Broadband Geoelectrical Signatures of Water and Ethanol Solutions in Ottawa Sand

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Abstract

Ethanol is fast becoming the most widely used and distributed biofuel since its introduction as a fuel oxygenate to replace MTBE in gasoline and the rise in use of "Flex Fuel" vehicles. Distilleries create and store vast quantities of ethanol, which is then shipped in large quantities across the country to be mixed into gasoline at refineries. With greater use and distribution, ethanol has become an environmental contaminant through unintended releases to the subsurface. Ethanol was introduced because it had similar combustion properties to formerly used oxygenates and is considered to be relatively harmless, but increased use has had unintended secondary environmental consequences. Where ethanol is included in gasoline as a fuel oxygenate, subsurface releases have resulted in increased solubility and the transport of harmful BTEX compounds. Additionally, ethanol is preferentially degraded by microbial communities in the subsurface. In the case of neat ethanol spills (pure or slightly denatured), large quantities of ethanol may initially reduce microbial populations, exacerbate pre-existing subsurface contamination in soil and groundwater, and potentially form explosive conditions through methanogenesis. Rapid assessment of subsurface releases may allow for quick remedial action. In many cases, surface and borehole geophysical studies can provide timely and reliable results to assess the extent of a release. Here, we measure the broadband geoelectrical signature of various ethanol and water mixtures in a matrix of Ottawa sand to determine select geoelectrical parameters which may be applied to field scale studies. In the lower frequency range (mHz to kHz), resistivity and induced polarization parameters were measured and compared to the well known Cole-Cole model. At high frequencies (MHz to GHz), the dielectric constant of several ethanol and water solutions was measured. We use the empirical complex refractive index model (CRIM) to compare measured and predicted values of the dielectric constant. Results suggest geoelectrical field measurements would be useful to delineate an ethanol release in the environment soon after a spill, unless site specific conditions preclude the application of these methods. Based on ethanol's propensity for biodegradation, however, more work is needed to assess the temporal evolution of an ethanol spill in complex environments.