

Humates in SportsTurf Management

by Michael DePew

Applied humates, humus, and humic substances are gaining popularity for use in turfgrass systems. While their use is not restricted to turfed areas, many turf cultural problems may be alleviated through application of this material. Interest in organic humates has been growing, fueled by public concern for the environment, and the desire to reduce the potential polluting effects of chemical fertilizers.

What are humates?

Humus generally refers to decomposed organic material. The term includes different fractions of organic matter, and any number of complexes formed by the reaction of chemical reagents with various organic substances. In natural systems, microorganisms play a vital role in converting organic material into humus.

The academic community defines humus as the fraction of organic material that contains no recognizable plant parts. It can be broken down into three distinct components: a humin fraction, a humic acid fraction, and a fulvic acid fraction. Older characterization schemes have also referred to an ulmic acid fraction.

Using a dilute sodium hydroxide (alkali) solution, it's possible to isolate the alkali-insoluble humin fraction of humus. From this solution of humic substances, the humic acid fraction can be separated by precipitation following an acid treatment. The acid treatment leaves a straw-yellow solution, or supernatant, over the precipitated humic acid fraction. This supernatant contains the fulvic acid fraction.

Humic substances, or humates, are colloidal in nature. In certain respects, they behave like clay minerals.

Despite use of the terms humic acid and fulvic acid, humates are not true acids. These materials are acids only when their molecular exchange sites are saturated with hydrogen ions.

The composition of the various organic compounds in humates depends on both the original source of tissue, and the environment in which decomposition occurred.



Figure 1. This SEM image shows organic colloids taken from an undiluted liquid humate aliquot. The dark material in the right center of the micrograph is the organic particulate material that has formed on and around the precipitated salt crystals from the bulk solution.

Courtesy: Michael DePew

The humin fraction is composed of relatively long, cross-linked carbon chains that represent the final decay product. As such, they are relatively inert, and their reactivity in the soil is based primarily on their surface area.

The humic acid fraction has shorter carbon chains, and its high ion-exchange capacity makes it relatively reactive. This fraction is not normally soluble in water unless it is saturated with mono-

valent (single-charged) ions such as hydrogen, potassium, and sodium.

In sodic (high-sodium) soils, humic acid dissolves and forms a black organic crust (black alkali) on the soil surface. A secondary growth of algae sometimes develops on this black crust.

The fulvic acid fraction has the shortest-chain carbon compounds of the three divisions of humates. They are generally soluble in water.

How do humic substances work?

Humates help convert essential elements into forms available to plants. Many interdependent physical, chemical, and biological (microorganism activity) processes contribute to this function.

With its low molecular weight (short carbon chain), the fulvic acid fraction plays a vital role in plant-membrane permeability, nutrient chelation, and growth stimulation through auxin-like reactions.

Numerous reports have documented the auxin-like effects of humic substances. Auxins are plant hormones that stimulate growth. Humates promote growth as well, by increasing seed germination and aiding seedling establishment.

The humic acid fraction provides a high ion-exchange capacity (both anion exchange and cation exchange). It provides a buffering capacity and increased water retention characteristics. The high adhesive and cohesive characteristics of this material are important to soil structure and aggregate stability.

The humic acid fraction also allows fulvic acid fraction compounds to become liberated as decay products via microbial activity. The liberated compounds are

APPLICATOR'S LOG

then available for reaction within the plant-soil medium.

Plants have a biochemical mechanism to transport nutrients across cell membranes at the soil-solution root interface. They exude certain ions and protons (hydrogen ions) to set up an electrochemical field that attracts other ions to the plant cell surface.

Once attracted to the surface, nutritional elements may be taken into the plant passively through ion-specific channels in the cell membrane called ionophores. Nutrients may also enter the plant through the active process of binding to an intrinsic protein molecule that is imbedded in the cell membrane.

Once nutritional elements bind to an intrinsic protein molecule, the protein rearranges and releases them into the plant cell. The protein then reverts to its original form so that it's ready to rebind with elements on the cell exterior.

Some researchers have implied that the presence of intrinsic-type proteins in the fulvic acid fraction creates the observed increase in membrane permeability. They speculate that these proteins become embedded in the cell membrane, and function like cell-manufactured protein.

It's also possible that membrane permeability increases due to increased microbial activity caused by the production of intrinsic protein molecules. If humates promote microorganism activity and a large turnover in microbes, then perhaps some of these types of intrinsic proteins found within the cellular membrane of microorganisms are released by the decay of microbes, and are then available for imbedding into plant-cell membranes.

Chelating agents are also known to be found within the fulvic acid fraction of humates. These are organic molecules which preferentially hold certain elements. Chelating agents hold these elements until triggered to release them.

Plants trigger this release of needed elements near the soil-solution root interface by the same exuding of protons and other ionic compounds that sets up a plant's electrochemical field.

How are humates used?

The value of adding organic material to soil has been recognized by growers since prehistoric times. However, scien-

tists remain divided over the subject of organics today. Debate continues to question the chemistry and mode of action of these substances.

Until Liebig (1862), it was thought that plants used humus directly as a nutritional element. Liebig's work showed that plants assimilate carbon from the atmosphere (CO₂), and that growth can be made dependent on inorganic compounds in an inert environment.

Since that time, many soil scientists have only viewed organics as fertilizer that releases plant nutritional elements into inorganic forms upon decomposition. Additional roles of organic matter—in soil aggregation, water-holding capacity, and cation-exchange capacity—have been better understood by soil scientists in this century.

Humate use has long been promoted in agriculture and horticulture, but mostly by uneducated and uninformed investor-promoter types and scam artists. This has helped reduce humates to the level of snake-oil remedies. In the past, poor quality control, poor processing methodologies, and use of untested natural deposits of humic materials contributed to unpredictable and contradictory results of humate use. This helped validate the negative perception.

Humic materials used in the past were often derived from coal, lignite, Leonardite, or well decomposed (concentrated) peat. One must realize that the characteristics of these materials may vary greatly over an area and with depths of burial. As such, areas of a deposit may contain varying concentrations of both humus content and trace minerals. In some instances, the humic materials may be saturated with elements that could be released in toxic amounts when placed in the plant-growth environment.

The environment in which organic material decomposes also influences its final characteristics. Humic substances derived from anaerobic digestion processes are generally higher in the inert humin fraction. They are less reactive than those humates derived from aerobic digestion.

How can humates help turf?

In the turfgrass industry, humates are being marketed as aids for reducing thatch and salt effects in the soil. Humates do increase microbial activi-

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ty, which hastens the microbial breakdown of thatch constituents. Further, humates increase cation-exchange characteristics and anion-exchange characteristics, which may put excess salt ions onto exchange complexes. This effectively "cleans" the salt from the soil solution.

Humates have also been marketed for relief of soil compaction. However, any impact on soil compaction would have to come from improvement in soil structure. On an already compacted soil, humates will only contribute to significant improvements when combined with an aeration or cultivation operation.

As with all new products, sports turf managers should consider the reliability of the material before purchase and application. The marketing company

should be able to provide credible scientific research and not just testimonials. Ask for an explanation of a product's mode of action. Insist on dealing only with knowledgeable and experienced sales representatives that have good reputations. Try applying the product on test areas before committing to blanket applications. □

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Manufactured Humate

by Michael DePew

A liquid humate material called Huma Base has been manufactured and promoted as a fertilizer and soil conditioner. It is unique among humate products because it does not rely on secondary processing of natural humic materials for its production. Instead, Huma Base is produced by processing a raw plant-waste product by chemical digestion.

The raw material for Huma Base manufacturing is a byproduct left when sugar is extracted from molasses. This material features a very uniform composition. Applying a controlled regimen of acid digestion followed by alkaline stabilization produces a humic substance that is consistent and uniform in its characteristics and properties.



Figure 2. This TEM image shows the small colloidal nature of humates (less than two microns). The image depicts 45,000X magnification; the scale bar represents 0.1 microns. Courtesy: Michael DePew

We conducted developmental studies to determine the colloidal nature of Huma Base and to study its surface characteristics. We used both Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM) in this study.

First we verified the colloidal nature (less than two microns in size) by TEM, as shown in **Figure 2**. We then characterized the surface morphology of the humate particulates with SEM imaging. The SEM imaging showed the high surface area characteristic of humic particulates, as they form "clusters" of organic colloids.

Centrifugation at high speeds (10,000 rpm) for more than 40 minutes allowed us to collect enough suspended solids for TEM mounting and examination. The difficulty in centrifuging attests to humates' very fine colloidal size. We brought the solids back into solution in deionized water by sonic dispersion, and then diluted and mounted them on a metallic TEM sample grid.

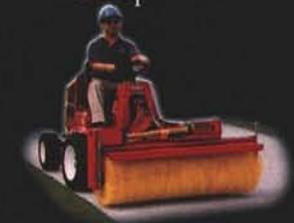
We produced SEM images by drying undiluted aliquots of the liquid Huma Base onto SEM mounts. To examine Huma Base's interaction with soil, we treated clean granitic sands in a leaching column with Huma Base dilutions at a rate of 150 gallons per acre. We applied an equivalent four-percent Urea solution to sand columns at 150 gallons per acre as a control.

The Huma Base treated sand columns showed humates coating the sand grains. The urea-treated sand columns showed no grain coatings of any kind.

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