

## Hong Kong Student Science Project Competition 2022

Template of Extended Abstract (Investigation)

(Word Limit: 1,000 words, Pages: 2 pages only)

**Team Number: SBBC024**

**Project Title: Natural Polymer-based membrane for Metal ions Refining**

**Project Type: Investigation**

**To our best knowledge and after thorough literature research, as at 6/7/2022, there are / are no\* similar works. If there are, the reference links are as below:**

**The enhancement our project has made for the existing related products or research is summarized as below:**

\*Please delete if not applicable. HKSSPC values the originality of works. Students must conduct literature research thoroughly to ensure that their works are unique, and to list relevant reference materials to complement the research or invention.

### I. Background

- Provide background information of project and/or state the problem to tackle
- Provide highlights of the **literature review** with the support of pertinent and reliable references
- Provide an overview of work and mention the **research gap that the project is trying to fill**

Sewage contamination has always been a problematic hazard that poses countless challenges to the well-being of humans. The culprit behind the many health risks caused by the polluted water is the heavy metal ions within, such as the most common  $Pb^{2+}$  &  $Cd^{2+}$  ions.

Our project aims to achieve selective metal ion ( $Pb^{2+}$  vs.  $Cd^{2+}$ ) separation using a natural and biodegradable polysaccharide named *alginate*.

### II. Objectives

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

Our project aims to achieve selective metal ion ( $Pb^{2+}$  vs.  $Cd^{2+}$ ) separation using a natural and biodegradable polysaccharide named alginate. It is known that alginate possesses chelation power so it can bind with certain metal ions (e.g.  $Ca^{2+}$ ,  $Al^{3+}$ ) to form a hydrogel membrane (e.g. CaAlg & AlAlg). We propose that the ion channels formed between walls of the chelated alginate chains could serve as 'tunnels' to permit a specific type of metal ions to penetrate, differentially setting groups of metal ions apart from each other. The higher the permeability of metal ions, the more effective the layer is at differentiating between them.

### III. Hypothesis

- Propose an explanation for a phenomenon and stating how the **hypothesis** can be tested by experiments

We propose that the ion channels formed between walls of the chelated alginate chains could serve as 'tunnels' to permit a specific type of metal ions to penetrate, differentially setting groups of metal ions apart from each other. The higher the permeability of metal ions, the more effective the layer is at differentiating between them.

#### IV. Methodology

- List out the materials used
  - Describe the **experimental protocol** including the set-up of **control experiment** (if any), **repeated experiment** (if any), and its scientific theory
  - Indicate with the support of reasons, the **analysis** used in the investigation
1. Add 0.5 ml NaAlg to the surface of the sieve only above the petri dish
  2. Use a syringe to spread NaAlg uniformly across the testing sieve
  3. Spray  $\text{Ca}(\text{NO}_3)_2 / \text{Al}(\text{NO}_3)_3$  vertically from above on the testing area for 5 times
  4. Wait 1 min for the  $\text{Ca}(\text{NO}_3)_2 / \text{Al}(\text{NO}_3)_3$  for thorough chelation
  5. Invert the sieve and spray  $\text{Ca}(\text{NO}_3)_2 / \text{Al}(\text{NO}_3)_3$  to the bottom of the sieve
  6. Fill a beaker with 88 mL of distilled water
  7. Add 44 mL of  $\text{Cd}(\text{NO}_3)_2 / \text{Pb}(\text{NO}_3)_2$  mixed solution (1:1) into the sieve
  8. Rest the sieve on the 100 mL beaker for the desired diffusion periods
  9. Collect the solution above and below the sieve with two beakers
  10. Add 8 mL 0.25 M  $\text{K}_2\text{SO}_4$  into both solutions (up & down) to precipitate  $\text{Pb}^{2+}$
  11. Filter the solution with pre-weighed filter paper
  12. Add 2 mL of 1 M  $(\text{COOK})_2$  into both filtered solutions (up & down) to precipitate  $\text{Cd}^{2+}$
  13. Filter the solution with pre-weighed filter paper
  14. Dry the filter paper and measure the weight of the residue

#### V. Results

Based on our trials, we reached a conclusion that the most ideal membrane for separating a mixed  $\text{Cd}^{2+}$  &  $\text{Pb}^{2+}$  solution is a combined Calcium-Aluminium Alginate Layer of 0.6 M  $\text{Ca}^{2+}/\text{Al}^{3+}$  & 0.80% alginate, achieving both the highest  $\text{Pb}^{2+}$  permeability &  $\text{Cd}^{2+}$  absorptivity at 31.32% and 40.16% respectively. Such membrane also exhibited an exceptional selectivity ratio (permeability of  $\text{Cd}^{2+}$  to that of  $\text{Pb}^{2+}$ ) of 1: 19.5, testifying to its capability to distinguish metal ions selectively. The separated metal ions could then be recycled to conserve chemical resources & energy.

#### VI. Conclusion

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

From our findings, it was found that 0.2 M calcium nitrate and 0.6% sodium alginate have the largest difference in cadmium(II) ions permeability and lead(II) ions permeability. Also it was found that 0.2 M calcium aluminium ion mixture solution with ( $\text{Ca}^{2+}:\text{Al}^{3+} = 3:2$ ) and 0.6% sodium alginate have the largest difference in cadmium(II) ions permeability and lead(II) ions permeability.

#### Our project is developed based on our school's previous project and the enhancement is as below:

1. On top of the Calcium-alginate layer developed last year,  $\text{Al}^{3+}/\text{Ca}^{2+}$  metal ions were employed for alginate/chitosan chelation to enhance its mechanical strength while contributing to the cationic permeability towards heavy metal ions.
2. Chitosan is mixed with alginate to introduce amine groups in addition to the carboxylate ions of alginate. This varied the cationic permeability of ion channels compared with the previous model.
3. Investigation of chelated alginate strength upon the addition of 8% ethanol was carried out.