KRÜSS

Application Report

Hydrogel Wetting

Application report:	AR255e
Industry section:	Polymers, Hydrogels
Author:	JC
Date:	August 2006

Drop Shape Analyzer – DSA100S

Method:

Keywords: hydrogels, basic research, methods, polymers, contact angle, wettability, captive bubble, environmental chamber

Methods for Wettability Determination on Hydrogels

Abstract

The measurement of surface properties and wettability of hydrogels, such as soft contact lenses and a variety of sol-gels, can be very difficult. The difficulties stem from the ability to measure wetting on a wetted surface as well as the probability of drying, and thus the changing of surface properties, as an experiment proceeds. Methods for determining wettability on such samples are described below, using either an environmental chamber or a captive bubble arrangement for measuring contact angles with water.

Background

A Krüss DSA100S instrument was used to determine contact angles of water on hydrogel polymers. The same instrument and samples were also used for determining captive bubble angles inside water.

Experimental section

Hydrogel production has expanded greatly over the last several years with the expanding popularity of soft contact lenses. The durability and comfort of lenses can often be related to the wettability of the hydrated polymers (hydrogels) contained in the lens. However, the measurement of this wettability is not always a straight forward proposition. Here, we will take 3 different approaches on hydrogel measurement.

1 – Water contact angle measured under ambient conditions

This experiment is very easy to accomplish and collect data. The lens is allowed to sit on the sample stage and a drop is placed on the sample. An 8 µl drop was formed and placed on the sample as the contact angle was measured by the cone section fit (Krüss “tangent method 1”).

2 – Water contact angle measured under an atmosphere of saturated humidity

In this experiment, a Krüss environment chamber TC3010 was used. A non-woven textile was saturated with water and placed in the chamber at room temperature. The chamber was allowed to come to equilibrium conditions so that a saturated (nearly 100%) relative humidity environment was achieved. At this point, the contact lens sample was introduced. Again, the chamber was allowed to come to an equilibrium saturation condition. At this point, a drop of approximately 8 µl was allowed to fall from a 0.5 mm OD needle tip and a movie of the event was subsequently recorded using Krüss DSA1.9 software on a CF3210 camera set to measure at 360 images per second. The movie was subsequently analyzed using a circular fit to the drop shape. The circle fit was applied since this is generally the best approach for drop contact angles of very small values (below 10 degrees).

3 – Captive bubble contact angle of air measured under water

For this experiment, a Krüss captive bubble needle and cuvette (part number SC13) was filled with water, and the sample was placed on the resting mechanisms. To prevent collapse of the lens sample, a specific chuck was made to support the lens of approximately the same radius of curvature as the interior of the lens itself. The curved needle was positioned by eye to be as centered as possible on the apex of the lens curvature. At this point, an air bubble of approximately 10 µl was placed on the lens apex and a contact angle was measured for the captive bubble with the needle still inside, by the cone section method fit ("tangent 1 method").

Results

Results for each experiment are contained in the table below.

During the experiment conducted under atmospheric conditions the lens dries out in less than 3 minutes. This desiccation of the lens adds to the difficulty of the experiment by introducing ripples and bends in the sample as demonstrated in the picture below.

Along with the difficulty of not being able to find an appropriate surface of the sample to measure on, the contact angle measured under these conditions is also no longer that of a completely hydrated polymer system. The drop stays on the surface for a reasonable amount of time and can be measured at the will of the user. The primary problem being that the sample can no longer be considered as its original hydrogel polymer.

For the second experiment, the problem stems from the issue of measuring the contact angle of a drop of water on a substrate that is wetted with water. As can be imagined, the contact angle is generally very low to begin with when a drop impacts on the surface. Following this, the drop tends to spread and completely wet on the already wetted surface. Even with a 360 frames per second high speed camera, the first readable contact angle measurement is at 9 ms after the drop appears in the image screen and gives a contact angle of approximately 8°. In the next frame, at 11 ms, the drop has completely vanished and has wetted the lens. It is difficult or impossible to collect comparative data between different formulations of hydrogels with such little data collected from the very fast wetting of such polymers.

In the third experiment, the contact angle of a captive bubble of air was determined against a contact lens immersed in water.

Again, to properly see the bubble three-phase point where it intersects the surface of the lens, an appropriate chuck needs to be fabricated which has the same approximate radius of curvature as the inside surface of the lens. Without this chuck, the lens collapses upward from the buoyancy of the bubble.

As you can see from the data table, the captive bubble contact angle is far different from that associated with the hydrated lens under saturated humidity conditions. This value must be interpreted conversely to that of usual wettability numbers. The higher this number is the greater is the wetting by the liquid contained in the captive bubble cuvette.

	Contact Angle (degrees)
water at atmospheric conditions	77
water at saturated humidity conditions	≤10
air contact angle in water	151

Tab. 1: Contact angle on contact lens hydrogel under each experimental condition

Summary

Measurement of wettability on solvated hydrogels can introduce a number of difficulties. The primary obstacle for hydrogels is the drying of the sample, which can change the results for such polymers greatly as the state of hydration is changed. Another avenue of experimentation that can be useful is to measure standard water contact angle on a sample that cannot dry out. This is achieved by placing the sample in a controlled environment chamber with a saturated humidity environment. Here, the problem occurs that even the fastest frame rates of movies of drops wetting an already wetted surface lead to a very limited amount of data. The simple solution to measuring on and comparing hydrated samples is to use the captive bubble method as described above. Although set up and acquisition of captive bubble experiments and data can be a bit tricky and time consuming, the data achieved will be useful and well worth the time consumed.