Water Activity and Plastics

One of the advantages of plastics is their freedom from attack by ambient moisture conditions. However, in the resin state prior to processing, plastics can absorb moisture. Failure to remove this absorbed moisture from the plastic resin can result in surface defects in the final product such as splay, sliver streaking, internal bubbles, and craters. Improper drying can also cause physical property such as loss of impact strength, loss of tensile strength, elongation or poorer melt flow. Surface absorbed moisture can usually be removed with hot air or hopper drying while moisture absorbed internally must be removed using dehumidifying drying.

When is the Resin Dry Enough

One of the challenges for the producers of plastic resins is knowing when the product is dry enough. The consequences of improper drying as listed above can be very costly. Plastic resin suppliers currently rely on moisture content to determine if the resin has been properly dried. Unfortunately, moisture content analyses have not proven to be a reliable method for determining if moisture remains in the resin. The failings result from a lack of sensitivity in moisture content analyses. Depending on the method used to analyze moisture, accuracy of the test can range from ±0.1% to ±0.5%. The common moisture contents of resin material that has not been properly dried is only about 0.5% to1.0%. With the limited accuracy of the moisture content analysis, it is impossible to determine if a moisture content of 0.5% means there is or is not moisture present. There are other tests that can be used to characterize moisture in a product. For example, water activity is a moisture analysis method that has greater sensitivity than moisture content and can be used to determine if resin material has been properly dried.

What is Water Activity?

Though not scientifically correct, it may help to picture water activity as the amount of available water in a system. It is not determined by how much water is present in a product, but is a comparison of how much the water in the product resembles and behaves like pure water. Water activity values represent a scale that ranges from 0 (bone dry) to 1.0 (pure water). As water activity decreases, the water in a product decreases in energy, is less available, and behaves less and less like pure water. For example, water in a product that has a water activity of 0.80 has enough energy to support mold growth while the water in a product with a water activity less than 0.60 cannot support the growth of any microorganism. Water also becomes more mobile as water activity increases, which influences molecular mobility as well as chemical and enzymatic reaction rates.

More scientifically, water activity represents the energy status of the water in the system and is equal to the relative humidity of the air in equilibrium with a sample in a sealed chamber. It is defined as the vapor pressure of water (p) over a sample divided by the vapor pressure of pure water (p_o) at a given temperature.

Why is Water Activity More Sensitive

The moisture sorption characteristics of plastic resin at 25°C are shown in Figure 1. The flatness if this curve is why water activity is more sensitive to moisture contamination than moisture content. Almost the entire range of water activity value represent only a 0.2% change in moisture content, less than the accuracy of most moisture analyzers. Water activity analyses are accurate to 0.003 a_w, which would only represent a 0.002 change in moisture

content, a 2 decimal place increase in sensitivity over conventional moisture content analyses (Table 1). Consequently, when the water activity test reports zero, it will mean that the resin actually is dry. Using water activity in place of moisture content to determine if plastic resin is dry will result in time and cost savings by reducing problems due to moisture contamination.

Figure 1. Moisture sorption isotherm for PVC resin pellets at 25°C.

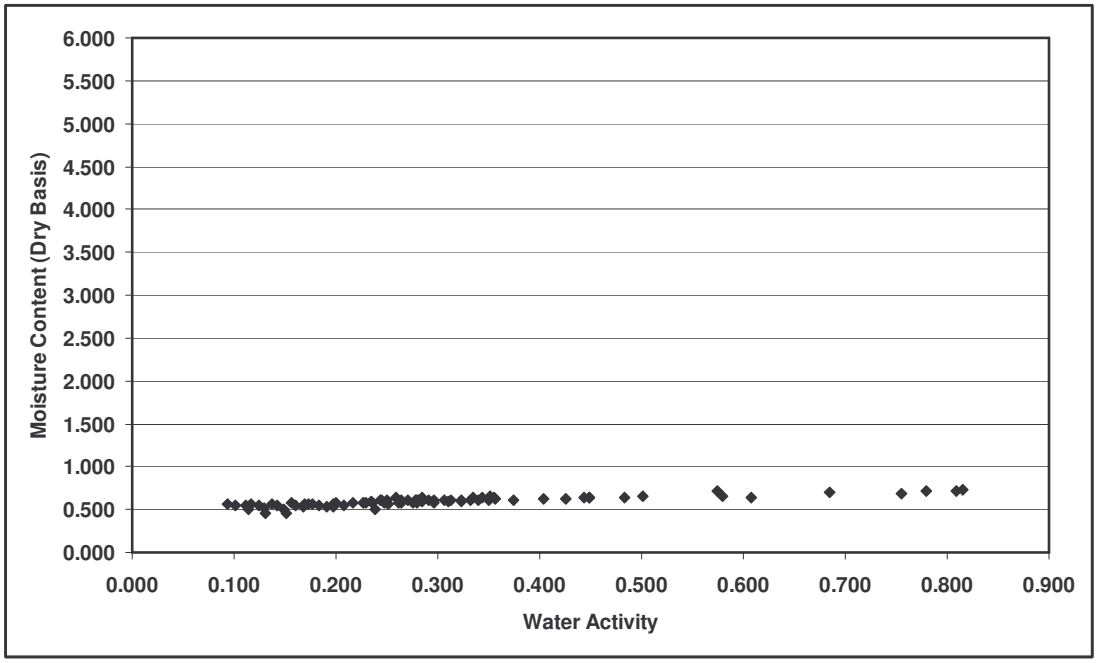

Table 1. Water activity and moisture contents for PVC resin pellets.

Water Activity	Moisture Content (dry basis)
0.200	0.557
0.203	0.559
0.206	0.561
0.209	0.563
0.212	0.564
0.215	0.566

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