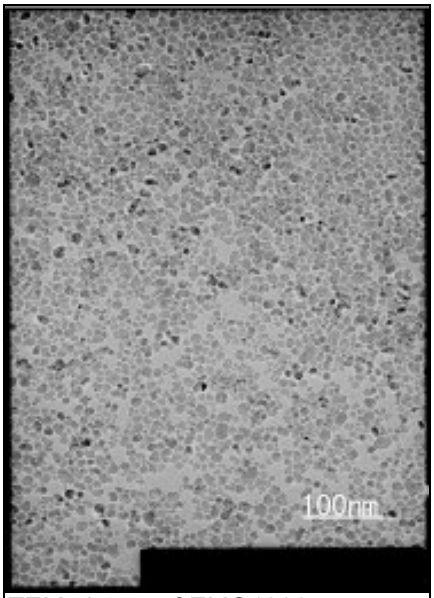
Magnetic Nano Particles for In-Vitro Diagnostics

Ferrotec Corporation has utilized its many years of experience in creating a "***Magnetic Nano-particles Developer Kit***" for in-vitro biomedical applications. The kit offers a unique combination of surface modified and unmodified superparamagnetic particles to researchers and engineers for study of microbead synthesis, hyperthermia, control drug delivery and MRI contrast agent. In the kit are included four types of surfactant coated dry particles with dispersability in various solvents, two types of aqueous based ferrofluids and one bare particles suspension.
This application note describes the main features of the Developer kit, solvents for different products and provides a bibliography of published work.



TEM picture of EMG1200

Dry surfactant coated particles when dissolved in an appropriate solvent form a stable colloid. These and other products in the kit (except for EMG1111) are referred to as ferrofluids. A short description of ferrofluids follows.

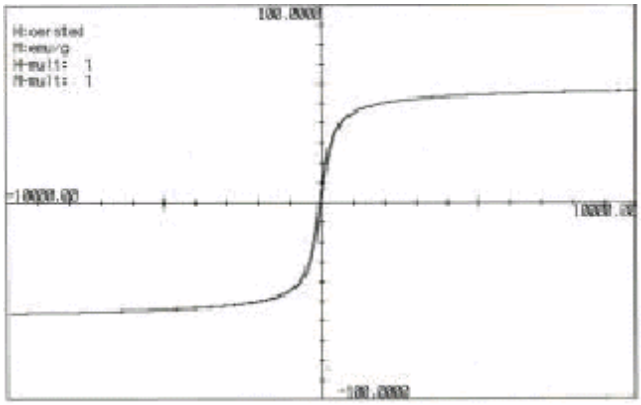

Ferrofluid is attracted to a magnet as one homogeneous phase

A ferrofluid is a stable suspension of nano order size magnetic particles in various carrier liquids. These particles are coated with stabilizers to prevent agglomeration. The physical properties of ferrofluids, such as volatility, environmental capability and viscosity, etc., are mostly determined by the choice of the carrier.

When a magnetic field is applied, a ferrofluid acquires a net magnetic moment due to the orientation of particles in the field direction. These fluids exhibit no remanence or hysteresis. The maximum obtainable moment per unit volume is proportional to the loading density of the magnetic material and is characterized in ferrofluid products as the saturation magnetization value. At saturation, all the particles have their magnetic moments aligned with the external field. Above saturation, the magnetization of fluid is independent of the applied field.

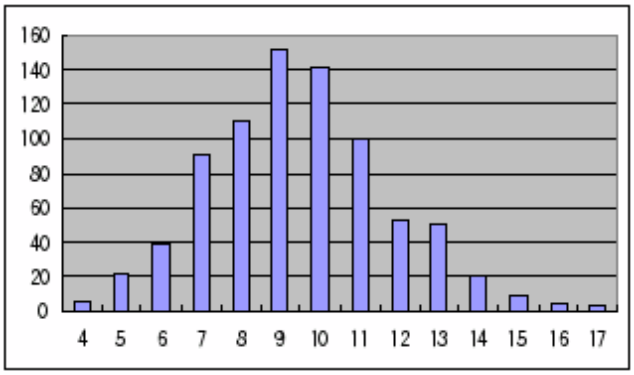
The magnetic particles contained in ferrofluids have a nominal diameter of 10 nm (1/100000 of 1 mm) and are single domain. Some distribution of particles may, however, be noted in TEM measurements. Stable colloidal suspensions in water are available from 1.7 volume percent to 5.0 volume percent of magnetic particles. Also higher concentrated ferrofluids for some particles in hydrocarbon solvent can be prepared. The cores of these particles are made of iron oxides which are known to be compatible with living tissues. From the X-ray measurements, the iron oxides are identified to be a mixture of Fe_3O_4 and gamma-Fe_2O_3.

In biomedical applications, the magnetic particles in ferrofluids are used either directly or as a component of polymeric supports for biologically active species. The magnetic properties of these supports allow them to be rapidly separated from complex liquid mixtures even by relatively weak magnetic fields. Depending on the nature of the biologically active species absorbed on the surface of the support; viruses, bacteria, and various cells may be selectively separated.



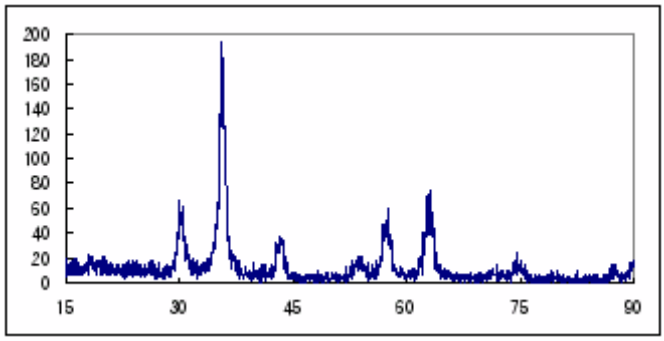
Magnetization curve for typical iron oxide nano particles. no remanence or hysteresis

Therapeutic agents have been incorporated into or onto the magnetically active polymer particles. The particles are concentrated by magnetic fields at specific body sites where they deliver high local concentration of drug. Ferrofluids have also been used to incorporate magnetic particles into preformed biologically active polymer gels which are then used as supports for affinity chromatography. The simplified separation is made possible due to the magnetic properties of the gels and eliminates the usual centrifugation and column chromatography steps.



Particle size distribution for typical iron oxide, counted from TEM picture

The advantage of using magnetic polymers in affinity chromatography lies in that they allow a rapid absorption of molecules from colloidal solutions or those containing cell debris. Conventional purification methods do not allow for such a quick retrieval. This method is particularly valuable if the requirement is to rapidly isolate labile enzymes or enzyme complexes after their liberation from the cell. It is likely that once the enzyme is affinity-absorbed within the pores of a gel, it is more protected, for example, against proteolysis enzymes.



XRD data for typical iron oxide particles

Application Note

Ferrotec Corporation offers a starter ***"Magnetic Nano-particles Developer Kit"*** consisting of (1) a selection of dry particles having different types of surface modifications, (2) water base ferrofluids stabilized with anionic or cationic surface active agents and (3) a slurry of magnetic particles. The slurry serves two main purposes: first, it allows the researcher to coat the particles with his/her own surfactant and second, some researchers require uncoated particles as reference sample. Nominal properties of each product in the kit are summarized in Tables I.

Appearance of "Magnetic Nano Particles Developer Kit"

Ferrofluid Type	**EMG 1200**	**EMG 1300**	**EMG 1400**	**EMG 1500**	**EMG 607**	**EMG 707**	**EMG 1111***
Form	Dry particles				Water base ferrofluid		Water base slurry *
Quantity	2 g	2 g	2 g	2 g	12 ml	12 ml	12 ml
coating nature	fatty acid	polymeric	hydrophobic	polar	Cationic	Anionic	no coating
Typical Particle Concentration in ferrofluid by weight (incl. surfactant)	-	-	-	-	19 %	17 %	19 %
Content of iron oxide in dry particles	about 70 %	about 70 %	about 80 %	about 75 %	-	-	-
Saturation Magnetization of ferrofluid	-	-	-	-	10 mT	10 mT	(about 16 mT)
Typical Saturation Magnetization of particles	82 μAm²/kg (60 emu/g)				57 μAm² kg^{-1} (45 emu/g)	57 μAm² kg^{-1} (45 emu/g)	82 μAm² kg^{-1} (65 emu/g)
Initial Susceptibility	0.20	0.22	0.23	0.25	0.36	0.36	0.65
Average Particle	10 nm						
pH	-	-	-	-	9-10	8-9	5-7
Density	-	-	-	-	1100 kg m^{-3}	1100 kg m^{-3}	1180 kg m^{-3}

*Table1: Nominal Properties of nano magnetic particles and ferrofluids in the Developer Kit, *EMG 1111 contains aggregates of particles.*

The process of dissolving the dry particles in a compatible solvent is simple. Take a small amount of dry particles in a dish or vial and add a solvent of choice from Table II. The particles can be easily dispersed in the solvent by stirring or shaking if the affinity between the particles and solvent is good. If the particles are hard to disperse, heating and stirring by appropriate means may be effective.
EMG 1111 is bare iron oxide particles with no surface treatment, so we recommend an ultra sound treatment (sonication) prior to use of the product.

	water	Methanol	IPA	Butanol	MEK	Methl acetate	Toluene	Heptane	Xylene
EMG1200	-	-	-	-	-	-	OK	OK	OK
EMG1300	-	-	-	-	-	-	OK	OK	OK
EMG1400	-	-	-	-	-	-	OK	OK	OK
EMG1500	-	-	-	OK	-	-	-	-	-
EMG606	OK	-	-	-	-	-	-	-	-
EMG707	OK	-	-	-	-	-	-	-	-
EMG1111	-	-	-	-	-	-	-	-	-

Table II: Solubility of nano magnetic particles in different solvents

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Ferrotec Corporation (JAPAN)
Tel: +81 479 73-6752 Fax: +81 479 73-6602 Email: ffsales@ferrotec.co.jp

Ferrotec (USA) Corporation
Tel: +1 603 883-9800 Fax: +1 603 883-2308 Email: sales@ferrotec.com

Ferrotec GmbH
Tel: +49 7022 9270-201 Fax: +49 7022 9270-1299 Email: fluid@de.ferrotec.com