Measuring the Water Activity of Vegetable Oil

Water activity is defined as the vapor pressure of water in a material divided by the vapor pressure of pure water at the same temperature. It is impossible to measure the vapor pressure of water directly in the sample. However, in a sealed system, the water vapor pressure in the headspace above a material will come into equilibrium with the vapor pressure of water in the sample. Once equilibrium has occurred, the vapor pressure of the headspace can be measured and used to determine the water activity of the material. The AquaLab water activity instrument from Decagon Devices, Inc. measures the vapor pressure of the headspace by determining the dew point temperature of the headspace using a chilled mirror system. Once a measurement is started in the AquaLab, a series of water activity determinations are made to establish that equilibrium has occurred. When two water activity tests are within a preset range of each other, equilibrium has occurred and the test is ended.

Some types of samples can present challenges when measuring water activity. One such sample type is vegetable oil. Due to its hydrophobic nature, vegetable oil cannot readily absorb moisture and water cannot easily move through the oil matrix. Consequently, in a sealed system such as is needed for water activity measurement, the vapor pressure in the headspace above vegetable oil will equilibrate with the vapor pressure in the vegetable oil at a much slower rate than most samples. This causes much longer read times than normal. While the common water activity measurement time in an AquaLab water activity instrument is 3-4 minutes, vegetable oil samples can take up to 20-30 minutes.

An even greater challenge is presented when the vegetable oil equilibrates so slowly that it fools the instrument into thinking that equilibrium has occurred. This occurs when water is either escaping from the oil or moving into the oil at such a slow rate that two subsequent water activity measurements in the series of measurements performed by the AquaLab during a test are so close together that the instrument thinks that equilibrium has occurred. However, upon further testing, it becomes apparent that equilibrium has not occurred since the results continue to change with each subsequent test. Figure 1 illustrates the results of a series of tests conducted on vegetable oil sampled right out of the bottle and analyzed in an AquaLab water activity instrument.

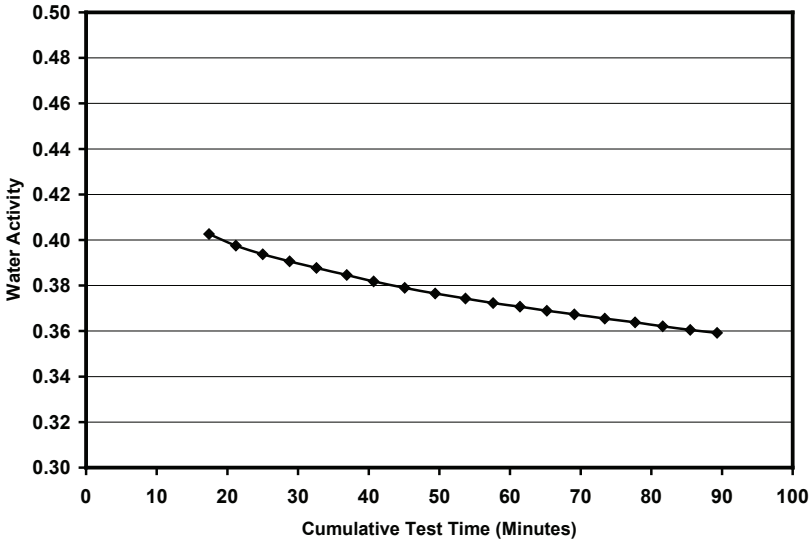

Figure 1. Consecutive Water activity results of Vegetable Oil using an AquaLab Series 3TE.

The initial test took 17 minutes to complete with a water activity of 0.4026. The next test took only 4 minutes, but the water activity was 0.3975. The 0.005 water activity range between the two tests is outside the expected +/- 0.003 precision of the AquaLab. Additional tests were conducted over a total of 90 minutes.

While average read times per test continued to be about 4 minutes, the water activity values never stabilized over the 19 measurements resulting in a standard deviation of 0.0131. This instability indicates that equilibrium never actually occurred, but instead vapor exchange between the oil and the headspace was occurring so slowly that it appeared to be equilibrated and the instrument completed the test. Consequently, if the any of these tests had been used as the actual water activity of the vegetable oil, the results would be inaccurate as equilibrium never actually occurred.

Conclusion: When measuring vegetable oil, special caution is needed to ensure accurate results. Ideally, the vegetable oil should be run in continuous mode on the AquaLab until two or more test results are within +/- 0.002 of each other. The average of the tests that fall within the accepted range should then be used as the water activity of the vegetable oil sample.

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