

Viscosity: the basics

ALL substances are made up of atoms or molecules held together by attractive forces. If these forces are very strong, the atoms or molecules cannot move very much, and the result is a solid such as wood.

If the forces are less strong, the atoms or molecules can move around each other fairly easily but cannot escape from each other altogether, and the result is a liquid such as water. If the attractive forces are very weak, each atom or molecule can go its own way, and the result is a gas such as neon.

Both liquids and gases are types of *fluid*. A fluid is any substance that can flow and has no fixed shape. Viscosity is a characteristic feature of fluids.

So what is viscosity?

In any fluid, there is always some attractive force between the atoms or molecules. As the fluid molecules slide past each other they experience friction, just like the friction between two solid surfaces. If the fluid is to flow, enough energy must be supplied to overcome this friction. In other words, you must do some work on the fluid — you must “push” it hard enough to get it moving.

You may not have to push very hard. When we walk, the air flows around our bodies without our having to make conscious effort. Stirring a cup of coffee is not especially exhausting. Some fluids, however, resist attempts to make them flow. Try to stir treacle as quickly as you

would stir your coffee and you will quickly feel the difference.

We say that treacle is “thicker” or “more viscous” than water. A “viscous” fluid is thick and sticky, like treacle or glue. It resists attempts to make it flow.

Viscosity is the amount of this resistance to flow. It is a measure of the effort you have to make to “shear” the fluid — to overcome the friction between layers of molecules.

Fluids have lower viscosity when they are hot. Atoms and molecules have more energy at higher temperatures. They move faster, overcoming the friction, so the viscosity falls.

Attraction is not the only force

Very big molecules such as polymers and plastics tend to get tangled up with each other as they move. Because this slows down the flow, it also contributes to the overall viscosity.

In the manufacture of acrylic polymers, for example, the viscosity of the reaction mixture is closely related to the degree of polymerisation. It is therefore possible to follow the progress of many industrial processes by monitoring viscosity.

A stirring tale

The viscosity of many fluids is unaffected by how hard you try to “cut” your way through the fluid (physicists use the word “shear”). The viscosity of coffee does not alter whether you stir it slowly or quickly, or not at all. These fluids are called “Newtonian”, after the English physicist Sir Isaac Newton (1642 – 1727), who gave the



first scientific definition of viscosity.

Other fluids, however, behaved differently. These fluids are called “non-Newtonian”. The viscosity changes depending on how vigorously you try to make the fluid flow. Non-drip paint, for example, is very thick and glutinous when at rest in the tin, but flows easily when you stir it or brush it on the wall.

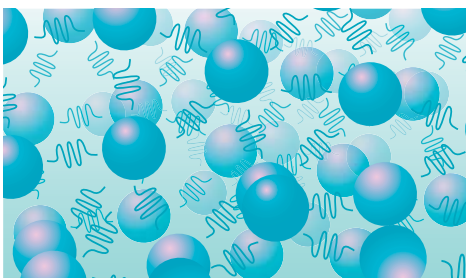
Other fluids become more viscous when you try to shear them. Some even become thick enough to walk on.

Walking on custard

You cannot walk on a fluid like water because its viscosity is low. The downward-bearing weight of your body is enough to push the water molecules out of the way, so you sink.

Custard is a different matter. Custard is thickened with cornflour (cornstarch), which makes the viscosity increase when it is moved. If you put enough cornflour in your custard, you will be able to walk on it. The impact of your foot raises the local viscosity of the custard to a point where it is virtually solid and will support your weight.

But you have to keep moving. If you stop, the viscosity will drop and you will start to sink. That is serious, because the more energetically you struggle to pull yourself out the more solid the custard will become. ➔



Viscosity: overcoming inter-molecular attraction