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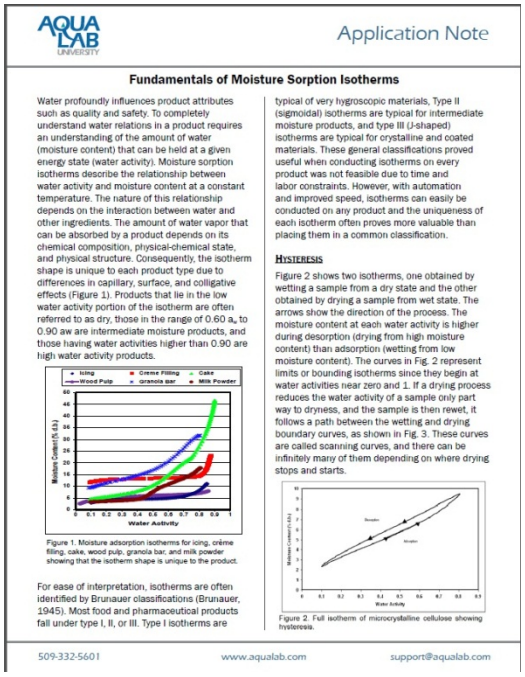

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Application Note

Fundamentals of Moisture Sorption Isotherms

Water profoundly influences product attributes such as quality and safety. To completely understand water relations in a product requires an understanding of the amount of water (moisture content) that can be held at a given energy state (water activity). Moisture sorption isotherms describe the relationship between water activity and moisture content at a constant temperature. The nature of this relationship depends on the interaction between water and other ingredients. The amount of water vapor that can be absorbed by a product depends on its chemical composition, physical-chemical state, and physical structure. Consequently, the isotherm shape is unique to each product type due to differences in capillary, surface, and colligative effects (Figure 1). Products that lie in the low water activity portion of the isotherm are often referred to as dry, those in the range of 0.60 a_w to 0.90 aw are intermediate moisture products, and those having water activities higher than 0.90 are high water activity products.

Figure 1. Moisture adsorption isotherms for icing, crème filling, cake, wood pulp, granola bar, and milk powder showing that the isotherm shape is unique to the product.

For ease of interpretation, isotherms are often identified by Brunauer classifications (Brunauer, 1945). Most food and pharmaceutical products fall under type I, II, or III. Type I isotherms are typical of very hygroscopic materials, Type II (sigmoidal) isotherms are typical for intermediate moisture products, and type III (J-shaped) isotherms are typical for crystalline and coated materials. These general classifications proved useful when conducting isotherms on every product was not feasible due to time and labor constraints. However, with automation and improved speed, isotherms can easily be conducted on any product and the uniqueness of each isotherm often proves more valuable than placing them in a common classification.

HYSTERESIS

Figure 2 shows two isotherms, one obtained by wetting a sample from a dry state and the other obtained by drying a sample from wet state. The arrows show the direction of the process. The moisture content at each water activity is higher during desorption (drying from high moisture content) than adsorption (wetting from low moisture content). The curves in Fig. 2 represent limits or bounding isotherms since they begin at water activities near zero and 1. If a drying process reduces the water activity of a sample only part way to dryness, and the sample is then rewet, it follows a path between the wetting and drying boundary curves, as shown in Fig. 3. These curves are called scanning curves, and there can be infinitely many of them depending on where drying stops and starts.

Figure 2. Full isotherm of microcrystalline cellulose showing hysteresis.

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