Using magnetism to control liquids without solid walls

06/05/2020

Just imagine a liquid tube without solid walls that allows other liquids to circulate on a microscopic scale. Researchers from the University of Strasbourg's Institute of Supramolecular Science and Engineering (ISIS) and Institute of Physics and Chemistry of Materials of Strasbourg (IPCMS) have invented this very device, which uses the magnetic field to control tubes composed of nanoparticles of iron oxide.

Microfluidics is a burgeoning technology that involves miniaturising fluid circuits to better control fluid flow. One issue is that, due to the small size of the channels that are sometimes only tens of micrometres wide, blockages, deposits on the inner walls, and an increase in pressure can occur, deteriorating the reliability of the systems.

"These difficulties are related to the use of rigid walls to confine flows", says Thomas Hermans, a researcher at ISIS who has been working on techniques to do away with solid walls since 2014. In order to obtain this objective, he collaborates with researcher Bernard Doudin and Peter Dunne, who is a joint post-doctoral fellow, at IPCMS. The collaboration is enhanced by the involvement of experts in magnetism from Trinity College Dublin (Ireland).

From left to right: Michael Coey, Peter Dunne, Bernard Doudin & Thomas Hermans, involved in Nature article. © DR

Changing the magnetic field in real time

The idea? To use a null magnetic field, with zero in the middle but strong outside, produced by four magnets that surround a plastic device made with a 3D printer. Inside, a magnetic liquid composed of iron oxide nanoparticles, which are attracted by the stronger field, forms a tube without solid walls. This tube can hold other kinds of liquids, e.g. water or blood, which are kept confined by the low field in the middle.

"With this system, there is less resistance, which allows more to be transported with less pressure and at the same speed, while allowing for an optimal preservation of the liquid's properties", explains Peter Dunne. This type of tube can also transport more viscous liquids (e.g. honey, glycerol, etc.), as well as gas or air. Another advantage: the magnetic field can be modified in real time. A valve can thus be created to open and close the pipes and generate pumping action.

A partnership with the Établissement français du sang

Thanks to a partnership with the French blood agency, the researchers were able to test their device in a closed circuit. "Blood suffers from cell degradation when it is put under duress. This magnetostaltic pumping method revealed a marked decrease in haemolysis, an indicator of red blood cell rupture. This helps to better preserve the cells from the blood", says Dunne. More practical and less dangerous to health, this system could be used in heart surgery as a peristaltic pump or in dialysis.

The liquid wall-less magnetic 'antitube' allows other liquids to circulate on a microscopic scale

The invention has been patented under the aegis of SATT Conectus. An offshoot has been the creation of a startup called Qfluidics in order to optimise the reliability and efficiency of these pumps and with the objective of marketing this technology. Another project is to continue the study by decreasing the size of the pipes, whilst monitoring the impact on cells other than blood cells. "There is considerable interest from companies in such a project", says Thomas Hermans. In the long run, the technologies of nanomagnetism and spin electronics, currently used for information storage, could thus be implemented to control nanofluidic circuits.

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- See the full article in *Nature*
- More reading on the same topic: New type of pipe for pumping blood is just liquid with no pipe

The article was originally published in French : Contrôler les liquides sans parois solides grâce au magnétisme