Really Beautiful Swimming Ferrofluids

by rogercarr

This is a description of how to make ferrofluids that swim beautifully in vessels full of clear liquid. There are many on-line descriptions of how to make up ferrofluids, which are liquid magnetic materials that form into beautiful shapes when exposed to a magnet. However, the common approaches using bulk iron oxide, laser printer toner, or dissolved magnetic tape really give you something more like ferrosludge; they are rough clumpy materials that are far less fun than the elegant effects you see in swimming-type ferrofluid devices. Here you will learn the essential secrets to getting the real thing; a ferrofluid blob suspended in a clear liquid that swims freely, forms beautiful shapes with a magnet, and does not stick to the vessel. The secrets are in how to prepare the ferrofluid, how to make the clear suspension liquid, and how to prepare a glass vessel. You need to do all these steps correctly or the ferrofluid will stick to the walls of the vessel and make a mess. The photo above shows a ferrofluid display I installed at the Chabot Space and Science museum in Oakland, CA in 2013, which is still working perfectly.

Step 1: Materials

1: Ferrofluid: Ferrotec, Inc, (www.Ferrotec.com) makes the ferrofluid. You can also obtain the fluid from Amazon and other retailers. The Ferrotec process is sophisticated nanoparticle chemistry that gives radically better results than you can get in the kitchen with crude materials. Ferrotec EFH1 material

prevents them from clumping together. The balance (85%) is a hydrocarbon oil, like kerosene, which serves as a vehicle to liquefy the ferrofluid.

2: Saturated brine solution for the ferrofluid to swim in. Commercial providers have proprietary formulas for this solution, but saturated brine (pure sodium chloride in pure water) works extremely well and is stable for years. Use Kosher salt or pure NaCl to make this; ordinary table salt contains anti-caking agents that make the solution cloudy. You can use alcohol based suspension solutions, but the much lower surface tension of these suspensions causes the ferrofluid to form stringy, spiky shapes with a

is 5% Fe2O3 nanoparticle precipitate from the reaction of FeCl3, ferric chloride, and NH3, ammonia. It is stabilized with the addition of 10% surfactant, a fatty acid like oleic acid; the exact formula and process is proprietary. Stabilization means that the nanoparticles are coated with surfactant, which

magnet, and not the graceful smooth shapes that most people desire.

3: Clean glass vessel to put the ferrofluid + suspension liquid in. The bottle, jar or whatever you use must be clean, and it helps to prepare it chemically. The vessel should be sealable with an airtight cap.

4: Clean glass container to prepare the suspension solution, Petri dish or equivalent, stirrer, lab gloves, hot plate or electric stovetop, glass thermometer, pipette (plastic is fine), scale.

Step 2: Prepare the Ferrofluid: Secret #1

EHF1 from Ferrotec is true ferrofluid and the best material, but even it can be improved for this purpose. EHF1 Ferrofluid from other sources may be cut with additional kerosene, which definitely requires reduction. Careful heating will evaporate some of the lighter hydrocarbons in the kerosene, and make the ferrofluid less sticky on glass and more viscous, which improves the visual effects.

As a starting point, for a few hundred cc sized vessel, you probably want at least 10cc of ferrofluid. Take the amount of ferrofluid you plan to use, put it in a shallow clean glass or metal dish (pipette transfer is good), like a Petri dish, place it on a hotplate at 100C until you reduce the weight of pure EHF1 by about 10%, or more for diluted ferrofluid. The result will be noticeably more viscous. Do this in a ventilated area to avoid kerosene fumes and fire danger, and use an electric hotplate or stovetop.

Ferrofluid is seriously messy; no matter how careful you are, you are likely to get black stains on hands or gloves, clothes, countertops, etc. It just is.

Step 3: Prepare the Suspension Solution: Secret #2

Clean a glass container with a harsh cleaning solution, like hot water and ammonia, until water does not form beads on the glass, but runs off in sheets. Rinse in hot water and dry. Pour an amount of room temperature distilled water into the container sufficient fill the vessel you plan for your ferrofluid device. Pour in Kosher salt steadily and stir with a clean stirring instrument (spoon just out of the dishwaher, clean glass rod) until no more dissolves, no matter how long you stir. Some undissolved salt will remain in the water. Water at 20C will dissolve 35.7 grams of NaCl per 100 ml of water. This is almost 6 oz/pint, an amazingly large amount. You may scoop out the undissolved salt and add a small percentage of distilled water to the saturated solution, so that salt does not precipitate out of (the resulting slightly less than saturated) solution.

Step 4: Prepare the Vessel: Secret #3

Plastic vessels don’t work; the kerosene will stick to them. Clean glass vessels are the best. We have had good success with vessels directly from glassblowers, and thus directly out of annealing ovens. We have also found that vinegar jars work very well, probably because they have held a weak acid for a long period. If you use another type of vessel, clean it as in step 3 first. It may help to put it in an oven or kiln, cycle it to high temperature (300C) slowly enough to avoid cracking, and then put vinegar in it for a day or two, and rinse with distilled water afterwards. Finally, put the brine solution in the glass vessel for a day or two before introducing the ferrofluid; all of this limits the tendency of the ferrofluid to stick to the glass.


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Step 5: Final Assembly

Pour the brine into the vessel and fill to the top. Do not allow undissolved salt into the vessel. With a pipette or small diameter clean tube, transfer the ferrofluid into the brine solution by putting the tip of the pipette and inch or so under the surface of the brine and releasing droplets of ferrofluid, which will sink to the bottom. The vessel will overflow, which is good. You may get some ferrofluid floating to the top of the water; suck it away by touching the water with a paper towel. Seal the vessel with a small air bubble at the top to give the brine a little room to expand with temperature. Avoid tilting the vessel so the ferrofluid can contact the cap, as it will tend to stick there.

Step 6: Voila!

Voila! This jar is 4 years old, with no sticking, and with beautiful magnetic effects.

Step 7: