Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Invention)

Team Number: SABC147

Project Title: MagNano

Project Type: Invention

***To our best knowledge, there are no similar works in the market*; (if there are,) related product links are as below:**

The enhancement our project made / the difference with related products are:

**Please delete if not applicable. The competition values the originality of works. Students must do enough literature research to ensure that their works are unique and list relevant reference materials before starting research or invention.*

I. Background

- Provide background information as to learn about the audience for whom the project is addressing
- Provide highlights of **literature review** and/or related technologies or devices, with the support of pertinent and reliable references
- Provide an overview of work, create a point of view as to define the needs and insights of the audience and mention the **research or technology gap the project is trying to fill**

Recently, there has been an Melioidosis outbreak in Hong Kong, with a total of 31 cases and 7 Melioidosis related deaths being recorded. Melioidosis is mainly transmitted in 2 ways, through contaminated soil and through surface water. Water is one of the main ways of Melioidosis transmission and drinking water is an inevitable ingredient in our daily lives.

In addition to pathogenic bacteria found in water, heavy metals such as lead, and copper have also been discovered in the drinking water in public estate tap water pipes in 2017. The consumption of drinking water containing metallic impurities may lead to severe diseases.

In this light of predicament, we aim to remove pathogenic bacteria and heavy metals from polluted drinking waters by synthesizing magnetic nanoparticles with antibacterial effect so as to reduce the chance of spreading infectious diseases such as Melioidosis and to minimize the number of cases of health problems caused by contacting or consuming heavy metal-contaminated water. In this project, we hope to create a cost effective and environmentally friendly water purifier that can be used to remove both bacteria and heavy metals from drinking water by utilizing magnetic nanoparticles. The nanoparticles can be removed from the water easily with a strong magnet after purification and could be reused easily.

II. Objectives

- State the **aim(s)** of project

Our project aims to create reusable magnetic nanoparticles which purify and remove pathogens from contaminated water.

III. Methodology

- Briefly describe the **approaches** used e.g. use of equipment, materials, tests and experiments
- Explain the selected implementation strategies with the **scientific theory**

Materials: green tea tea bag, green tea powder, lime, starch, glucose, iron(III) chloride, iron(II) sulphate, iron(III) sulphate, ammonia, sodium hydroxide, ethanol, lead(II) nitrate, sodium iodide, deionized water, acetone, propanone

Apparatus: beakers, conical flask, measuring cylinders, filter funnel, centrifuge tubes, agar plate, pipette, heating plate, centrifuge, magnetic stirrer, electronic balance, thermometer `

Using green tea teabags to prepare nanoparticles

1. Soak green tea teabags in water
2. Pour out 30cm^3 of green tea to a beaker and put it over a magnetic stirrer
3. Add iron(III) chloride solution, containing Fe^{3+} ions, or/and iron(II) sulphate solution, containing Fe^{2+} ions, to 30cm^3 of green tea
4. Add 3M NH_3 dropwise to the solution until the pH becomes 10
5. Allow the mixture to stir for 15 minutes
6. Centrifuge the mixture

7. Wash the nanoparticles with deionised water followed by ethanol

Test for Antibacterial effect

1. Prepare dirty water
2. Add dirty water to samples
3. Shake the centrifuge tubes to ensure that the dirty water and nanoparticles mix well
4. Allow the mixtures to sit for 30 minutes
5. Centrifuge the samples
6. Pour the liquid into agar plates and allow it to sit for 5 minutes
7. Pour away the dirty water from the agar plate and seal the agar plate with tape
8. Incubate at 37 ℃ for 2 days and observe the result

Test for the ability to remove heavy metals from water

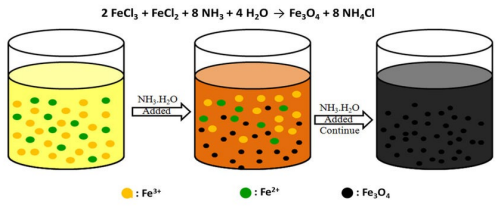
1. Put the filter papers into an oven
2. Weigh the filter paper to obtain its dry mass
3. Add 10mL of 0.1 lead(II) nitrate solution to the nanoparticles
4. Allow it to sit at room temperature for one day
5. Filter to remove nanoparticles
6. Add excess 0.2M sodium iodide solution to the filtrate
7. Filter the mixture to obtain lead(II) iodide precipitate as residue
8. Dry the lead(II) iodide precipitate together with the filter paper in an oven
9. Measure the dry mass of the lead(II) iodide precipitate

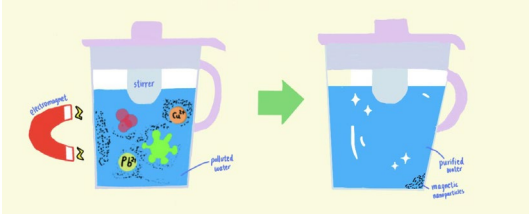
Measurement of nanoparticle size by Dynamic Light Scattering

1. Pour the nanoparticle solution samples into cuvettes
2. Add water to the samples to act as the dispersant
3. Put the samples into a zetasizer to measure the particle size by dynamic light scattering

IV. Design of Invention

- Describe the **<u>design</u>** and the **<u>principle</u>** of invention (e.g. The ideation of the projects, the prototypes or creative solution as far as applicable)
- Provide sketches / drawings / photos of the invention





Synthesis of magnetic nanoparticles can be achieved via co-precipitation, thermal decomposition, micro-emulsion and hydrothermal synthesis. As compared with other synthesis routes, co-precipitation is more facile and convenient. [7] This method is used especially to obtain iron oxide nanoparticles, the technique involves reducing a mixture of metallic ions such as Fe^{3+} and Fe^{2+} ions using a basic solution, typically NaOH or NH_3 at temperatures below 100 ℃.

The aim of this project is to create a water purifier. Magnetic iron oxides nanoparticles synthesised from Fe^{3+} and Fe^{2+} ions which exhibit antibacterial properties and heavy metal removal functions will be incorporated into the design. A stirrer will be installed in the water purifier to mix the polluted water samples with the iron oxides nanoparticles, which can effectively remove bacteria and heavy metals such as lead from water. An electromagnet will be used in the water purifier to remove the nanoparticles from the purified water samples to be reused again.

V. Application / Market Need

- Explain the area of **application** and function of invention
- Indicate the market need and impact of invention
- Discuss **limitation** and compare with existing related works (if any)

In this project, we hope to create a cost effective and environmentally friendly water purifier that can be used to remove both bacteria and heavy metals from drinking water by utilizing magnetic nanoparticles.

Due to the COVID19 pandemic, there has been an increasing awareness regarding the cleanliness of drinking water. People have been increasingly concerned about the purification of water, with more and more people buying water purifiers to be installed at home. Therefore, it is believed that there is great market potential If nanoparticles produced in this project were to be used in household water purifiers to remove pathogenic bacteria and heavy metals from polluted drinking waters.

VI. If your team will compete the Sustainable Development Award, please indicate the specific sustainable development goal the project is related to, and provide justification for competing for this award. ***(Word limit: 300 words)***

Our project is related to the 6th sustainable development goal according to the United Nations: Clean Water and Sanitation.

According to the United Nations, SDG 6 seeks to ensure safe drinking water and sanitation for all, in which safe drinking water means water that is free from hazardous substances such as microorganisms and chemical substances.

Our project aims to create reusable magnetic nanoparticles which purify and remove pathogens from contaminated water. If these nanoparticles were to be added inside water purifiers, bacteria and heavy metals would be removed from the drinking water, thereby making clean water more easily accessible to the public.

VII. If your team will compete the Social Innovation Award, please list the target group or social issue the project focuses on, and provide justification for competing for this award. ***(Word limit: 300 words)***

VIII. Conclusion

- Make a **data-driven** conclusion of the project and the way forward of the invention process
- Justify if the proposed project meets the objective(s)

This project aims to synthesize magnetic nanoparticles with antibacterial properties and heavy metal removal functions by using the co-precipitation method.

Results showed that iron oxides nanoparticles synthesized using the extract from green tea teabags as the stabilizer exhibited magnetic properties. The nanoparticles showed the strongest magnetic effect when Fe^{2+} and Fe^{3+} ions being added at a ratio of 1:2 at pH 10 and at a temperature of 65 ℃. All samples of iron oxides nanoparticles synthesized using green tea teabags as the stabilizer showed antibacterial properties and can successfully remove lead.

In conclusion, magnetic iron oxides nanoparticles are produced. The nanoparticles show magnetic strength and have antibacterial effects. The magnetic nanoparticles are reusable and are thus applicable in purifying water to remove bacteria and heavy metals.

☐ **Our project is developed based on previous project and the enhancement is below:**