Photonics Spectra Magazine
Technology World/December 2005

Photonics Examines Pharmaceuticals at Environmental Interfaces

by Anne L. Fischer

With the increased use of antibiotics, hormones, herbicides and pesticides in agriculture, the environmental effects of these substances have become a concern. The discharge of veterinary antibiotics can lead to drug resistance in target microbes, and herbicides, pesticides and hormones could affect humans, resulting in premature puberty, decreased fertility, neurological disease and other conditions.

Optical techniques offer information about the mobility of an antibiotic commonly fed to cattle and present in agricultural runoff. Courtesy of Franz M. Geiger, Northwestern University.

Understanding how these chemicals are bound to environmental interfaces and how they travel through soils is an important step in protecting human health. To this end, a group of researchers at Northwestern University in Evanston, Ill., is using nonlinear laser spectroscopy to study the mobility of the agricultural antibiotic morantel in silica-rich soils.

Morantel is widely used in the cattle industry as a dewormer, but about 75 percent is excreted from the animal in essentially its original form. Understanding the mobility of morantel in soil is helping the US Department of Agriculture evaluate the risks associated with its use.

Northwestern chemistry professor Franz M. Geiger explained that work by others in this field typically entails collection of soil samples in several areas, followed by chemical analyses to assess the concentration of the substances of interest. However, these bulk studies do not afford real-time tracking of the contaminants directly at soil/water interfaces, and they do not provide spectroscopic signatures of the surface-bound species.

Morantel exhibits electronic transitions in the ultraviolet between 285 and 318 nm and characteristic carbon hydrogen stretches in the infrared. Using a regeneratively amplified Ti:sapphire Hurricane laser system from Spectra-Physics of Mountain View, Calif., the researchers applied vibrational sum-frequency generation and resonantly enhanced second-harmonic generation to identify surface-bound morantel, and then used second-harmonic generation as a real-time probe to track its interaction with fused quartz/water interfaces. The results offered spectroscopic and structural information on the surface-bound pharmaceutical as well as thermodynamic and kinetic parameters that helped them understand retardation factors.

The scientists found that morantel is highly mobile in silica-rich soil environments, and they made a link between mobility and risk, which may lead to the development of measures needed to prevent the drugs from entering groundwater.

The group is continuing its studies by examining the pH dependence of morantel mobility to determine how pharmaceuticals are bound and distributed in soils with different levels of acidity.