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| **TITLE: NANOTECHNOLOGY TO CLEAN UP OCEANS. An Educational Innovation Project for the inclusion of Sustainable Development Goal SDG 14 in Secondary and Higher Education** | |
| **Educational Institution:** C. SAGRADA FAMILIA, UNIVERSITAT DE VALÈNCIA, UNIVERSIDAD POLITÉCNICA VALENCIA | |
| **Contest:** SCIENTIFIC AND PRACTICAL PAPERS | **Section:** Ecology |
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## 1. Abstract and objectives

The oil spills in the sea suppose a very important environmental problem. The enormous task of cleaning up oil spills in oceans and seas has burdened industry, government, and environmentalists for decades. The cleanup is almost always difficult. It involves great amounts of time, resources, and money to remove the oil from the water, and the cleanup is often only partially successful. Today, however, scientists are coming to the rescue, developing a new technique that combines nanotechnology and magnetism. In particular, a team of researchers from the Massachusetts Institute of Technology (MIT) has developed a method to separate oil from water using magnets. This technique would allow oil to be reused later so that the cleaning costs would be compensated.
The proposed method consists of adding a ferrofluid to the mixture. The ferrofluid is a fluid with magnetic nanoparticles suspended in it to then separate the oil using a magnet.

The objective of our project is to study the efficiency of separating oil from water using various amounts of ferrofluid and a strong neodymium magnet.

## 2. Materials and Experimental Procedure

MATERIALS

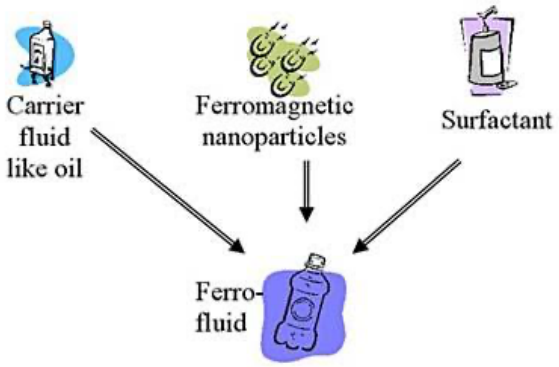
- Ferrofluid, 25 mL
- Mineral oil, 50 mL
- Neodymium magnet
- Petri dishes, 60 mm x 15 mm (10)
- Graduated cylinder, 25 mL volume (3)
- Plastic transfer pipettes, graduated (9)
- Nitrile gloves, pairs (3)
- DC Engine controlled by Arduino electronic board
- Solar cell

EXPERIMENTAL PROCEDURE

- Preparation of water. Fill a cup with at least 100 milliliters (mL) of tap water. Add one or two drops of food coloring to the water and mix so the food coloring dissolves in the water.
- Preparation of mineral oil. Pour about 25 mL of mineral oil in a small cup.
- Prepare three Petri's capsules with 30 mL of coloured water and 2,5 mL of mineral oil.
- Add in the second Petri capsule one drop of ferrofluid (0,05 mL) over the oil and five drops of ferrofluid (0,025 mL) in the third one.
- Clean up the oil using the neodymium magnet. We use a DC engine controlled by an Arduino electronic board to move the neodymium magnet.
- Repeat the movement in the three capsules.

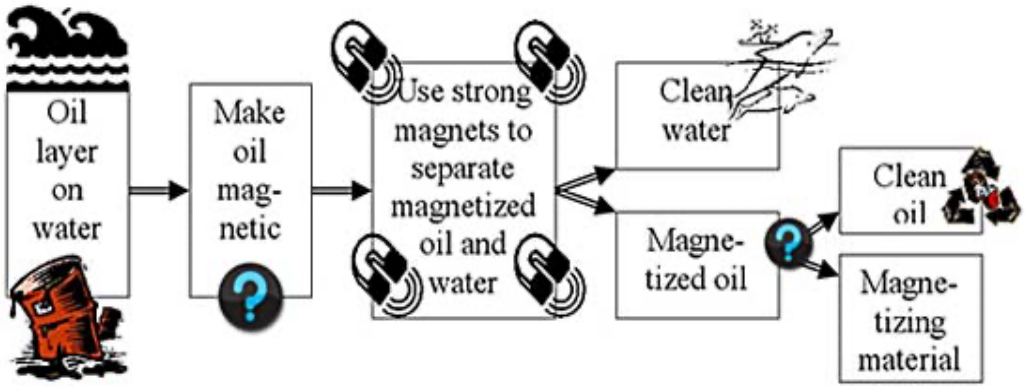
**Physical principles involved and its relationship with technological applications**

A ferrofluid is a liquid that is polarized in presence of a magnetic field. Ferrofluids are composed of microscopic ferromagnetic particles in a carrying fluid that commonly is an organic solvent.

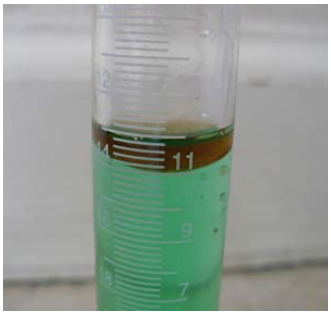



A ferrofluid is not an homogeneous liquid, it is a colloid, a mixture in which the particles of a substance are uniformly distributed in another one. The particles of the dispersed phase are very small, it is not possible to detect them with an optical microscope, we need an electronic one to detect them.

Ferrofluids don't show ferromagnetism because they do not retain their magnetization in absence of an applied field. In fact, ferrofluids show paramagnetism and they are normally identified as superparamagnetic due to their great magnetic susceptibility.




## 3. RESULTS



Measure how much oil is left on the water. To measure it, carefully transfer all of the leftover liquid (water, oil, and ferrofluid) from the petri dish to the graduated cylinder. Wait until all of the oil settles on top of the water in the cylinder.
Read the amount of oil left on top of the water and calculate the efficiency with the equation:

$$Efficiency = 1 - \frac{Leftover\ oil\ volume\ (mL)}{2.5\ mL}$$

Complete the next chart:

| Mineral oil left Volume (mL) | | | |
|---|---|---|---|
| | Control: Cleaning procedure without the use of ferrofluid | Cleaning procedure using a drop of ferrofluid | Cleaning procedure using five drops of ferrofluid |
| **Test 1** | | | |
| **Test 2** | | | |
| **Test 3** | | | |
| **Media** | | | |
| **Efficency** | | | |
| **Observations** | | | |

The cleaning procedure will be carried out with three magnets of different densities to assess and compare the results obtained with each of them.

Once the efficiency is calculated the remaining liquid will be collected in a plastic bottle that will be deposited at a city waste collection point

## 5. CONCLUSIONS

The efficiency obtained when carrying out the project will allow to determine the suitability of this technique that tries to separate oil from water using the magnetic properties of a ferrofluid.

The first results obtained using two of the available magnets have already shown that it is possible to remove 60 and 88% of the initial oil, respectively, therefore, we believe that the future prospects that the use of nanotechnology can offer in the cleaning of oil spills in seas and oceans can be very interesting.

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