Contact Angle Measurement on Wood Using Videotape Technique[1]

Direct determination of the contact angle on solid surfaces is difficult when the angle soon starts to change because of interaction between the solid and liquid. Such is the case with wood and water. This note describes a videotape technique allowing unhurried measurement of the contact angle at any desired elapsed time. This procedure may be useful for contact angle measurements on other materials as well.

INTRODUCTION

There are several methods for determining contact angles of liquids in contact with wood (1–6), and all have certain drawbacks. Direct measurement of the contact angle of a liquid on wood (1, 2) is often difficult because wood interacts with many liquids, and the angle starts changing soon after contact. Nguyen and Johns (2) determined the contact angle by arbitrarily selecting an elapsed time at which to attempt the measurement.

At the Forest Products Laboratory, we use a direct videotape method to measure and a modified Wilhelmy procedure to calculate the contact angle on wood. This note describes the relatively simple videotape technique which may be useful for determining contact angles on othersolids that provide only a brief time interval approximating an equilibrium between a liquid drop and the solid surface.

EXPERIMENTAL

Videotape Techniquefor Direct Contact Angle Measurements

A videotape of the appearance of liquid drops on wood surfaces was made, using a Panasonic[2] WV-6000 video camera with a Saticon tube and a built-in stopwatch, a 105-mm Nikkor lens with Nikon bellows, and a "C" mount to Nikkor adapter. Magnification was 4:1 on a 13-inch television monitor (Fig. 1) (M85 0403). Liquid drops, 14 nl in volume, were deposited singly on wood samples from a Gilson Pipetman precision microliter pipet, with fiber optic lighting aimed at the drops.

Procedurefor Direct Contact Angle Determination

Changes in the shape of liquid drops on wood surfaces with time were viewed with the videotape. The earliest time with a stable drop shape (an approximation of equilibrium) was selected, using the elapsed time indicator and the replay capability. The image was frozen at the desired instant and the contact angles were measured with a transparent overlay sheet resembling a protractor (Fig. 2) (M85 0405-12).

Wood Samples

Wood samples were in the form of 3.8-cm-long sticks, 0.64 cm in thickness. Two surfaces were planed; the rest were Sawn with a carbide-tipped, hollow ground blade. Wood was obtained from newly felled trees and was kept frozen until sawing and kiln drying at or below 70°C.

For the contact angle determinations, five samples were used with each kind of wood. With the videotape technique, contact angles were measured separately on the two planed and the two sawn sides of each sample. Contact angles were determined on the left and the right sides of each drop of liquid. Numerical contact angle values were averaged.

RESULTS AND CONCLUSIONS

Contact angles of water on wood, determined by three methods. are shown in Table I. In contrast to the videotape technique, the other two methods involve sample immersion and calculations. The latter two procedures are described in more detail elsewhere (6), and the data are shown here for comparison. Contact angle values and standard deviations show that data obtained with the videotape technique and the other procedures are comparable.

Contact angles for various species of wood are clearly

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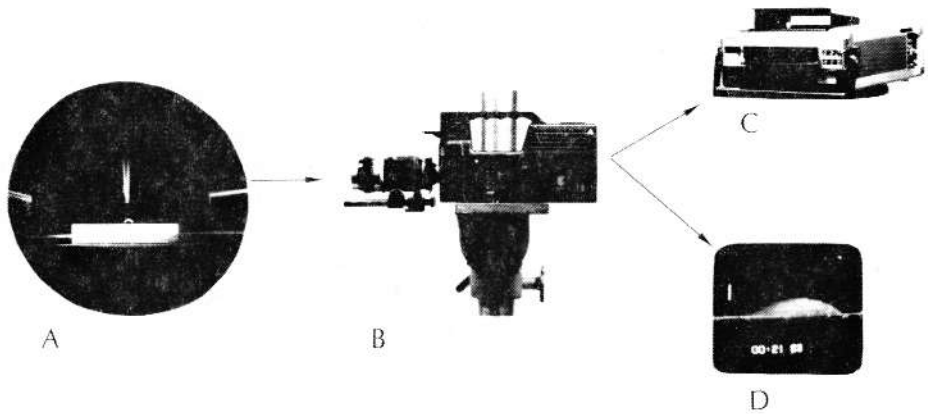

FIG. 1. Arrangement for direct videotape contact angle measurement. (A) Specimen. (B) Video camera. (C) Videotape recorder. (D) Video image on TV monitor (M85 0403).

different; we suggest morphological and chemical differences as the reason. With the videotape technique, differences between contact angles of planed and sawn surfaces also were observed. Several variables related to wood samples are being studied separately for their effect on contact angles, including species, heartwood-sapwood, roughness, drying history, aging effect, etc.

This procedure may be useful on materials other than wood where contact angles have a tendency to change rapidly following a brief period of relative stability. Measurements can be done conveniently on frozen images at desired elapsed times that are chosen during viewing of the videotape. We did not study the importance of drop size, but depending on the solid surface characteristics,

FIG. 2. Contact angle made by a drop of water on wood surface being measured from videotape image at l-s elapsed time (M85 0405-12).

TABLE I

	Average contact angle					
	Based on five samples[a]		Based on ten samples			
Wood species	θ°_{VT} [b]	SD	θ°_{F} [c]	SD	θ°_{W} [d]	SD
Aspen	53.0	4.8	50.4	4.5	54.3	3.1
Birch	59.5	3.9	60.2	5.2	58.8	6.9
Oak	60.5	7.7	60.7	4.5	61.7	4.7
Pine	52.7	6.1	51.5	5.4	53.1	8.2

[a] Measured on at least two sides of a sample, both angles of each drop.

[b] Contact angle was determined directly by the videotape technique; measurement was made at 3 to 5 s elapsed time. Liquid is distilled water.

[c] Contact angle was determined from a force equation: $F = P\gamma \cos \theta$, where P = perimeter of immersed sample, γ = surface tension of liquid, and F = force acting on immersed sample.

[d] Contact angle was determined from a work equation: $W = \gamma(1 + \cos \theta)$, where W = work done to strip liquid from 1 cm^2 of solid surface.

there could be a minimum size below which the contact angle would be affected. A plot of drop size versus contact angle would show this.

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