

## FERROFLUIDS

### Overview

This module based on ferrofluids is intended to provide students with an opportunity to develop chemical formulas and stoichiometric relationships. The production and properties of ferrofluids are controlled by chemistry. Once prepared, they have the captivating property of exhibiting “spikes” when placed in the proximity of a strong magnet. Ferrofluids are easy to synthesize, and the procedures used in their synthesis creates a framework within which to discuss a variety of chemical and physical concepts. Ferrofluids are increasingly being used as damping devices for high-resolution speakers, rotating shaft seals in computer hard disk drives, and in a similar capacity in reduced gravity environments like those encountered by satellites. Biomedical applications such as site-controlled medication are currently being investigated.

Ferrofluids consist of a colloidal suspension of magnetic nanoparticles, typically magnetite, in a liquid medium such as paraffin oil or water. Investigations and demonstrations in this module explore the structure of magnetite, using the ICE solid state model kit. From its inverse spinel structure, the formula of magnetite can be determined and its magnetic properties discussed. A model for understanding these properties in terms of each particle of the fluid acting as a tiny magnet can be presented, as well as a more sophisticated model that includes electron configurations, oxidation states, tetrahedral and octahedral crystal sites, surfactants, and magnetic domains. An experiment concluding the module allows students to determine the correct stoichiometric ratio for the production of a ferrofluid with optimal “spiking” characteristics. This unit also serves as an introduction to nanoscale materials and technologies.

Research continues into the properties and uses of these remarkable substances. It has even been suggested that the migration of fish species such as trout back to their breeding habitat may involve a ferrofluid-like substance closely surrounding a sensory nerve center in the head of the fish.