Magnetic Fluids - They're Alive!

Magnetic fluids are liquids that have some really interesting properties, especially when they are brought close to a strong magnet. Magnetic fluids are an example of a non-Newtonian fluid made by mixing iron filings in water, oil or Silly Putty. When exposed to a magnetic field, these fluids get thicker (more viscous) and more difficult to flow. Bring the magnet close to a puddle of magnetic fluid and you can pull, move and distort the magnetic fluid to create beautiful kinetic art or make the fluid slowly spread like a slime creature as it oozes over and digests all magnets within reach.

What you will need to get started

- Iron filings
- Water, thick vegetable or silicon oil, Silly Putty
- Probes – several strong magnets
- Plastic cups and wooden sticks to mix fluids
- Several Petri dishes or shallow bowls
- Clean up - Paper towels, soap and water

How to make a magnetic fluid

1. We will make two different magnetic fluids
2. Magnetic Fluid 1 - Add 3 parts iron filings to 1 part oil or water in a plastic cup and mix with the wooden stick until you have made a thick paste. To keep the particles from settling too quickly you can add a drop of dishwashing detergent to the mixture.
3. Magnetic Fluid 2 - Slowly incorporate 3 or 4 teaspoons of iron filings into a ball of Silly Putty. You will need to slowly and carefully knead the Silly Putty until the iron filings are reasonably well distributed.

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The Society of Rheology
K12 Outreach Activities

Science is FUN!

Let's experiment!

1. Start with Magnetic Fluid A - Pour the fluid into a Petri dish or a flat glass/plastic bowl. Take one of the magnets and place it on the bottom of the bowl. What happens? What do you see? Describe the shapes
2. Move the magnet around slowly and then more quickly. What happens? How does the response of the fluid change as you move faster?
3. Use the magnet to pull all the fluid to one side of the dish. Now place the magnet into the dish on the other side. What do you see? If you didn't know this was science would you believe that the magnetic fluid was alive?
4. Now stand the magnet up on its edge. How high will the fluid climb?
5. Repeat these experiments with different strength magnets.

More experimental fun

1. Now let's move on to Magnetic Fluid B
2. Find the strongest magnet you can.
3. Slowly bring Magnetic Fluid B close to the magnet. Be careful, the fluid can jump right out of your hand. If you can place the fluid on the magnet.
4. Watch what happens. Describe what you see.
5. Is the fluid alive? Try bringing other magnets or metal objects close to Magnetic Fluid B. Is there anything this fluid won't digest?

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How does it work?

In this activity, we made a liquid that can be pushed and pulled by a magnetic field. This concoction is an example of a suspension (a mixture of two substances). In this case, it is solid magnetic iron oxide particle dispersed in a number of different liquids.

All fluids have a property known as viscosity—the measurable thickness or resistance to flow in a fluid. Honey and ketchup are liquids that have a high resistance to flow, or a high viscosity. Water has a low viscosity. Sir Issac Newton stated that individual liquids flow at consistent, predictable rates. These magnetic fluids DO NOT follow those rules – if the magnetic fluid is exposed to a magnetic field, the iron oxide particles within the solution rearrange themselves to align with and follow the magnetic field lines. In a strong enough magnetic field, they can even form chains that bridge across the fluid from one side to the other. The presence of these particle chains can greatly increase the viscosity of the liquid making it very difficult for the liquid to flow. The particle chains can also produce some beautiful kinetic art when a liquid interface is present like in the case of a large drop or pool of fluid.

The presence of the magnetic field can also induce flow in the fluid. The magnetic iron oxide particles are attracted to the magnet. As the particles move, they drag the liquid along with them resulting in a flow driven only by the presence of a strong magnetic field.