While sulfur-coated urea has little effect on soil salinity, it can reduce soil pH slightly because of the sulfur coating, which also is a sulfur source for plants. Sulfur-coated urea tends to be a low-cost, slow-release nitrogen source compared with other coated materials. Leaching and volatilization losses generally are small, assuming that the application of moisture is not excessive. The nitrogen content of SCU ranges from 32% to 38%, depending on the thickness of the sulfur coating.

**Plastic/Resin-Coated Urea.** A relatively new technology similar to that used to produce SCU is a resin-coating (or polymer-coating) process that involves coating a soluble nitrogen source, such as urea, nitrate, or ammonium, with resin or plastic. Resin-coated fertilizers rely on osmosis rather than on coating imperfections to release nitrogen. Low concentrations of salts on one side of the resin or plastic membrane permit high salt concentrations to diffuse to the other side through the coating. As the fertilizer particle swells, either the pellet cracks open due to internal pressure, releasing urea, or urea is forced out through the pores. Since the coating is semipermeable, nitrogen is time-released. Thus controlled release in resin-coated products is more predictable than in sulfur-coated products, enabling turf managers to control nitrogen availability to a greater degree. Release rates generally vary from 70 to 270 days, depending on coating thickness and dissolution of water into the prill.

The major disadvantage of poly-coating is that it costs more than other slow-release fertilizers. *Agriform* and *Escote* are two commercial plastic-coated urea sources.

Multiple coating of urea is a recently developed technique. Urea is coated first with one layer of sulfur, then with a polymer that further protects nutrients and, in combination with the sulfur layer, determines the rate of release. Diffusion, the release mechanism of nitrogen, can be regulated by varying the levels of the coating components. In addition to a controlled release rate, multiple coating offers better resistance to abrasion than SCU. Dust problems associated with handling the material are also minimized. *Poly-S*, a product line from the Scotts Company, is one of the first commercially available dual-coated fertilizer sources created with this technology.

A nitrogen source marketed under the trade name *Poly-N*, formulated with a technology similar to that of Poly-S, consists of two coats of resin instead of one, plus one coat of sulfur. The first resin coating reacts with the urea, and the second resin coating with the first coating, to form a hard coating that does not break easily when the product is handled. The coatings are very thin but effective. The thickness of the coating can be manipulated to produce varying release rates. Dissolution of water into the prill also controls the nitrogen release rate, but temperature does not appear to greatly influence it.

**Controlled-Release Synthetic Nitrogen Sources.** *Isobutylidene diurea (IBDU)*. IBDU is a Japanese product marketed in the United States by Vigoro Industries under the trade name *Par Ex*. IBDU is formed when isobutyraldehyde reacts with urea in an acid solution. The resulting product contains 31% nitrogen, 90% of which is water-insoluble. In the presence of water, IBDU hydrolyzes back to urea and butyric acid. IBDU's nitrogen-release rate is predominantly affected by soil moisture level and particle size and is not as dependent on temperature. Higher soil moisture content and smaller particle size result in a faster release rate. Higher temperatures also increase the rate of nitrogen release, making it 2 to 3 times higher at 75°F than at 50°F. Conversely, organic nitrogen sources and urea-formaldehyde may exhibit a tenfold decrease in release rate within a similar range of temperatures.

An optimum pH range for IBDU nitrogen release is between 5 and 8, with a significant rate reduction occurring outside these ranges. Because nitrogen release is independent of microbial activity, IBDU nitrogen is released more readily during cool weather than other slow-release sources. Nitrogen release, however, is somewhat dependent on particle size, with finer particles providing a greater surface area and a faster rate of hydrolysis, the mechanism for nitrogen release. Usually, a