$

Where C is the mean circumference of the ring, D is the density of the heavier liquid, d is the density of the lighter liquid, R is the radius of the ring, and r is the radius of the wire of ring.

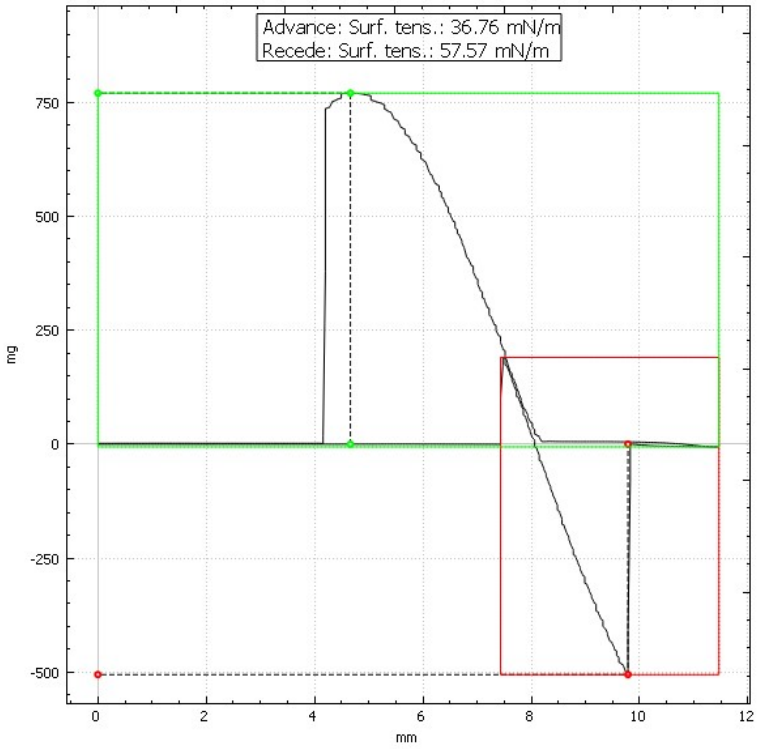

Figure 12: example of surface tension experiment measured by the Du Nouy ring

10.2 Contact Angle

When collecting the contact angle data, from the Wilhelmy equation, F x g = γ x PR x cosθ, it can be seen that cosθ can only be obtained if the other parameters are known or measured. Therefore, in the method, it's necessary to enter g, γ, and dimension of the solid probe correctly.
Under this sampling technique, both advancing and receding contact angles are measured.

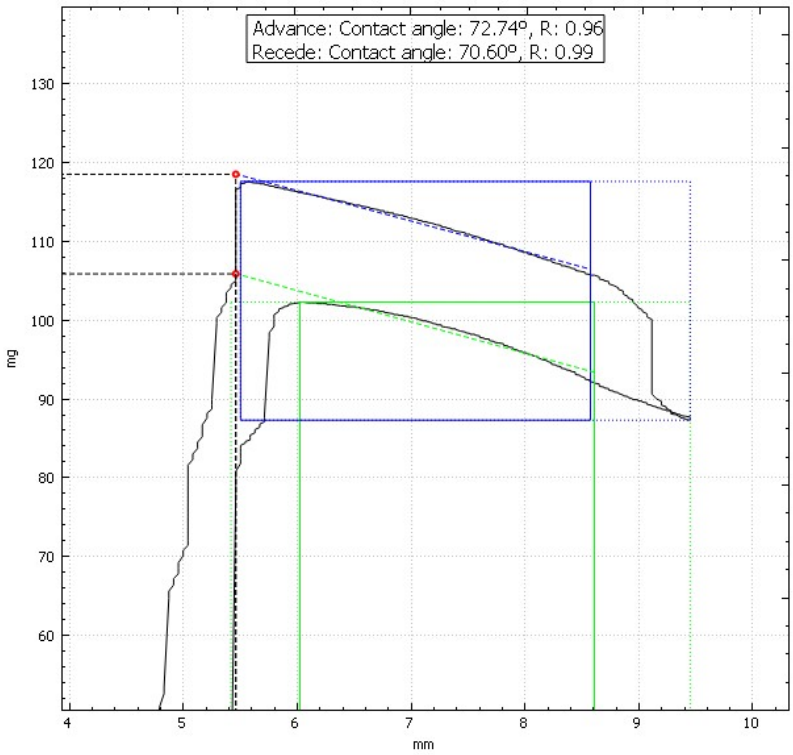

Figure 13: example of contact angle experiment

10.3 Interfacial Tension

Similar to the Surface Tension technique, both the Wilhelmy plate and Du Nouy ring can be used as the solid probe to measure the interfacial tension between two liquids, a light liquid on top of a heavier liquid. It is required that the solid probe pass only once between the interface of the two liquids, typically from the heavier to the lighter liquid.

The experimental steps, however, are more complicated than those of a surface tension measurement. If a Wilhelmy plate is used, all of the plate should be immersed in the light liquid. Only the ring itself should be immersed in the liquid, if a Du Nouy ring is used. This is to ensure that the probe returns to the same position once it's pulled out of the heavier liquid and returned to the zero position.

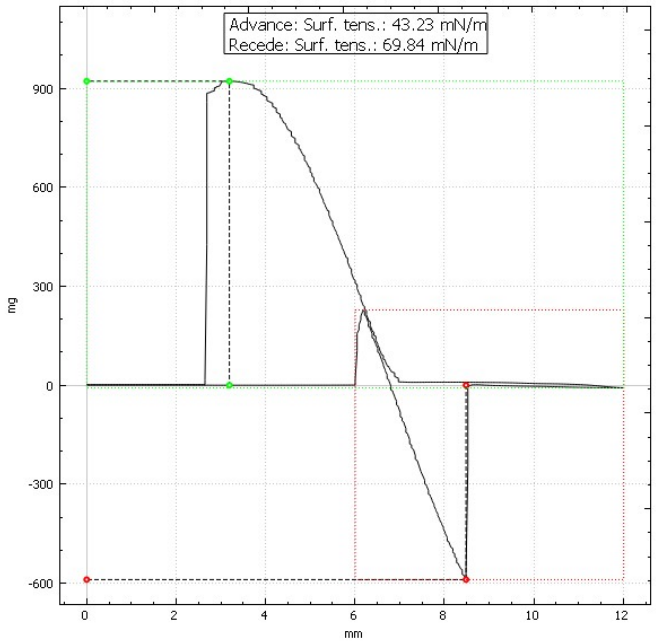

Figure 12: example of interfacial tension experiment measured by the Du Nouy ring