UNIVERSIDADE FEDERAL DE OURO PRETO
INSTITUTO DE CIÊNCIAS EXATAS E BIOLÓGICAS
DEPARTAMENTO DE FÍSICA
MESTRADO EM CIÊNCIAS COM ÊNFASE EM FÍSICA DE MATERIAIS

Processo Seletivo 2019/2

Exame de Proficiência em Língua Inglesa.

Instruções:

- O exame terá início as 14h00min do dia 16 de Julho de 2019 com duração de 3 (três) horas.
- Esse exame é composto por dois textos em língua inglesa:
  - Texto 1 - 'Nanoemulsion' gels offer new way to deliver drugs through the skin
  - Texto 2 - A new 2D magnet draws future devices closer
- Cada texto possui três questões de caráter dissertativo.
- As respostas às questões propostas devem ser formuladas em português.

Texto 1

‘Nanoemulsion’ gels offer new way to deliver drugs through the skin

June 24, 2019, Massachusetts Institute of Technology

MIT chemical engineers have devised a new way to create very tiny droplets of one liquid suspended within another liquid, known as nanoemulsions. Such emulsions are similar to the mixture that forms when you shake an oil-and-vinegar salad dressing, but with much smaller droplets. Their tiny size allows them to remain stable for relatively long periods of time.

The researchers also found a way to easily convert the liquid nanoemulsions to a gel when they reach body temperature (37 degrees Celsius), which could be useful for developing materials that can deliver medication when rubbed on the skin or injected into the body.

“The pharmaceutical industry is hugely interested in nanoemulsions as a way of delivering small molecule therapeutics. That could be topically, through ingestion, or by spraying into the nose, because once you start getting into the size range of hundreds of nanometers you can permeate much more effectively into the skin,” says Patrick Doyle, the Robert T. Haslam Professor of Chemical Engineering and the senior author of the study.

In their new study, which appears in the June 21 issue of Nature Communications, the researchers created nanoemulsions that were stable for more than a year. To demonstrate the emulsions’ potential usefulness for delivering drugs, the researchers showed that they could incorporate ibuprofen into the droplets.

Seyed Meysam Hashemnejad, a former MIT postdoc, is the first author of the study. Other authors include former postdoc Abu Zayed Badruddoza, L'Oréal senior scientist Brady Zarket, and former MIT summer research intern Carlos Ricardo Castaneda.

Energy reduction

One of the easiest ways to create an emulsion is to add energy – by shaking your salad dressing, for example, or using a homogenizer to break down fat globules in milk. The more energy that goes in, the smaller the droplets, and the more stable they are.

Nanoemulsions, which contain droplets with a diameter 200 nanometers or smaller, are desirable not only because they are more stable, but they also have a higher ratio of surface area to volume, which allows them to carry larger payloads of active ingredients such as drugs or sunscreens.

Over the past few years, Doyle's lab has been working on lower-energy strategies for making nanoemulsions, which could make the process easier to adapt for large-scale industrial manufacturing.

Detergent-like chemicals called surfactants can speed up the formation of emulsions, but many of the surfactants that have previously been used for creating nanoemulsions are not FDA-approved for use in humans. Doyle and his students chose two surfactants that are uncharged, which makes them less likely to irritate the skin, and are already FDA-approved as food or cosmetic additives. They also added a small amount of polyethylene glycol (PEG), a biocompatible polymer used for drug delivery that helps the solution to form even smaller droplets, down to about 50 nanometers in diameter.

"With this approach, you don't have to put in much energy at all," Doyle says. “In fact, a slow stirring bar almost spontaneously creates these super small emulsions.”

Active ingredients can be mixed into the oil phase before the emulsion is formed, so they end up loaded into the droplets of the emulsion.

Once they had developed a low-energy way to create nanoemulsions, using nontoxic ingredients, the researchers added a step that would allow the emulsions to be easily converted to gels when they reach body temperature. They achieved this by incorporating heat-sensitive polymers called poloxamers, or Pluronics, which are already FDA-approved and used in some drugs and cosmetics.

Pluronics contain three “blocks” of polymers: The outer two regions are hydrophilic, while the middle region is slightly hydrophobic. At room temperature, these molecules dissolve in water but do not interact much with the droplets that form the emulsion. However, when heated, the hydrophobic regions attach to the droplets, forcing them to pack together more tightly and creating a jelly-like solid. This process happens within seconds of heating the emulsion to the necessary temperature.

Tunable properties

The researchers found that they could tune the properties of the gels, including the temperature at which the material becomes a gel, by changing the size of the emulsion droplets and the concentration and structure of the Pluronics that they added to the emulsion. They can also alter traits such as elasticity and yield stress, which is a measure of how much force is needed to spread the gel.

Doyle is now exploring ways to incorporate a variety of active pharmaceutical ingredients into this type of gel. Such products could be useful for delivering topical medications to help heal burns or other types of injuries, or could be injected to form a “drug depot” that would solidify inside the body and release drugs over an extended period of time. These droplets could also be made small enough that they could be used in nasal sprays for delivering inhalable drugs, Doyle says.

For cosmetic applications, this approach could be used to create moisturizers or other products that are more shelf-stable and feel smoother on the skin.

The research was funded by L’Oréal.

Story Source:

Materials provided by Massachusetts Institute of Technology. Original written by Anne Trafton. Note: Content may be edited for style and length

`ScienceDaily. ScienceDaily, 24 June 2019.`
`<www.sciencedaily.com/releases/2019/06/190624111435.htm>.`

Questions:

1) How long were the nanoemulsions stable in the researchers‘new study?

2) What‘s the problem with several of the surfactants that have previously been used for creating nanoemulsions?

3) How can the properties of the gel be tuned by the researchers?

Texto 2

A new 2D magnet draws future devices closer

June 17, 2019, Ecole Polytechnique Fédérale de Lausanne

We are all familiar with the image of electrons zipping around an atom's nucleus and forming chemical bonds in molecules and materials. But what is less known is that electrons have an additional unique property: spin. It is difficult to make an analogy, but one could crudely describe electron spin as a spinning-top rotating around its axis. But what is even more interesting is that, when spins of electrons align together in a material, this leads to the well-known phenomenon of magnetism.

One of the most cutting-edge fields in technology is spintronics, a still-experimental effort to design and build devices – such as computers and memories – that run on electron spin rather than just the movement of charges (which we know as electrical current). But such applications demand new magnetic materials with new properties. For example, it would be a huge advantage if magnetism occurs in an extremely thin layer of the material – the so-called two-dimensional (2D) materials that include graphene, which is basically an atom-thick layer of graphite.

However, finding 2D magnetic materials is challenging. Chromium iodide (CrI3) recently revealed many interesting properties, but it degrades rapidly in ambient conditions and its insulating nature doesn't promise much in the way of spintronics applications, most of which require metallic and air-stable magnetic materials.

Now, the groups of Andras Kis and Oleg Yazyev at EPFL have found a new metallic and air-stable 2D magnet: platinum diselenide (PtSe2). The discovery was made by Ahmet Avsar, a postdoc in Kis's lab, who was actually looking into something else entirely.

To explain the discovery of magnetism in PtSe2, the researchers first used calculations based on density functional theory, a method that models and studies the structure of complex systems with many electrons, such as materials and nanostructures. The theoretical analysis showed that the magnetism of PtSe2 is caused by the so-called "defects" on its surface, which are irregularities in the arrangement of atoms. "More than a decade ago, we found a somewhat similar scenario for defects in graphene, but PtSe2 was a total surprise for us," says Oleg Yazyev.

The researchers confirmed the presence of magnetism in the material with a powerful magneto-resistance measurement technique. The magnetism was surprising, since perfectly crystalline PtSe2 is supposed to be non-magnetic. "This is the first time that defect-induced magnetism in this type of 2D materials is observed," says Andras Kis. "It expands the range of 2D ferromagnets into materials that would otherwise be overlooked by massive database-mining techniques."

Removing or adding one layer of PtSe2 is enough to change the way spins talk to each other across layers. And what makes it even more promising, is the fact that its magnetism, even within the same layer, can be further manipulated by strategically placing defects across its surface – a process known as "defect engineering" that can be accomplished by irradiating the material's surface with electron or proton beams.

“Such ultra-thin metallic magnets could be integrated into the next generation spin-transfer torque magnetic random-access memory [STT MRAM] devices,” says Ahmet Avsar. “2D magnets could reduce the critical current required to change magnetic polarity, and help us with further miniaturization. These are the major challenges that companies are hoping to solve.”

Story Source:

Materials provided by Ecole Polytechnique Fédérale de Lausanne. Note: Content may be edited for style and length.

Journal Reference:

Ahmet Avsar, Alberto Ciarrocchi, Michele Pizzochero, Dmitrii Unuchek, Oleg V. Yazyev, Andras Kis. Defect induced, layer-modulated magnetism in ultrathin metallic PtSe2. Nature Nanotechnology, 2019 DOI: 10.1038/s41565-019-0467-1

`ScienceDaily. ScienceDaily, 17 June 2019.`
`<www.sciencedaily.com/releases/2019/06/190617110546.htm>.`

Questions:

1) What are the problems with 2D Chromium iodide (CrI3)?

2) What causes magnetism in thin platinum diselenide (PtSe2) layer?

3) What happens if someone removes or adds one layer of PtSe2?