2022/23

香港科學青苗獎

Hong Kong Budding Scientists Award

資料匯編

Collection of Students' Proposals To Future World Problems / Authentic Problems

教育局課程支援分部資優教育組
Gifted Education Section
Curriculum Support Division
Education Bureau

目錄

前言

教育局資優教育組於二零零五年開始籌辦第一屆「香港科學青苗獎」計劃及相關的培訓活動，目的在現有的平台以外，為學生提供一個以科學領域為背景的全面培育機會。

起初構思「香港科學青苗獎j的計劃時，我們已了解到本地有各式各樣的科學比賽，因此計劃的設計，除注重培育科學資優生的潛能外，同時亦注入與其他比賽不同的元素，包括情意教育，避免資源重疊。計劃首先要求參加比賽的學生，進行相關文獻的整理 和研究，發揮他們的創意，為一個「未來世界難題 / 現實難題」提供不同的解決方案，從中訓練他們資料搜集、分析、綜合、評鑑及應用科學知識的能力。之後，學生需要訪問本地一位從事科學研究的學者。我們希望學生可透過面對面的訪談，了解成功科學家的奮鬥過程，他們 / 她們的科學研究對社會的貢獻，學習他們 / 她們那種百折不撓的態度和精神，並且能夠深入認識科學的本質。我們相信，受人尊崇的成功科學家所應具備的素質，不單包括豐富的學科 知識，而且還須具備良好的解決問題能力和道德修養。最後，評判更會提問學生有關解決方案的詳細資料，參與的學生便要磨練自己的應對及表達能力。

整個「香港科學青苗獎」計劃，歷時大半年，每一個環節都與下一個環節緊緊相扣。我們希望參與計劃的學生，視整個計劃為一個學習的歷程，並且能夠虛心聽取別人（指導教師及評判）的意見，不斷檢討現況，改進自己。

教育局籌辦這個比賽，不但給予學生多一個機會發掘及發展自己在科學方面的潛質，同時亦希望藉此機會，將比賽的題目，學生比賽時的經歷與評判學者的專業意見，整理成有高度參考價值的教材。我們期望教師們能夠參考本資源套，於學校層面推展相類的活動；或於校本課程中引入本計劃的理念，調適現有課程，讓更多的學生能夠受惠。

教育局課程支援分部資優教育組

比賽規則

I. 初賽

參賽學生需要遞交一個「未來世界難題 / 現實難題」的解難方案及一個「科學家專訪報告」

1. 「未來世界難題 / 現實難題」的解難方案

參賽校隊需要從3條「未來世界難題 / 現實難題」中選擇一題，提交解難方案；而方案需包括：

- 簡介：簡單介紹所選難題的背景；
- 解決方案：建議解難方案，並提出理據作解釋；需輔以插圖、圖片、圖表與相片等幫助說明所建議的解難方案；
- 討論：討論解決方案的利與弊；
- 總結及建議：作總結、討論所提出的方案的限制，以及建議如何改善實驗設計及方法等及；
- 參考資料

備註： 比賽主辦單位期望遞交的解難方案，會有實驗設計，包括實驗步驟、實驗結果、實驗分析與結論。學生宜把實驗的過程及結果拍照或錄影。

- 解難方案須以學校報名時所選擇的語言（中文或英文）撰寫；
- 小學組的報告字數不得多於1,500字；中學組不得多於2,000字；
- 圖像、圖表與模型相片的總數，不得超過15張；同時，所用的圖像、圖表與模型 / 實驗的相片，必須符合版權法的「合理使用」；
- 所提出的解難方案必須為原創（original），並且未曾於本港、全國及 / 或國際的其他比賽中匯報；
- 超出所限字數的解難方案將會被扣分；
- 解難方案所包括的圖像、圖表或模型相片的附註解說，不會計算在解難方案的字數總和。

2. 「科學家專訪報告」

- 參賽校隊須訪問一位本地的科學家，然後遞交整理好的專訪報告。科學家專訪報告需包括學生的反思部分 – 例如受訪科學家對社會的貢獻及學生從科學家身上學到的事情等；
- 受訪的科學家須正從事科學研究，並曾在權威的科學期刊，發表學術論文；
- 科學家專訪報告使用的語言需與遞交的解難方案所選用的語言相同；小學組不超過1,500字，中學組不超過2,000字；

II. 決賽

決賽以網上形式進行，進入決賽的隊伍須向評判匯報參賽的解難方案，並解答評判團的提問。

比賽題目(未來世界 / 現實難題)

1. **與運動科學有關的科學探究**

   識別一個與「運動科學」有關的難題，然後建議一個解難方案。解決方案必須實用、具經濟效益、符合科學原則，並有證據支持，且富創意。請給予所要探究的難題一個探究題目。

2. **香港的海洋污染**

   本港海洋污染問題一直引起市民的關注。香港特別行政區政府竭力保護海洋環境，免受到任何污染問題。試建議一個方案以處理其中一種香港的海洋污染問題。解決方案必須實用、具經濟效益，符合科學原則，並有證據支持，且富創意。請給予所要探究的問題一個探究題目。

3. **其他**

   試描述一個你們感興趣並與科學相關的「未來世界難題」/「現實難題」。遞交的解難方案，應把重點放在科學和科技層面上。另外，解難方案必須實用、具經濟效益、符合科學原則，並有證據支持，且富創意。請給予所要探究的難題，一個探究題目。

Problems of the Heat

(Future World Problems / Authentic Problems):

1. **A Scientific Investigation on a problem related to sports science**

   Identify a problem related to sports science. Suggest in your proposal how to tackle the problem. The suggestion(s) in your proposal should be practical, cost-effective, scientific, evidence-based and creative. Please also suggest a title for your investigation(s).

2. **Marine Pollution in Hong Kong**

   Marine pollution in Hong Kong has long been raising concerns among citizens. The Hong Kong Government strives to protect its environment from any marine pollution problems.

   Suggest in your proposal how to tackle marine pollution problems in Hong Kong. The suggestion(s) in your proposal should be practical, cost-effective, scientific, evidence-based and creative. Please also suggest a title for your investigation(s).

3. **Others**

   Describe a science-related future world problem or real-life problem in which your school team has interest.

   Suggest in your proposal how to tackle the problem. The focus of the proposal should focus on scientific and technological aspects. The suggestion(s) in your proposal should be practical, cost-effective, scientific, evidence-based and creative. Please also suggest a title for your investigation(s).

小學組:

冠軍

第十六屆香港科學青苗獎

吃得到的水球

聖保羅男女中學附屬小學

參賽學生： 陳皆攸、張智南、莊梓麟、何沐珈、田澤沛

指導老師： 陳穗雯老師、黃旭霖老師

引言

在長跑比賽中，主辦大會為了讓運動員補充水份，會在路旁預備樽裝水或用紙杯盛水。賽事完結後便製造了大量垃圾。為減少賽後產生的垃圾，我們嘗試以符合食用安全的物料製作的可吃用的水球，並進行科學探究，找到最好的「配方」和儲存方法。

原理

實驗原料是乳酸鈣和海藻酸鈉。乳酸鈣(Calcium Lactate)是乳酸菌和鈣結合的化合物，經常加入食品中，能增加風味、延長食品期限以及作為營養補充品。[1]海藻酸鈉(Sodium Alginate)是從褐藻提煉的化學物質，可用於食品中。[2]

當兩者混合時，海藻酸鈉中的鈉離子和被鈣離子取代，生成海藻酸鈣。鈣離子的電荷特性使分子之間連結得更強，令分子流動性降低，形成透明薄膜。參考圖 1[3]。

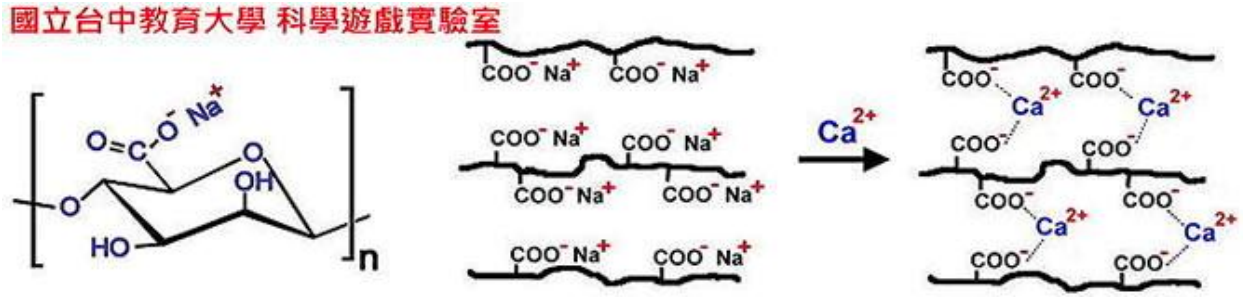


圖 1. 鈣離子取代鈉離子與海藻酸結合

基本球化(basic spherification)(參考圖 2 [4])

把海藻酸鈉水滴倒入乳酸鈣時，鈣離子擴散入水滴中，取代鈉離子位置，由於鈣離子是小粒子，可以穿透最外層的海藻酸鈣薄膜，並在水滴內自由移動，因此即使水球從海藻酸鈉溶液中移走，只要放置一段時間，便會形成一個固體啫喱。

反向球化(Reverse spherification)(參考圖 2 [4])

將乳酸鈣水滴加入海藻酸鈉溶液中，鈣離子與海藻酸在水滴外形成海藻酸鈣薄膜，當移走水球，反應便停止。我們選用反向球化的原理，因為希望製作的水球的能盛載液體而不是啫喱球。

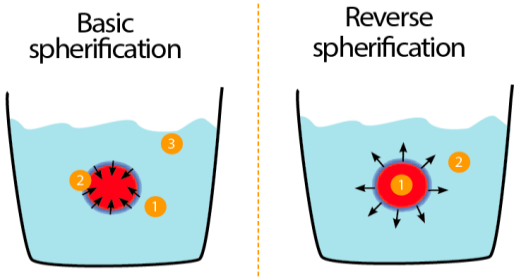


圖 2. 基本球化(左)和反向球化(右)的反應原理

探究目標：製作可吃用水球，並探究在不同環境下水球盛載水的情況

以下是實驗進程

一、探究乳酸鈣和海藻酸鈉化學反應所需時間

二、探究由不同濃度的乳酸鈣製作的水球承重能力

三、探究水球在不同溫度環境下水份流失的情況

四、探究水球放在水中在不同溫度環境下水份流失的情況

實驗前的工序

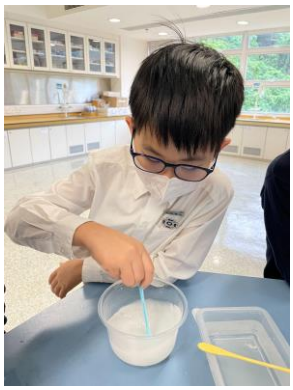
為提升實驗的公平性，我們利用冰模來製作乳酸鈣冰球，一方面盡量確保每個放入海藻酸鈉的冰球體積相同，另一方面的減少人為因素（例如將乳酸鈣的放入海藻酸鈉溶液技巧）的影響水球的製作成果。每個冰球的直徑為 3.2cm, 體積約為 17.2cm^3。

圖 3. 冰模的外觀

圖 4. 冰球的直徑

製作冰球

- 材料及用具：乳酸鈣粉末(圖 5)、水、冰模
- 方法：用水溶解乳酸鈣粉(圖 6)，靜待十五分鐘，待水中的泡泡消失。然後倒入冰模, 放在冰箱一夜。
- 以下是 5 個不同濃度的乳酸鈣冰球[5]：
  水與乳酸鈣粉的比例
  300mL 水 + 3g 乳酸鈣 =1%
  300mL 水 + 6g 乳酸鈣 =2%
  300mL 水 + 9g 乳酸鈣 =3%
  300mL 水 + 12g 乳酸鈣 =4%
  300mL 水+ 15g 乳酸鈣 =5%

	
圖 5. 乳酸鈣粉末	圖 6. 將乳酸鈣粉末溶入水

製作海藻酸鈉溶液

- 材料及用具：海藻酸鈉(圖 7)、水、攪拌器
- 方法：用水溶解海藻酸鈉粉, 用攪拌機混合, 放在雪櫃一夜。
- 濃度：3g 海藻酸鈉粉加入 600g 水 ，即 0.5%海藻酸鈉溶液

圖 7. 海藻酸鈉粉末

製作海藻酸鈣膜包裹着的水球（下稱「水球」）

1. 實驗前一小時從雪櫃取出海藻酸鈉溶液。

2. 從冰模中取出乳酸鈣冰球(圖 8)，把冰球放在海藻酸鈉溶液中，由於冰球浮於液體面，會令冰球上方的接觸不到海藻酸鈉，因此要不斷將液體用小匙撥向冰球上方(圖 9 及圖 10)，冰球溶解時，最外層會形成薄膜，逐漸變成水球。

3. 按各組實驗所定的時間，將水球取出，放入水中，令海藻酸鈉和乳酸鈣反應停止，便完成製作水球。

		
圖 8. 將乳酸鈣冰球將冰模取出來	圖 9. 製作水球的過程(一)	圖 10. 製作水球的過程(二)

一、探究乳酸鈣和海藻酸鈉化學反應所需時間

實驗目的：乳酸鈣冰球浸入海藻酸鈉溶液後，溶解了的乳酸鈣溶液中的鈣離子才能和海藻酸形成薄膜，此實驗希望找出不同濃度的乳酸鈣冰球浸入海藻酸鈉溶液的最適時間

步驟：

1. 根據製作水球的方法，把不同濃度的乳酸鈣冰球放入海藻酸鈉溶液，然後分別於 5 分鐘, 15 分鐘, 30 分鐘, 45 分鐘後把水球取出放在清水中洗淨(圖 11)。
2. 一小時後從水取出水球，量度水球淨重量(圖 12)。
3. 將水球的水擠出, 量度海藻酸鈣外層的大約重量(圖 13), 得出水球盛載水的容量。

圖 11. 水球放在清水中

圖 12. 量度水球的重量

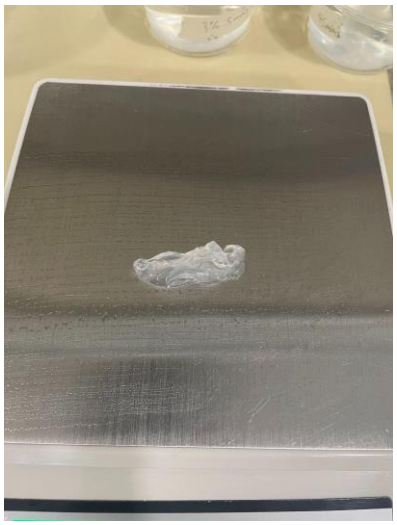


圖 13. 量度水球外層的大約重量

實驗結果：

時間(分鐘)	5	15	30	45
水球淨重量(g)	5.6	11.2	23.2	23
水球外層大約重量(g)	0.9	1.9	3.4	4
水的大約重量(g)	4.7	9.3	19.8	19

表 1. 1%乳酸鈣冰球加入海藻酸鈉溶液

時間(分鐘)	5	15	30	45
水球淨重量(g)	9	17	24	31
水球外層大約重量(g)	0	1	3	10
水的大約重量(g)	9	16	21	21

表 2. 2%乳酸鈣冰球加入海藻酸鈉溶液

時間(分鐘)	5	15	30	45
水球淨重量(g)	4.3	17.3	17.5	19.8
水球外層大約重量(g)	量度淨重量後已爆	0.4	0.6	1.1
水的大約重量(g)	量度淨重量後已爆	12.9	13.1	13.8

表 3. 3%乳酸鈣冰球加入海藻酸鈉溶液

時間(分鐘)	5	15	30	45
水球淨重量(g)	9.1	15.6	19.4	21.3
水球外層大約重量(g)	0.6	0.8	0.9	0.8
水的大約重量(g)	8.5	14.8	18.5	20.5

表 4. 4%乳酸鈣冰球加入海藻酸鈉溶液

時間(分鐘)	5	15	30	45
水球淨重量(g)	11	18	25	27
水球外層大約重量(g)	5	6	5	6
水的大約重量(g)	6	12	20	21

表 5. 5%乳酸鈣冰球加入海藻酸鈉溶液

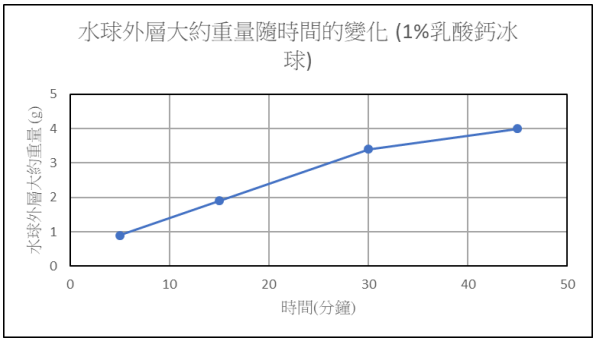


圖 14a. 由 1%乳酸鈣製作的水球的外層重量

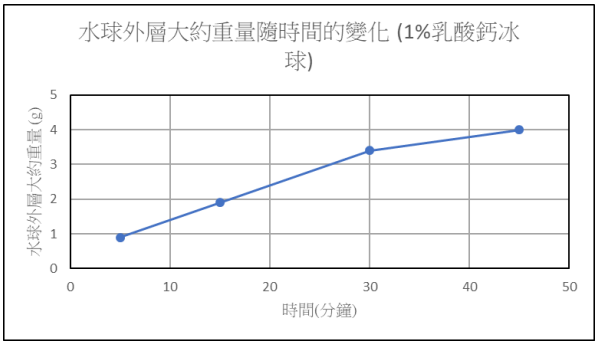


圖 14b. 由 1%乳酸鈣製作的水球盛載的水量

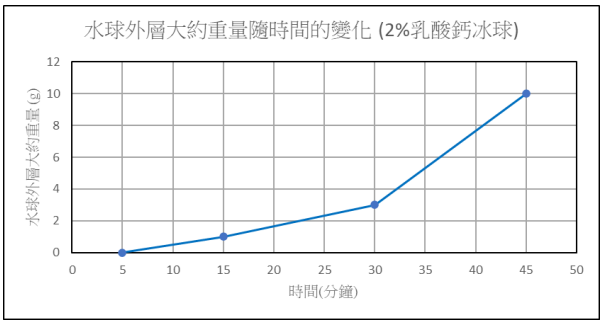


圖 15a. 由 2%乳酸鈣製作的水球的外層重量

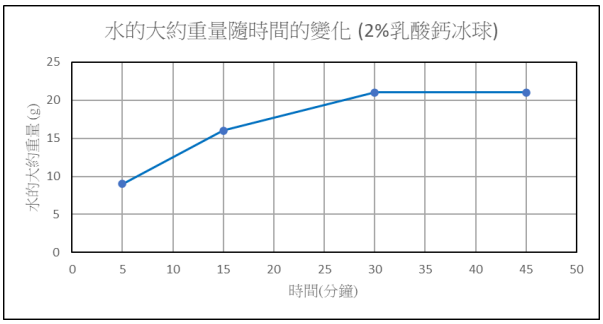


圖 15b. 由 2%乳酸鈣製作的水球盛載的水量

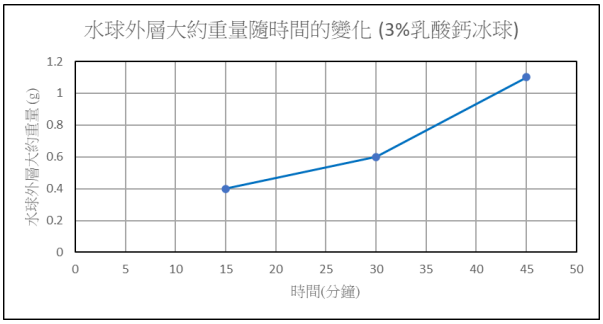


圖 16a.由 3%乳酸鈣製作的水球的外層重量

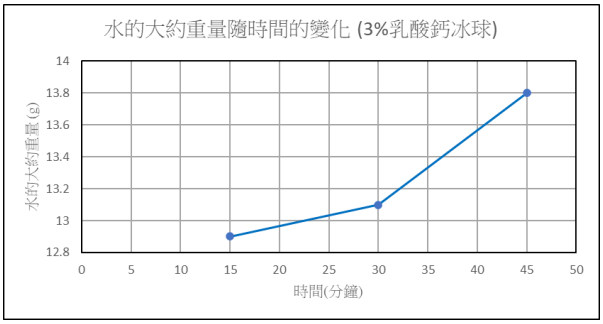


圖 16b. 由 3%乳酸鈣製作的水球盛載的水量

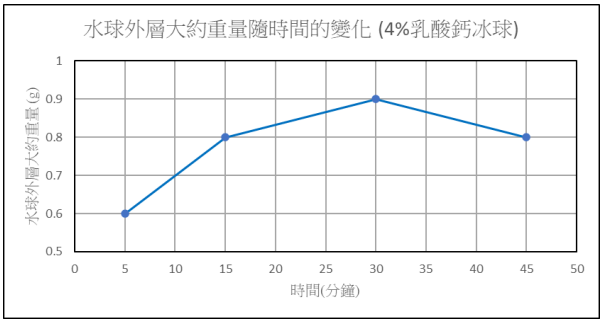


圖 17a. 由 4%乳酸鈣製作的水球的外層重量

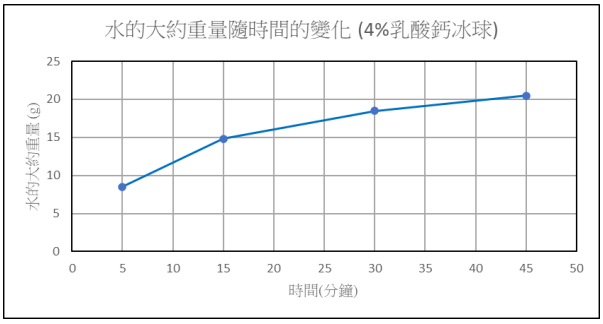


圖 17b. 由 4%乳酸鈣製作的水球盛載的水量

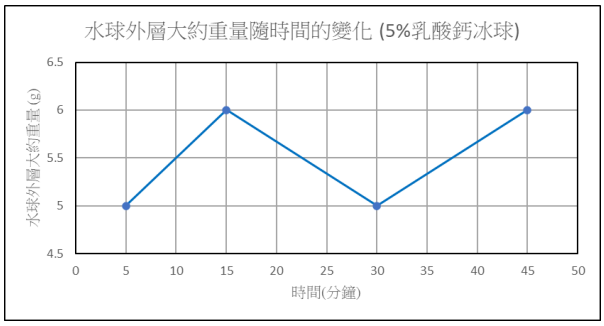


圖 18a. 由 5%乳酸鈣製作的水球的外層重量

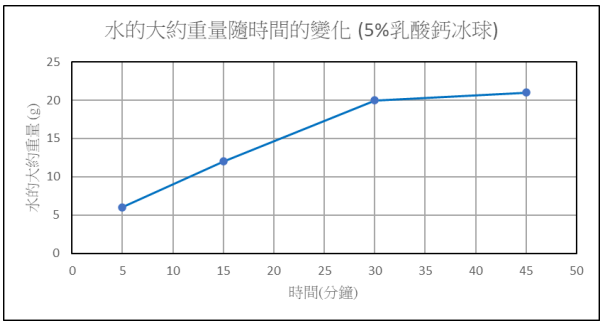


圖 18b. 由 5%乳酸鈣製作的水球盛載的水量

分析：

從圖 14a、15a、16a、17a 及 18a 可見，若水球在 30 分鐘後取出，其水球外層大約重量普遍都比在 5 分鐘或 15 分鐘取出的高。從圖 14b、15b、16b、17b 及 18b 可見，水在水球中的大約重量和浸泡在海藻酸鈉溶液的時間有正相關關係。

而根據實驗結果，乳酸鈣冰球放入海藻酸鈉溶液 5 分鐘和 15 分鐘，取出的水球不完整或較小，至少 30 分鐘後，水球的水量才飽和，即是薄膜形成得較完整，使水不會漏出，冰球放入海藻酸鈉溶液時間超過 45 分鐘，取出的水球會有很多啫喱包圍，這些啫喱結構較鬆散(圖 19），在清水中洗淨後會溶解，不會成為水球的一部分，但卻防礙取出來的過程，因此我們決定 30 分鐘作為最適合的時間。

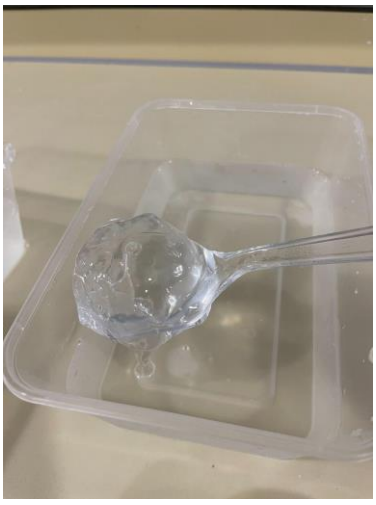


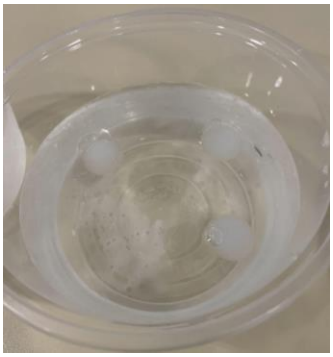
圖 19. 放入海藻酸鈉溶液時間超過 45 分鐘的水球

二、探究不同濃度的乳酸鈣製作的水球承重能力

實驗目的：水球作為供人飲用的器皿，需要具備一定的堅韌程度，不能在製作和搬運過程中輕易破爛，另一方面讓人可以咬破，因此透過承重測試，我們希望找出具一定承重能力，適合製作成水球的乳酸鈣濃度。

步驟：

1. 根據製作水球的方法，把不同濃度的乳酸鈣冰球（各三粒）放入海藻酸鈉溶液（圖 20），於 30 分鐘後把水球取出放在清水中洗淨（圖 21）
2. 一小時後從水取出水球，量度水球淨重量
3. 將水球放進測量用的杯子（圖 22）
4. 將較小的杯放在水球上（圖 23），加入沙直至水球破裂（圖 24），量度沙子連杯的重量，記錄數據，得出水球承受的重量。

<table>
<tr><td>  </td><td>  </td></tr>
<tr><td>圖 20. 相同濃度的冰球放在海藻酸鈉溶液</td><td>圖 21. 30 分鐘後把水球取出</td></tr>
<tr><td>  </td><td>  </td><td>  </td></tr>
<tr><td>圖 22. 把水球放入杯中</td><td>圖 23. 把小杯放入水球之上</td><td>圖 24. 把沙倒入小杯中, 直至水球破裂</td></tr>
</table>

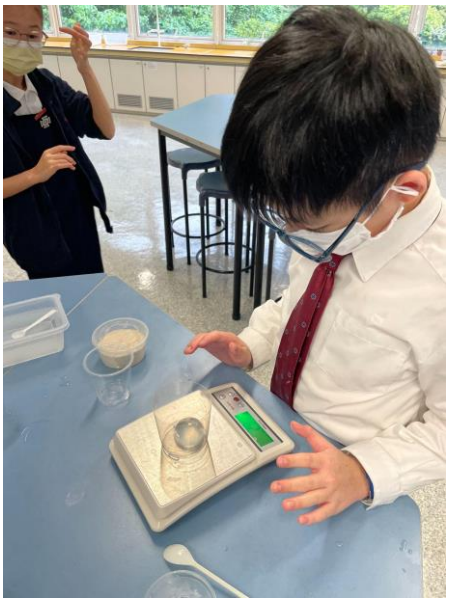


圖 25. 學生進行承重實驗情況（一）

圖 26. 學生進行承重實驗情況（二）

實驗結果：

	第一粒	第二粒	第三粒	平均值
水球淨重量(g)	21.2 	21.7 	20.6 	21.2
所承受重量(g)	126.3 	122.9 	57.7 	102.3
所承受重量和水球淨重量的比(倍)	5.96	5.66	2.80	4.83

表 6. 由 1%乳酸鈣製成的水球的承重測試

	第一粒	第二粒	第三粒	平均值
水球淨重量(g)	10.3（不完整） 	20.9 	21.4 	21.2（只計算第二粒和第三粒）
所承受重量(g)	水球不完整，不進行測試	124.4 	144.3 	134.4（只計算第二粒和第三粒）
所承受重量和水球淨重量的比(倍)	不適用	5.95	6.74	6.34

表 7. 由 2%乳酸鈣製成的水球的承重測試

	第一粒	第二粒	第三粒	平均值
水球淨重量(g)	22.4 	20.3 	20.4 	21.0
所承受重量(g)	108.6 	141.2 	166.1 	138.6
所承受重量和水球淨重量的比(倍)	4.85	6.96	8.14	6.60

表 8. 由 3%乳酸鈣製成的水球的承重測試

	第一粒	第二粒	第三粒	平均值
水球淨重量(g)	21.9 	21.9 	22.2 	22.0
所承受重量(g)	178.3 	143.3 	110.3 	144.0
所承受重量和水球淨重量的比(倍)	8.14	6.54	4.97	6.55

表 9. 由 4%乳酸鈣製成的水球的承重測試

	第一粒	第二粒	第三粒	平均值
水球淨重量(g)	20.5 	21.3 	20.0 	20.6
所承受重量(g)	128.3 	132.8 	141.1 	134.1
所承受重量和水球淨重量的比(倍)	6.26	6.23	7.06	6.51

表 10. 由 5%乳酸鈣製成的水球的承重測試

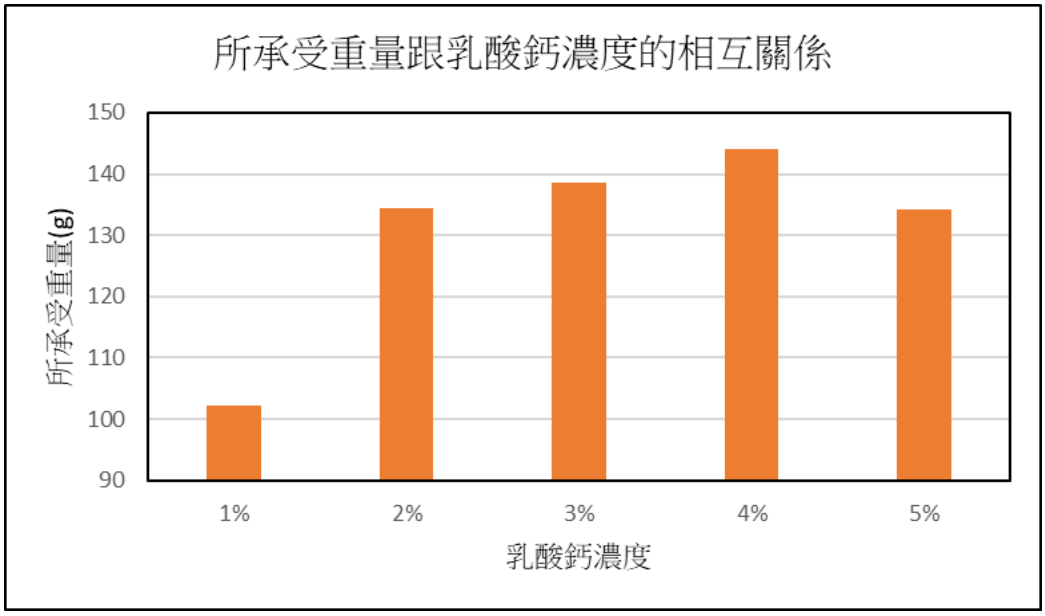


圖 27. 不同濃度的乳酸鈣水球能承受的重量

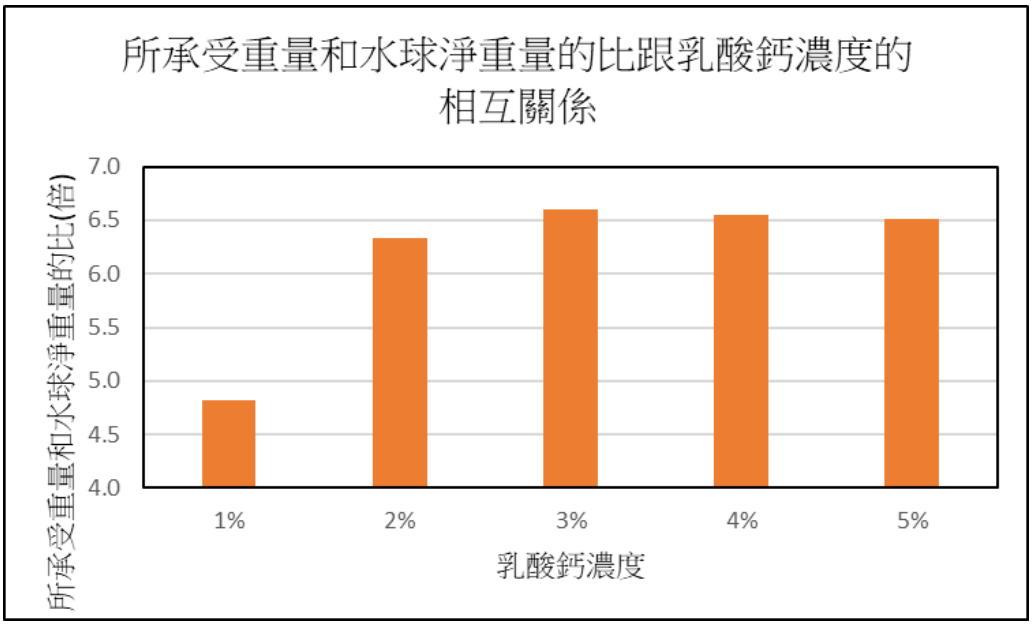


圖 28. 不同濃度的乳酸鈣水球能承受的重量與水球淨重量比

分析：

單以水球能承受多少重量來分析水球的承重能力不夠客觀，因為水球自身的淨重量愈大，它能承受的重量也應該愈多，所以應該運用所承受重量和水球淨重量的比來分析水球的承重能力，以增加公平性。

根據實驗結果及圖 28，1%的乳酸鈣製成的水球所承受的沙子重量較輕，即承重能力較弱，它的承重量僅是其自身淨重量的 4.83 倍，較加入了其他濃度乳酸鈣的水球都低。而

2%或以上濃度的乳酸鈣水球都能承受 130g 以上的重量，也即是承受的重量是自身淨重量 6.34 倍至 6.60 倍，所以我們應專注在 2-5%的濃度。

而 2-5%濃度之間，我們會選擇以 2%繼續進行實驗，因為水球的目的是為運動用補充水，而不是補充鈣質，所以應盡量減少水以外的物質的成份。因此在之後的實驗，我們會測試 2%濃度的乳酸鈣水球。

三、探究水球在不同溫度環境下水份流失的情況

實驗目的：一般的馬拉松比賽歷時約 3 小時，我們希望了解水球放置在不同溫度下 3 小時，水球內水份流失的情況，我們會在室溫（圖 29）和攝氏 40 度（圖 30）環境下的進行測試。

公式: 本報告使用以下公式研究水球內的水份流失情況。

$$\text{水球重量下降率} = \frac{\text{實驗前的水球重量} - \text{儲存在特定環境 3 小時候的水球重量}}{\text{實驗前的水球重量}}$$

		
圖 29. 室溫	圖 30. 調較焗爐溫度，提供攝氏 40 度環境	圖 31. 將水球放在焗爐內進行測試

		第一粒	第二粒	第三粒	平均值
實驗前	水球重量(g)	17.4 	20.1 	16.0 	17.8
1 小時後	水球重量(g)	15.7 	18.1 	14.4 	16.1
2 小時後	水球重量(g)	15.0 	17.0 	13.5 	15.2
3 小時後	水球重量(g)	13.7 	16.2 	12.7 	14.2
	水球重量下降率	21.3%	19.4%	20.6%	20.4%

表 11. 2%乳酸鈣水球放在室溫下 3 小時的重量記錄

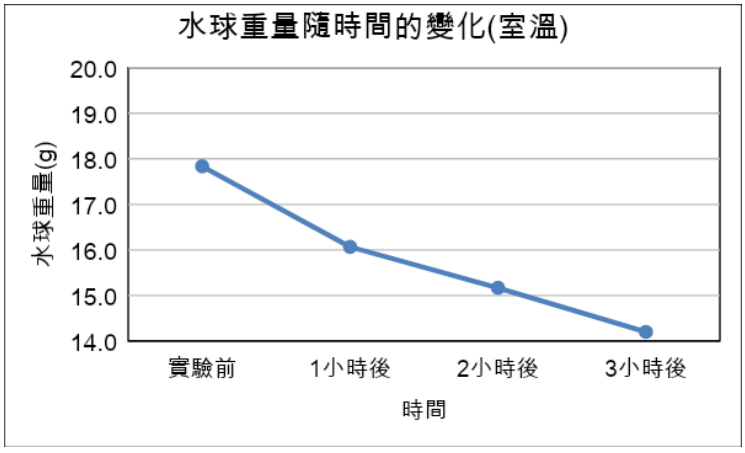


圖 32. 2%乳酸鈣水球放在室溫下 3 小時的重量變化

40 度		第一粒	第二粒	第三粒	平均值
實驗前	水球重量(g)	19.1 	17.5 	19.9 	18.8
1 小時後	水球重量(g)	17.3 	15.7 	17.9 	17.0
2 小時後	水球重量(g)	16.2 	14.6 	16.7 	15.8
3 小時後	水球重量(g)	14.8 	13.6 	15.4 	14.6
	水球重量下降率	22.5%	22.3%	22.6%	22.5%

表 12. 2%乳酸鈣水球放在攝氏 40 度環境下 3 小時的重量記錄

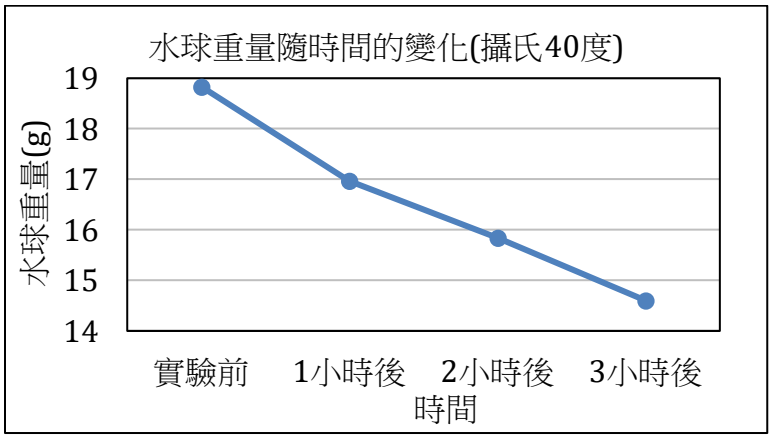


圖 33. 2%乳酸鈣水球放在攝氏 40 度環境下 3 小時的重量變化

結果及分析：

圖 32 及圖 33 展示了水球重量在不同環境下隨時間的變化，兩幅折線圖都展示了向下斜斜的趨勢，可見水球的水份在 3 小時內逐漸流失，下降率超過 20%。

而出現這些趨勢的原因，相信是由於水球的海藻酸鈣薄膜具有滲透性，加上水球內的水壓，令水份會慢慢滲出並蒸發。

四、探究水球放在水中在不同溫度環境下水份流失的情況

目的：承接以上實驗，為了改善水球水份流失的情況，我們嘗試將水球放在水中儲存(圖 34)，希望減少內部水壓令水份流失。實驗同樣是放在室溫(圖 34)及攝氏 40 度環境(圖 35)。

	
圖 34. 水球放在水中儲存(在室溫環境)	圖 35. 水球放在水中儲存(在攝氏 40 度環境)

室溫水中		第一粒	第二粒	第三粒	平均值
實驗前	水球重量(g)	18.7 	17.3 	18.6 	18.2
1 小時後	水球重量(g)	18.3 	17.2 	17.0 	17.5
2 小時後	水球重量(g)	18.0 	17.0 	17.6 	17.5
3 小時後	水球重量(g)	17.9 	16.9 	17.6 	17.5
	水球重量下降率	4.3%	2.3%	5.4%	4.0%

表 13. 放在水中的 2%乳酸鈣水球的在室溫環境下 3 小時的重量變化

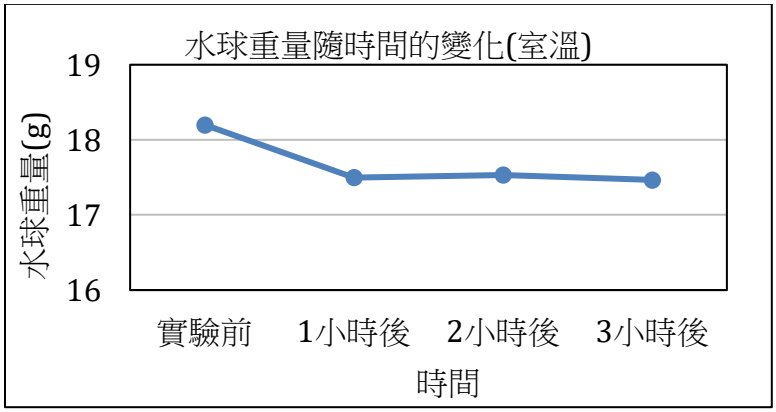


圖 36. 放在水中的 2%乳酸鈣水球放在室溫下 3 小時的重量變化

40 度水		第一粒	第二粒	第三粒	平均值
實驗前	水球重量(g)	18 	18.1 	19.3 	18.5
1 小時後	水球重量(g)	17.2 	17.6 	18.8 	17.9
2 小時後	水球重量(g)	17.1 	17.0 	18.2 	17.4
3 小時後	水球重量(g)	16.2 	16.8 	17.7 	16.9
	水球重量下降率	10.0%	7.2%	8.3%	8.5%

表 14. 放在水中的 2%乳酸鈣水球的在攝氏 40 度環境下 3 小時的重量變化

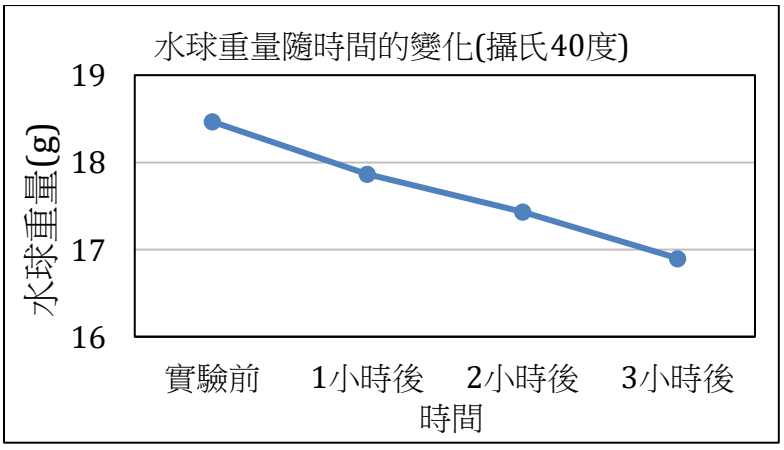


圖 37. 放在水中的 2%乳酸鈣水球放在攝氏 40 度環境下 3 小時的重量變化

結果及分析：

圖 36 及圖 37 展示了放在水中的水球重量在室溫和攝氏 40 度環境下隨時間的變化，兩幅折線圖都展示了向下斜斜的趨勢，可見水球的水份在 3 小時內逐漸流失，下降率分別為 4%及 8.5%。

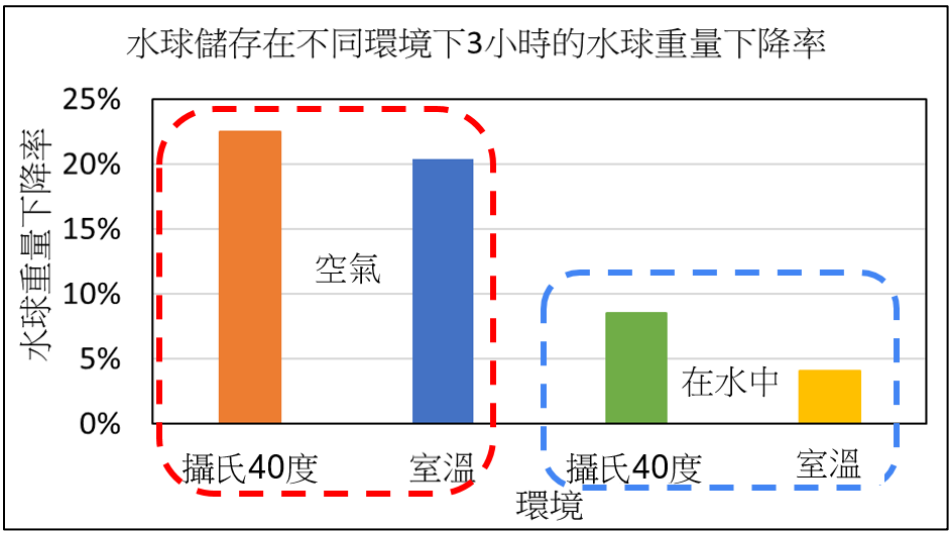


圖 38. 水球儲存在不同環境下 3 小時的水球重量下降率

以上棒形圖綜合了第三及四部分的實驗結果，展示了水球儲存在不同環境下的水球重量下降率，四條棒的高度不一(由 4%至 22.5%不等)。右方的兩條棒(水球儲存在水中)較左方的兩條棒(水球非儲存在水中)矮，代表水球儲存在水中能有效減少水球的水份流失。同時，溫度也是影響水份流失的關鍵。左一的棒和右二的棒分別比左二和右一的棒高，代表溫度愈高，水球的水份流失得愈快。

總結：

1. 乳酸鈣冰球放入海藻酸鈉溶液 30 分鐘後取出能得到最理想的水球。

2. 2-5%濃度的乳酸鈣水球的承重能力較好；製作水球應盡量減少水以外的物質的成份，因此我們選定 2%濃度的乳酸鈣水球。

3. 水球的水份會隨時間流失，三小時後放在室溫和攝氏 40 度環境下水份流失約 20.4%及 22.5%。

4. 將水球放在水中儲存，三小時後放在室溫和攝氏 40 度環境下水份流失約 4%及 8.5%。

5. 溫度越高，水份流失越快。

建議：

要製成可吃用的水球的方法是將 2%的乳酸鈣冰球加入 0.5%海藻酸鈉溶液中，待 30 分鐘後取出，然後放在水中儲存，能有效地減少水份流失。

限制：

儘管利用冰模製作冰球，希望令每個水球的大小盡量一致，但由於過程中涉及不少人手操作的部份，例如向浮於海藻酸鈉溶液的冰球上方潑溶液、從溶液中取出水球過程等，令水球的大小和外層的均勻程度難以一致。因此我們第二三四個探究實驗中都會以三粒水球來測試，取其平均值以減少產生數據偏差。

由於實驗用具和環境並不適合製作食物，我們並沒有真正嚐過水球的味道，只能憑嗅覺及網上的說法推測其味道，因此不能對水球的味道作評價。

這次探究主要是了解水球的濃度比例及儲存方法，並沒有慮實際環境下如何製作和放置，若真的要取代塑膠或紙杯，相信還要在衞生和食物安全的角度考慮。

延伸：

我們希望將來進一步測試以不同液體代替水進行實驗，例如能量飲品、牛奶等。此外，這次實驗只以直徑 3.2cm 的冰模製作水球，我們希望將來利用更大的冰模製作更大容量的冰球，了解製作水球的大小上限。

參考資料

1. 乳酸鈣的用途參自 https://health.ltn.com.tw/article/breakingnews/3343093
2. 海藻酸鈉的用途參自 http://scigame.ntcu.edu.tw/chemistry/chemistry-019.html
3. 乳酸鈣和海藻酸鈉的反應的說明圖取自 http://scigame.ntcu.edu.tw/chemistry/chemistry-019.html
4. 基本球化和反向球化的說明圖取自 https://www.facebook.com/HowItWorksMagazine/photos/the-science-behind-bubble-teato-add-an-explosion-of-flavour-to-a-dish-or-cocktai/10156555916781044/
5. 乳酸鈣和海藻酸鈉濃度比例參自 https://www.chefsteps.com/activities/reverse-spherification

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現實難題主題: 香港的海洋污染

題目 : 廚餘廢油皂，環保又易做

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目錄

一、簡介

垃圾徵費將於今年推出，很多屋苑的配套不足，只有少量屋苑設有廚餘機，回收廚餘一直都是難題。近年，因為疫情的影響，我們在家煮食的機會增加了。我們發現廚餘和煮食後的廢油都不容易處理，不少人更會將廢油與廚餘一起丟棄。我們希望可以找到解決方法，有效運用廚餘，減少浪費。

一般家用洗潔精是一種含有表面活性劑的清潔劑，它可以將油脂和污垢從表面去除。但是，當洗潔精被排放到海水時，它可能對海洋環境造成負面影響。

一方面，洗潔精可能會對水生生物造成毒性影響。洗潔精中的表面活性劑可以破壞水中生物的細胞膜，導致它們死亡。此外，洗潔精可能含有其他有害物質，如磷酸鹽和氯，這些物質也可能對海洋生物產生毒性影響。

另一方面，洗潔精可能會對海洋生態系統造成影響。洗潔精中的表面活性劑可以降低水的表面張力，使得水中的氧氣和其他物質更容易被溶解和吸收。這可能會導致水中的氧氣含量下降，嚴重時會形成紅潮，令水中生物大量死亡，長遠或會影響食物鏈。

當我們在網上搜尋資料時，我們發現可以利用廢油制作手工皂，它可以被生物分解，能夠替代化學清潔劑，減低對海洋的污染。有些組員分享，與家人在茶樓飲茶，幫忙清洗用具時，察覺到茶有去油的感覺，就萌生想法，嘗試加入不同廚餘在肥皂中，例如茶葉、果皮、咖啡渣等，觀察會否增加肥皂的清潔能力和親膚能力。

我們想探討利用廢油和廚餘制作的肥皂，它們的清潔能力和親膚能力。希望可以把「廢油再皂」，廚餘物盡其用，讓大家都可以善用資源，為環保出一分力。

二、科學原理

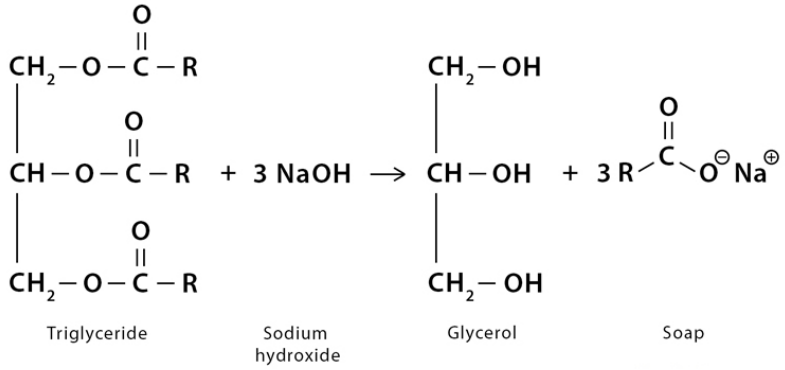
肥皂的清潔原理

肥皂的分子中含有兩種不同的部分：親水性和疏水性。親水性的部分會溶於水，而疏水性的部分則會吸附油脂。

當肥皂水與衣物上的污垢或油脂接觸時，肥皂分子會包圍它們，形成一個稱為「乳化劑」的混合物，使油污與衣服分開。這個混合物可以讓油脂和污垢分散在水中，進而被清洗掉。

皂化反應 (Saponification)

肥皂是由油分、鹼（比如氫氧化鈉）和水混合製成的。這種過程叫做皂化反應。油分當中存有三酸甘油脂 (Triglyceride)，它由一個甘油分子 (Glycerol) 及三個脂肪酸分子 (Fatty Acid) 組成。而這些脂肪酸會和鹼發生化學反應，分別成為甘油及肥皂。



圖片1：皂化反應的化學方程式

脂肪酸的種類對清潔力和肥皂硬度的影響

脂肪酸是組成油的成分，分為飽和脂肪酸與不飽和脂肪酸。每一種油脂中的脂肪酸種類和比例都不一樣。這些差異會影響肥皂的清潔力和硬度。

- 飽和脂肪酸，常溫下為固體。油中所佔的比例越多，手工皂的清潔能力和堅硬程度較高。
- 不飽和脂肪酸，常溫下為液體，能滋養肌膚。油中所佔的比例越多，手工皂的清潔能力和堅硬程度較低。

	飽和脂肪酸	不飽和脂肪酸

花生油	18%	82%
粟米油	14%	86%
芥花籽油	8%	92%

表格1：常用食用油的飽和脂肪酸比例

皂化值

表示在特定條件下，1克油脂形成皂化所需的氫氧化鈉克數。

	皂化值 (NaOH)
花生油	0.137
粟米油	0.136
芥花籽油	0.133

表格2：常用食用油的皂化值(NaOH)

三、探究目的

探究以常用煮食油和廚餘制作而成肥皂的清潔能力和特性。

1. 利用不同的煮食油 (花生油、粟米油和芥花籽油)，加入廚餘 (橙皮、蕉皮、咖啡渣和蛋殼) 制成環保肥皂。
2. 測試環保肥皂的清潔能力、硬度、pH值。
3. 探究利用廢油和廚餘制作肥皂的可能性。

四、假設

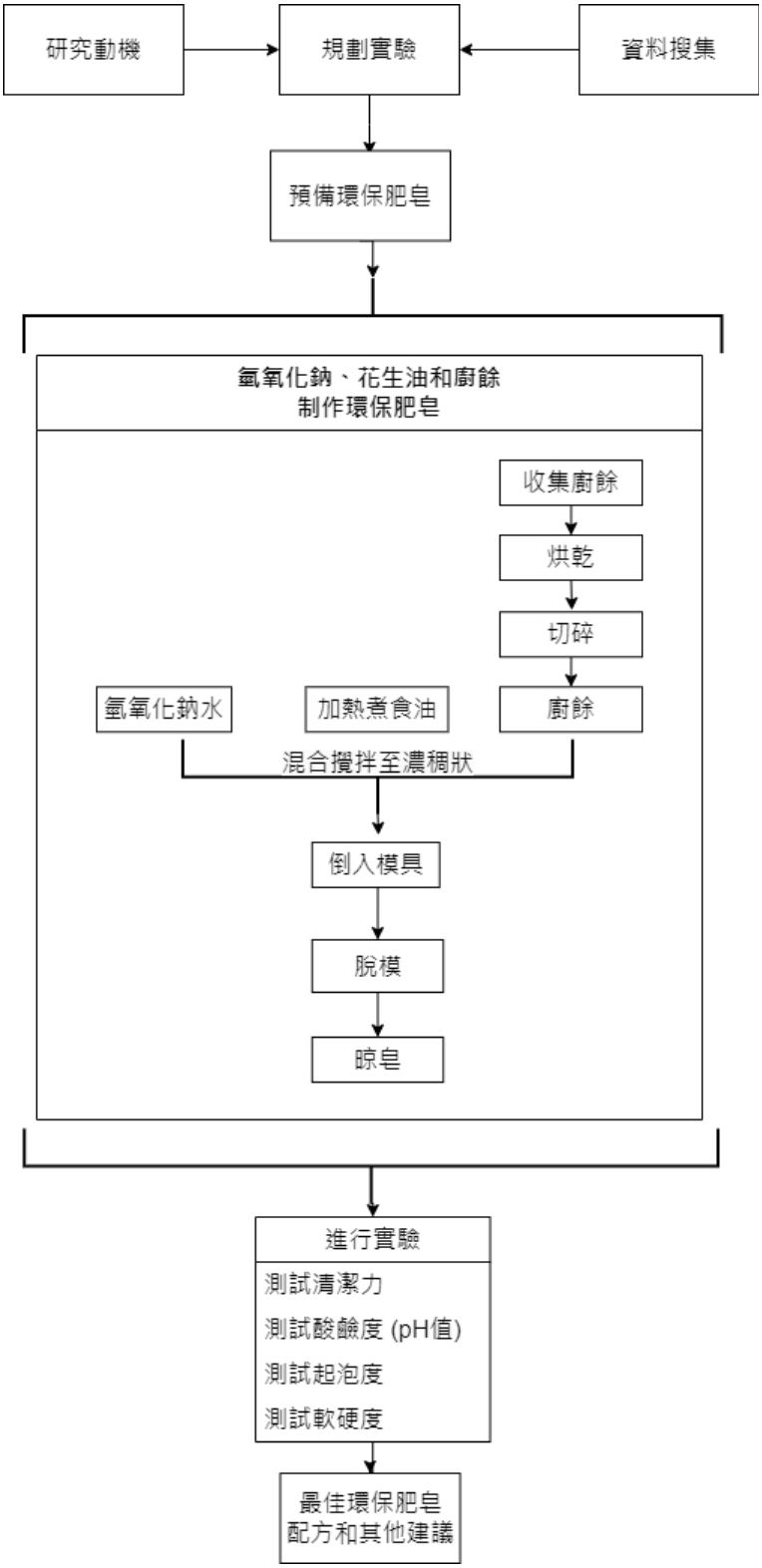
- 利用廚餘和廢油而制成的肥皂，比起市面上的肥皂，清潔力更佳。因為有些廚餘(如：茶葉和果皮) 本來也能用作清潔劑，所以估計加入廚餘後，可以加強清潔力。
- 加入廚餘的肥皂，能有助肥皂成形。部份廚餘的酸鹼度(pH值)偏酸，能減低製成後肥皂的pH值，能縮短晾皂的時間和減低對皮膚的傷害。

五、實驗材料及用具

實驗材料			實驗用具			
玉米油	橙皮	茄汁	燒杯	玻璃棒	化妝棉	焗爐
花生油	茶葉	豉油	量筒	電動攪伴器	風筒	剪刀
芥花籽油	蕉皮	辣椒油	滴管	食品温度計	各式模具	實驗鐵架台
氫氧化鈉	蛋殼	咖啡	直尺	pH值檢測計	電磁爐	砝碼
水	咖啡渣		透明方格片	電子秤	煮食鍋	萬字夾
			小膠箱			

表格3：實驗材料和用具

六、研究過程及方法



圖片2：研究架構流程圖

七、實驗設計及步驟

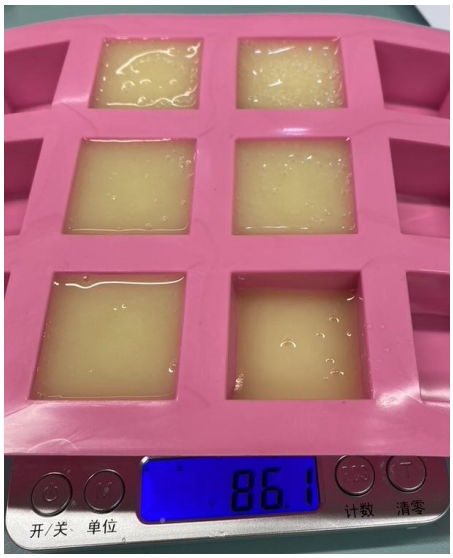
製作廢物油肥皂步驟

（一）準備廢油

了解廚房中最常用來油炸食物的三種油品後，分別購買三種未經使用的芥花籽油、玉米油及花生油作測試。我們先將油加熱10分鐘，再冷卻至45° C，以製成廢油。

（二）製作廢油肥皂

1. 查詢皂化價：上網查詢皂化價，得知三種廢油皂化價相近，在0.133 - 0.137之間。
2. 製作鹼水：在玻璃瓶中放13 - 14ml 的自來水，再倒入6 - 7g的氫氧化鈉，在玻璃杯裏攪拌這兩種物質，製成氫氧化鈉水溶液（鹼水）。
3. 加熱油脂：將50g 油脂加熱，使溫度上升至45℃。
4. 混合鹼水與油脂：將鹼水加入油脂裡。
5. 攪拌至濃稠狀：直到皂液變得像美奶滋般濃稠，攪拌器劃過表面會留下明顯的痕跡為止。
6. 入模：將濃稠狀的皂液倒入模具中。
7. 脫模：等待皂液凝固、變硬後，即可將肥皂由皂模中取出。
8. 揮發：將肥皂放在通風陰涼處，等待揮發，降低pH值，約一星期後，自製肥皂即完成。



選取花生油製作廢油肥皂

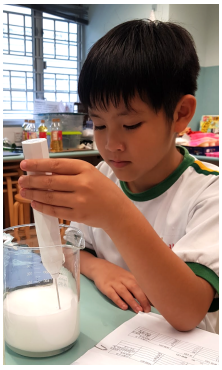
我們分別利用了花生油、粟米油和芥花籽油來製作廢油肥皂，發現花生油皂的成形及脫模時間時間只需一天，粟米油皂的成形及脫模時間時間需要三天，芥花籽油則難以成形，甚至放了幾天後表面形成了一層液體油脂，所以最後我們決定使用花生油製作廢油肥皂。

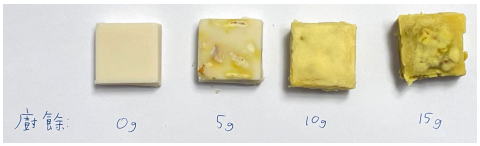
其次，雖然我們希望利用最低濃度的氫氧化鈉溶液來製作肥皂，但發現濃度低於50%的廚餘廢油肥皂硬度不足，因為在加入廚餘後，肥皂的成形速度變得更慢，硬度及堅固度亦有所影響，所以我們最後得出以下的廚餘花生油皂配方：以50g的花生油來計算，所需的氫氧化鈉＝50g x 0.137＝6.85g，加入6.85g ÷ 50%＝13.7g的水，最後分別加入5g、10g、15g的廚餘。　我們揀選了幾種常見廚餘：橙皮、蛋殼、蕉皮、咖啡渣及茶葉，希望能測試各款廚餘廢油肥皂的性能。

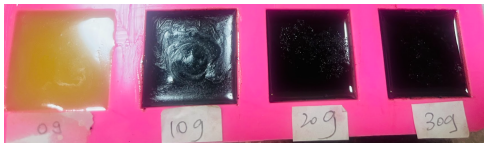
花生油 (g)	氫氧化鈉 (g)	水 (g)	廚餘 (g)
50	6.85	13.7	0
50	6.85	13.7	5
50	6.85	13.7	10
50	6.85	13.7	15

表格4: 廚餘花生油皂配方







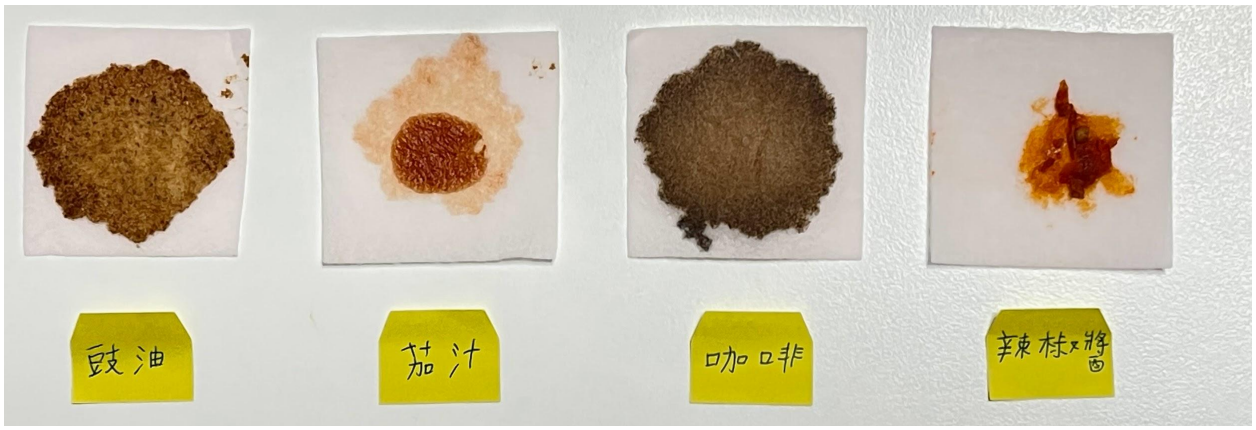
I. 測試清潔能力

實驗步驟:

1. 將 0.1g 肥皂 + 50ml 自來水，完全攪伴溶化，製成肥皂水。
2. 在5cm x 5cm的化妝棉的中央，滴上1ml的污漬。
3. 把染有污漬的化妝棉徹底烘乾。
4. 把染有污漬的化妝棉，放入準備好的肥皂水中。
5. 浸泡 5分鐘後，觀察污漬的變化。

圖片3：不同的食物污漬

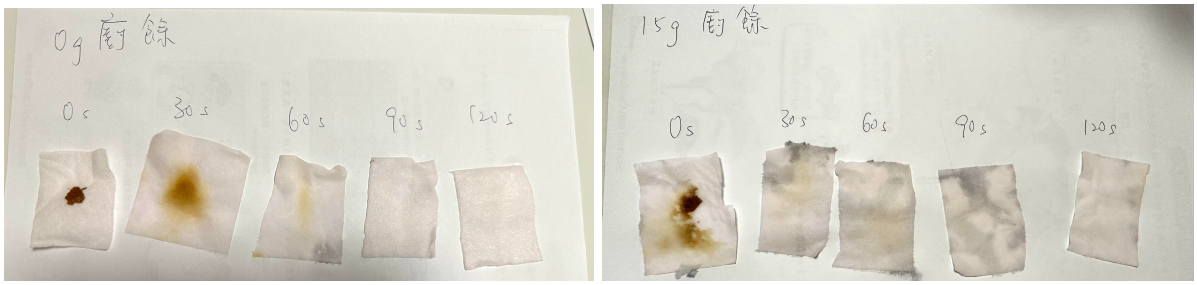
我們選擇了四種顏色較明顯的食物污漬來進行測試，分別是豉油、茄汁、咖啡、辣椒油。



圖片4：未浸泡前的污漬

其他測試清潔能力的方法:在肥皂水內攪拌

在實驗的途中，我們也曾經嘗試使用攪拌30秒的方式來測試廚餘廢油肥皂的清潔能力，可是經過30秒攪拌後，污漬都能完全消失，難以分辨明顯差異，所以我們決定用浸泡形式來做測試。



圖片5：在0g及15g蛋殼花生油皂水內攪拌30秒後的污漬

II. 測試酸鹼度(pH值)

透過測試pH值，檢驗廢油肥皂的安全性和親膚能力。如果pH值低於10，便是安全使用的肥皂。

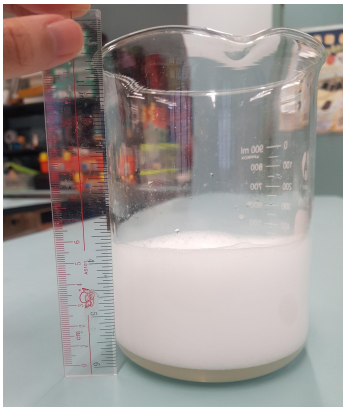
實驗步驟：

1. 利用0.1g 的肥皂與100ml 水混合。
2. 用電動攪拌器攪拌肥皂與水，直至肥皂溶於水中，製成泡泡水。
3. 將pH值檢測計放入泡泡水裏，測試泡泡水pH值。

III. 測試起泡度

實驗步驟:

1. 利用0.1g 的肥皂與100ml水混合。
2. 用電動攪拌器攪拌肥皂與水，製成泡泡水。
3. 利用直尺量度起泡高度，量度的高度，便是起泡度。

IV. 測試肥皂硬度

實驗步驟：

1. 彎曲曲別針的一端，然後將另一端貼在一個小膠箱的底部，作為測量肥皂硬度的儀器。
2. 加入5g　的水進膠箱裏，將曲別針的針對着肥皂，放開膠箱，10秒之後，看看曲別針能否插進肥皂的底部，如果不能，不斷重複以上步驟直至成功。(當水的重量比50g重時，便可改用一個砝碼)
3. 放開膠箱時，要輕微托着它，讓它保持平衡，也不要出力，讓它只靠膠箱、水及/或砝碼的重量插入肥皂。
4. 計算水及砝碼的總重量後，加上膠箱的重量，以得到肥皂能承受的重量，即其硬度。

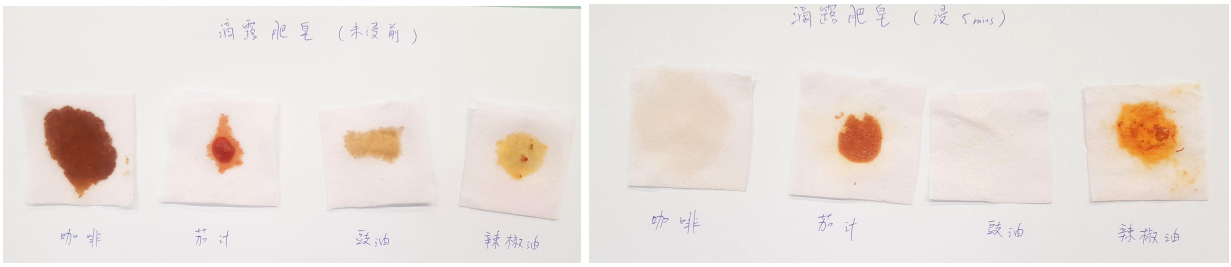


八、實驗結果及討論

I. 清潔力測試結果

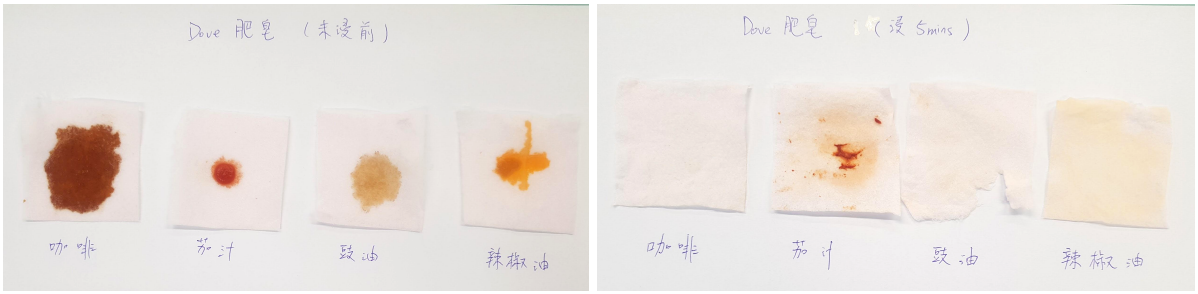
實驗結果：

1. 滴露肥皂，浸泡 5分鐘。



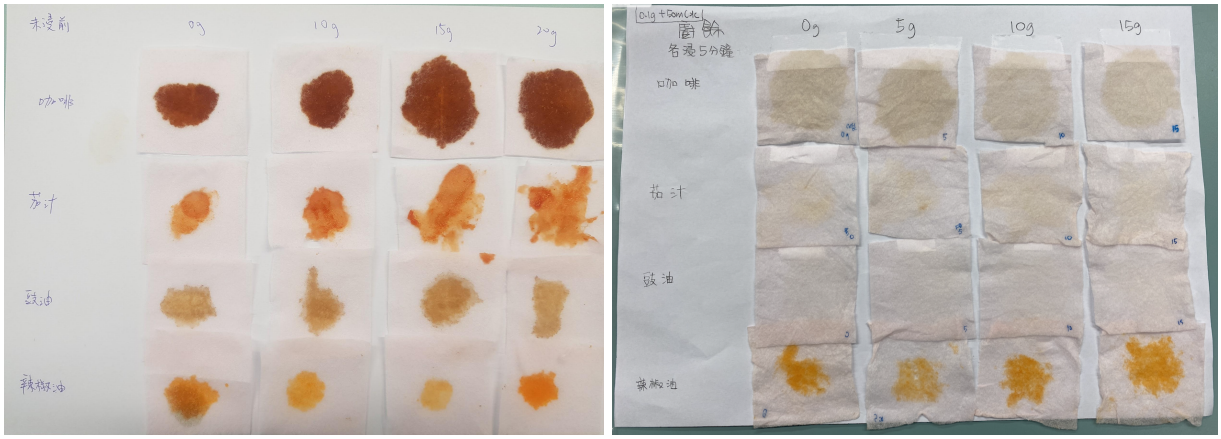
圖片6：不同污漬浸泡在滴露肥皂水五分鐘後的結果

2. Dove肥皂，浸泡 5分鐘。



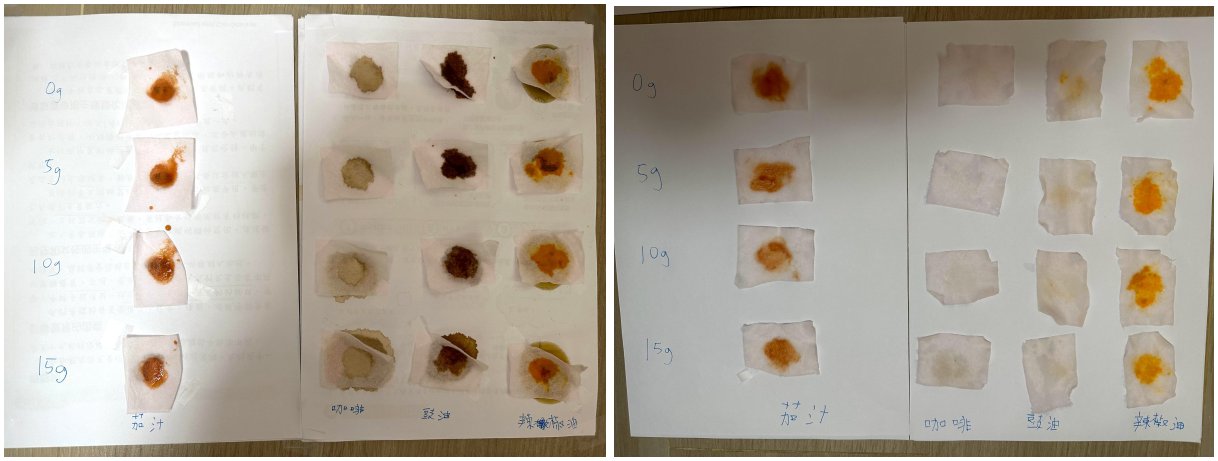
圖片7：不同污漬浸泡在Dove肥皂水五分鐘後的結果

3. 橙皮+廢油肥皂，浸泡 5分鐘。



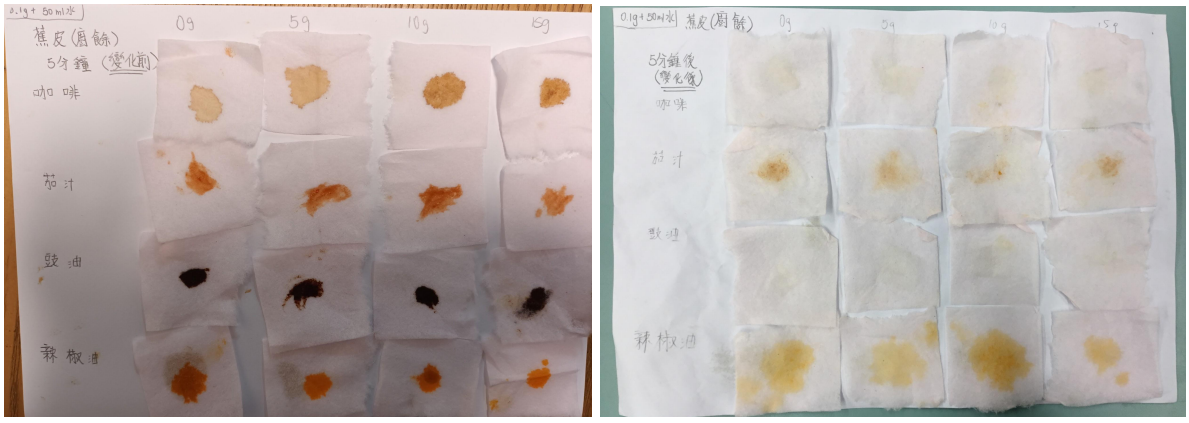
圖片8：不同污漬浸泡在橙皮+廢油肥皂水五分鐘後的結果

4. 蛋殼+廢油肥皂，浸泡 5分鐘。



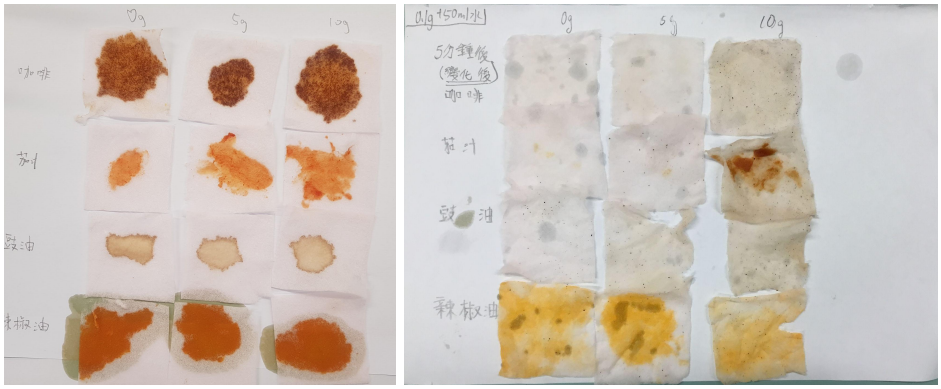
圖片9：不同污漬浸泡在蛋殼+廢油肥皂水五分鐘後的結果

5. 蕉皮+廢油肥皂，浸泡 5分鐘。



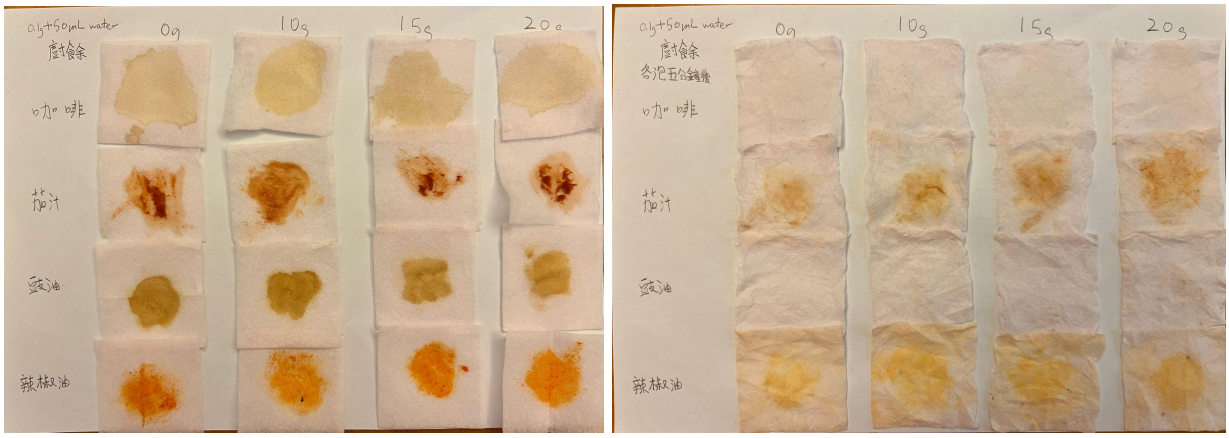
圖片10：不同污漬浸泡在蕉皮+廢油肥皂水五分鐘後的結果

6. 咖啡渣+廢油肥皂，浸泡 5分鐘。



圖片11：不同污漬浸泡在咖啡渣+廢油肥皂水五分鐘後的結果

7. 茶葉+廢油肥皂，浸泡 5分鐘。



圖片12：不同污漬浸泡在茶葉+廢油肥皂水五分鐘後的結果

清潔力比較結果

評分準則：
完全清潔污漬 - 3分;大量清潔污漬 - 2分;少量清潔污漬 - 1分;不能清潔污漬 - 0分。
(選擇清潔力最高的一組廚餘肥皂，作為該廚餘的代表)

污漬類型	滴露	Dove	橙皮10g	蕉皮15g	蛋殼10g	茶葉15g	咖啡渣5g
咖啡	2	3	1	3	3	3	3
茄汁	0	1	2	1	1	1	3
豉油	3	3	3	3	2	3	3
辣椒油	0	2	1	2	1	1	1

表格5：比較各種肥皂的清潔能力

	滴露	Dove	橙皮10g	蕉皮15g	蛋殼10g	茶葉15g	咖啡渣5g
綜合清潔能力	5	9	7	9	7	8	10

表格6：比較各種肥皂的綜合清潔能力

根據圖表結果顯示，5g咖啡渣廢油肥皂 (油:咖啡渣的比例是10:1)的綜合清潔能力最高。它在浸泡測試中，都能完全清潔咖啡、茄汁和豉油污漬。它只能少量清潔辣椒油的污漬，跟其他肥皂清潔效能相若。整體而言，比起部份市面上的肥皂(滴露和Dove)和其他廚餘廢油肥皂，5g咖啡渣廢油肥皂的清潔效力最佳。

II. 酸鹼度測試結果

肥皂種類	傳統肥皂pH值
滴露肥皂	8.93
Dove肥皂	7.98

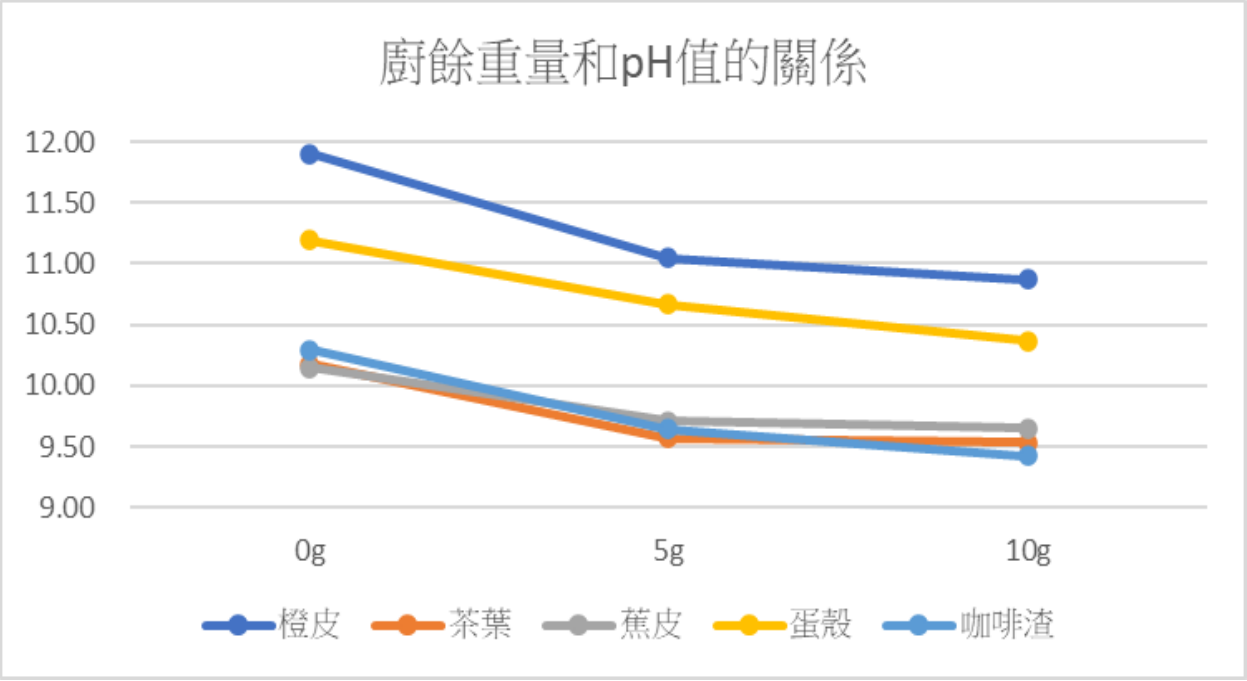
表格7：傳統肥皂pH值

	廢油肥皂pH值		
肥皂種類	0g廚餘	5g廚餘	10g廚餘
橙皮廢油肥皂	11.90	11.05	10.87
茶葉廢油肥皂	10.18	9.57	9.53
蕉皮廢油肥皂	10.15	9.71	9.65
蛋殼廢油肥皂	11.19	10.67	10.37
咖啡渣廢油肥皂	10.29	9.64	9.42

表格8：各廢油肥皂pH值

	pH值變化百份比%	
肥皂種類	5g	10g
橙皮廢油肥皂	7.14	8.66
茶葉廢油肥皂	5.99	6.39
蕉皮廢油肥皂	4.33	4.93
蛋殼廢油肥皂	4.65	7.33
咖啡渣廢油肥皂	6.32	8.45

表格9：各廢油肥皂pH值變化百份比



圖片13：廚餘重量和pH值關係折線圖

我們測試了不同的廚餘廢油肥皂，發現原來普遍加了廚餘的肥皂的pH值是會降低的。根據折線圖顯示，加入的廚餘越多，對應的pH值越低。這樣可以加快肥皂揮發時間，更快可以使用。

用蕉皮所製的肥皂，pH值的變化最小，只減少4%的肥皂pH值，即蕉皮需要較長時間才可以降低肥皂的pH值。用橙皮所制的肥皂，pH值的變化最大，最有效減低肥皂的pH值，可以在短時間內降低肥皂的pH值，使肥皂可以更快使用。

pH值越接近4.5-6.0的肥皂，會較親膚，對皮膚損害越少。如果初生嬰兒使用的話，會建議用橙皮做的肥皂，因為嬰兒不能接受太高pH值的產品，會傷害皮膚。

III. 起泡度測試結果

	最高起泡高度(cm)		
種類	0g 廚餘	5g 廚餘	10g 廚餘
橙皮+廢油肥皂	5.9	5.2	5.2
茶葉+廢油肥皂	4.9	6.8	6.9
蕉皮+廢油肥皂	9.5	6.0	5.7
蛋殼+廢油肥皂	7.0	6.4	4.8
咖啡渣+廢油肥皂	4.6	5.0	7.6
滴露肥皂	4.1		
Dove 肥皂	8.6		

表格10：各肥皂的最高起泡度

我們測試了廢油肥皂加上不同的廚餘做成的肥皂的起泡度，發現加入了橙皮、蕉皮和蛋殼的肥皂，加入的廚餘越多，起泡度越低。而加入了茶葉和咖啡渣的肥皂，剛好相反，加入的廚餘越多，起泡度越高。

各測試肥皂的起泡度中，Dove肥皂起泡度最高。而廚餘廢油肥皂中，咖啡渣10g的廢油肥皂(油和咖啡渣的比例是 5 : 1)起泡度最高。

IV. 硬度測試結果

肥皂種類	水及/或砝碼重量 (g)	肥皂能承受的重量[註1] (g)
滴露	720	755
Dove	660	695
花生油 及 橙皮 5g	25	60
花生油 及 橙皮 10g	10	45
花生油 及 橙皮 15g	5	40
花生油 及 蕉皮 5g	10	45
花生油 及 蕉皮 10g	0	35 註2
花生油 及 蕉皮 15g	0	35 註2
花生油 及 雞蛋殼 5g	60	95
花生油 及 雞蛋殼 10g	125	150
花生油 及 雞蛋殼 15g	620	655
花生油 及 茶葉 5g	5	40
花生油 及 茶葉 10g	0	35 註3
花生油 及 茶葉 15g	0	35 註3
花生油 及 咖啡渣 5g	0	35 註4
花生油 及 咖啡渣 10g	0	35 註4
花生油 及 咖啡渣 15g	0	35 註4

表格11：各肥皂的承受重量

註

1、 即當膠箱(重量約35 g)、水及/或砝碼的重量，能讓曲別針成功插進肥皂的底部

2、 蕉皮10g製成的肥皂與蕉皮15g製成的肥皂所承受的重量一樣，但蕉皮10g製成的肥皂比蕉皮15g做的肥皂需要較多時間插進底部，因此蕉皮10g比較堅硬

3、 茶葉10g製成的肥皂與茶葉15g製成的肥皂所承受的重量一樣，但茶葉10g製成的肥皂比茶葉15g做的肥皂需要較多時間插進底部，因此茶葉10g比較堅硬

4、 咖啡渣5g、10g、15g製成的肥皂所承受的重量一樣，但咖啡渣5g、10g、15g做的肥皂需要越多時間插進底部，因此咖啡渣5g、10g、15g的硬度逐漸下降

我們測試了廢油肥皂加上不同的廚餘做成的肥皂的硬度，發現加入越多橙皮、蕉皮、茶葉、咖啡渣會使肥皂的成型及硬度減弱，與我們一開始的假設有所不同。加入了雞蛋殼的肥皂，硬度有明顯提升，可是硬度及堅固度亦不及傳統肥皂。我們發現加入太多雞蛋殼會使肥皂變得易碎。

九、應用及建議

1. 給皮膚易敏感人士、嬰兒使用: 橙皮廢油肥皂

傳統手工肥皂最少需要晾曬及揮發一個月後，等待酸鹼值低於10才可安全使用，但加入了橙皮便能有效幫助降低肥皂的酸鹼值，而且大大縮短自製肥皂的等待可使用時間。

2. 清潔食物污漬（餐廳或家居洗碗、清洗衣服）: 咖啡渣廢油肥皂

一般家用清潔劑、洗衣粉的酸鹼值都很高，除了容易會有殘留物在碗碟及衣服上，環境亦有一定傷害，咖啡渣廢油肥皂使用環保材料做成，其清潔力甚至高於一般市面售賣的肥皂，適合餐廳及家庭主婦進行清潔時使用。

3. 可投入大量生產: 蛋殼廢油肥皂

加入雞蛋殼的廢油肥皂，硬度和堅固度在所有廚餘廢油肥皂當中最高，而且長時間擺放亦沒有出現任何發霉現象。而且我們曾經在攪拌清潔測試當中，發現經過攪拌30秒後，所有污漬都完全消失，雞蛋殼的細碎加強摩擦，幫助拭擦污漬。

4. 製作廚餘廢油肥皂水

由於加入廚餘會令肥皂的硬度及堅固度降低，而某些廚餘廢油肥皂的酸鹼值即使晾曬及揮發了一個星期，其酸鹼值依然高於10，我們建議可以加入多一些水，打碎高酸鹼值的廢油肥皂，製作成廚餘廢油肥皂水。在未來甚至可以研究這些廚餘廢油肥皂水，會否像環保酵素一樣，隨著時間提供其清潔能力。

5. 廚餘廢油肥皂配方

經過反覆的失敗及試驗，我們推薦製作廚餘廢油肥皂的配方如下，因應廢油的分量，可以使用大約0.135倍的氫氧化鈉、0.27倍的水、0.2 倍的廚餘。

十、限制及改善

我們進行實驗過程當中，有很多限制，這些限制可能會影響我們的實驗結果，例如：

一、制定公平測試的限制

- 環境因素：由於我們需要進行很多實驗，必定要涉及分工合作。因此我們各組員也要分別在家中進行部分實驗，但我們各組員家的溫度、濕度、位置等外在因素都不一樣，所以制成之肥皂的硬度、用來測試之污積頑固度也不同。
- 製作肥皂材料份量誤差：當我們用電動奶泡器攪拌材料混合物時，有機會材料濺出，造成材料份量的誤差。
- 製作污漬限制：化妝棉吸收污漬會影響肥皂清潔效能，例如化妝棉對油分污漬吸收力較弱，故污漬比較置於化妝棉表面。另一方面，污漬擺放時間不一致，也會影響清潔難易程度。
- 打泡程度誤差：各人放置電動攪拌器放在水中的位置不同、觀察角度、相隔測量起泡度的時間長短不一、估算程度不同，使測試肥皂的起泡度一樣。
- 測量誤差：
    - 量度肥皂份量的誤差：我們只需0.1g之廚餘肥皂的材料，制作泡泡水，但由於我們的電子秤限制，所量度的份量會有誤差。
    - 測量油溫誤差：各組員量度熱油作肥皂的材料之溫度計，會有偏差。
    - 測量清潔力誤差：起初我們很想量化污漬所佔的面積，不過後來發現經過清洗後，污漬的變化其實是不規則的，所以我們最後選擇了直觀地記錄污漬顏色的深淺，而去判斷各種肥皂的清潔能力。

綜合各種原因，我們的並不能做到完全公平之測試。

要解決這些問題，我們要盡可能在同一個地方去做實驗，而我們攪拌或量度材料時，也要盡量小心謹慎一點，避免造成偏差。

二、資源、人力和時間之限制

- 資源限制：我們沒有精細的儀器和工具，例如我們需測試制成之肥皂的硬度，但沒有直接的測量工具。為了解決這問題，我們嘗試自製儀器來測試硬度。雖然都可以作為量度之用，但可能未必完全準確。
- 人力和時間限制：由於所製成的廢油肥皂最少都需要一星期後才能做測試，每次發現新問題後，重複製作肥皂和實驗的過程十分費事。如有更多的資源和時間，我們期望在多個月後可再次測試各肥皂的表現。

如果我們可改善這些問題，相信下一次能夠得到更準確之實驗結果。

十一、總結

總括而言，傳統的化學清潔劑因含有不能分解的有害物質，在食物鏈中不斷累積，最終會被人類攝取，亦對海洋造成嚴重污染；因此我們應盡量使用廢油手工皂，以保護海洋環境的生態。

我們測試了加入了不同的廚餘的廢油肥皂的起泡度、清潔力、pH值等數據，發現用廚餘做肥皂不僅環保，還有很多益處。例如：普通手工肥皂一開始的pH值都很高，至少要放置一個月才能把pH值降到能給正常人使用的高度。可是，如果加了橙皮、茶葉等廚餘，就能大大的降低pH值，加快可供使用速度。還有，加了廚餘的肥皂的清潔能力也明顯比沒加的好。因此，我們非常建議加入廚餘做肥皂。

今年年底便實施垃圾徵費了。我們都十分推薦大家一起製作廚餘廢油肥皂。它不單有良好的清潔能力，而且它可以被生物分解，減低對海洋的污染。既能善用廚餘，又可以「轉廢油為寶」，一舉兩得。只要參考我們的製作流程及建議配方，廚餘廢油皂，環保又易做！

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季軍

紙の重生術

利用「抹手紙」生產「生質酒精」的可行性及效能探究

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意念來源

現時世界各國會利用「植物纖維素」生產「生質酒精」，但開發新農地時有機會破壞生態，而原本用來生產糧食的土地拿來種植能源農作物，亦會減少糧食生產。

我們一位小息剛去完洗手間的組員忽發奇想，認為在洗手間垃圾桶內的大量抹手紙不也是纖維素嗎？為何不廢物利用，反而特意種植植物去生產酒精？由此，我們正式展開了這趟「抹手紙變酒精」之旅！

探究目的

了解利用抹手紙生產生質酒精的可行性。

背景資料

1. 抹手紙——香港的使用情況

抹手紙是一種不能回收、全被直送堆填區的都市固體廢物。根據 2017 年的統計，香港抹手紙的每日棄置量達 2532 公噸，而另外一個統計亦顯示香港人於 2019 年共使用了逾 6500 萬張抹手紙，足以見得抹手紙為環境帶來巨大的負面影響。

2. 抹手紙——本校的使用情況

而通過實地觀察，我們發現我校耗用抹手紙的情況同樣嚴重，每天洗手間的垃圾桶內都會放滿被棄置的抹手紙。據了解，同學一般認為使用抹手紙抹手方便，亦能保持環境乾爽，尤其疫情期間習慣了多洗手，抹手紙的耗用比以往用得更多。我們再訪問工友姨姨，知道全校 16 個廁所平均約 3 天就需添置一次抹手紙（一包抹手紙為 250 張）。

3. 生質酒精

又稱為「燃料乙醇」，已被廣泛應用，其中「纖維素乙醇」是我們想針對發展的部分。現今比較普及的有使用粟米的稈、柳枝、芒草和木屑等來生產乙醇。

圖片來源：https://info.organic.org.tw/2129/

探究過程

第一階段：資料搜集

我們在資料搜集時發現，要把「纖維素」變為「酒精」，只需進行幾個簡單步驟：包括把抹手紙「液化」、「糖化」及「發酵」。但深入了解時，原來「液化」、「糖化」及「發酵」的背後原理均牽涉到複雜的化學知識，並非我們小學階段能掌握的！而且按老師的了解，「糖化」過程似乎要使用「強酸」進行「水解」，這更不可能是小學生做到的。這樣是否代表我們要輕易放棄？

第二階段：訂定方案

後來我們再上網進行資料搜集，發現一份文章提到植物纖維素的「糖化」除了使用「強酸」進行「水解」外，現實上亦有用「酶」或「微波」的方式的，只要在特定的環境下進行就能夠成功。

就這樣，我們決定購買「纖維素(液化)酶」、「糖化酶」及「酵母」，在不知分量的情況下，嘗試是否可以生產酒精。

我們自知小學階段是難以尋找出「最」具效能的方案，因此我們的第一步是先嘗試其「可行性」，如發現真的能產生酒精，就會用「公平測試」探索較具效能的組合。

第三階段：實踐方案

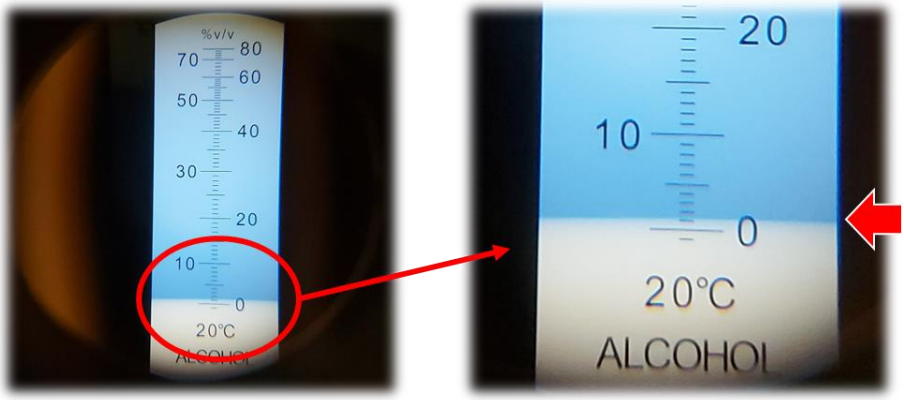
事實上，我們都做好心理準備迎接失敗，但懷著強烈的好奇心及求真的科學精神，我們決意一試。我們把 5 張抹手紙撕成碎片並放進攪拌器攪爛，隨即加入「纖維素酶」，再在 50°C 熱水中進行「液化」，期望「酶」能把抹手紙中的「纖維素」分子破壞，為「糖化」做準備。




我們參考一些酒廠發酵紅酒白酒的過程，在一天後同時加入「糖化酶」及發酵用的「酵母」，讓「糖化」及「發酵」同時進行。我們期望「糖化酶」把「纖維素」轉換成「葡萄糖」後，「酵母」中的微生物會把「葡萄糖」轉換成「酒精」。一天後，我們使用「乙醇檢測儀」檢定「發酵物」內是否具有「乙醇」(酒精)。

第四階段：分析結果

經過兩天的等待，我們探究的結果終於正式揭曉：我們竟在發酵物中探測出 1.5% 的「乙醇」！



我們似乎已能證實到其可行性了！

第五階段：訂定新方案

雖然我們似乎已能證實到其可行性，惟歡呼聲過後，我們開始反思及提出質疑：是否真的是「纖維素」導致這個結果，還是那些酶或酵素導致的？

於是我們決定訂定新方案，進行三個公平測試。

測試紀錄及結果

1. 公平測試 (一)

探究問題：	酒精的出現，是否真的由纖維素（抹手紙）導致？	
實驗假設：	酒精的出現由纖維素（抹手紙）導致，故此 抹手紙數量增加，發酵後酒精的分量亦會增加	
控制因素：	唯一變項	抹手紙的數量 (1 張、4 張、7 張、10 張)
	依變項	酒精的分量
	不變項	瓶子的樣式、大小及擺放的位置 水的分量 纖維素酶的分量、反應溫度及時間 糖化酶的分量、反應溫度及時間 酵素的分量、反應溫度及時間

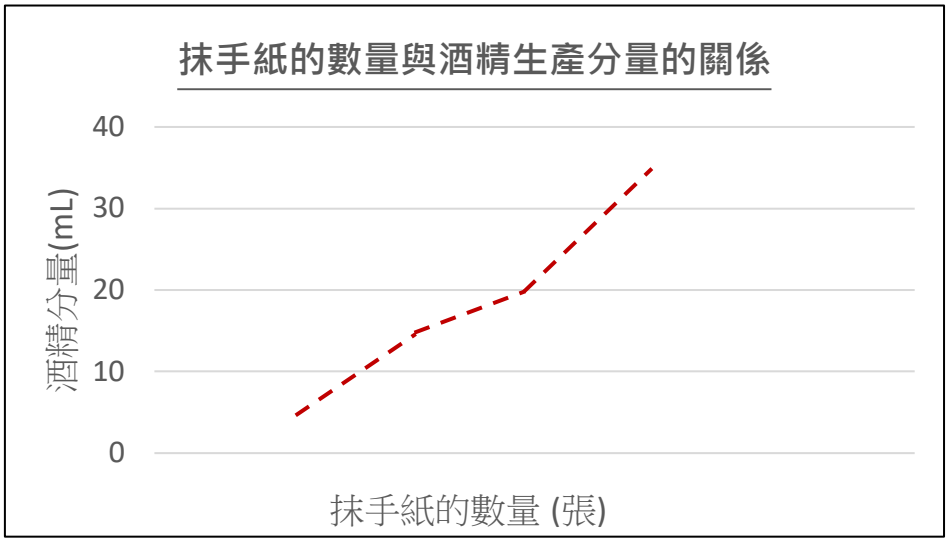
實驗設計：

加入纖維素酶前的情況

實驗結果：

抹手紙的數量	1張	4張	7張	10張 (18.4克)
水的分量	500mL	500mL	500mL	500mL
纖維素酶	2克 / 50°C / 1天	2克 / 50°C / 1天	2克 / 50°C / 1天	2克 / 50°C / 1天
糖化酶	2克 / 室溫 / 5天	2克 / 室溫 / 5天	2克 / 室溫 / 5天	2克 / 室溫 / 5天
酵素	2克 / 室溫 / 5天	2克 / 室溫 / 5天	2克 / 室溫 / 5天	2克 / 室溫 / 5天
酒精濃度	1%	3%	4%	7%
換算酒精分量	5mL	15mL	20mL	35mL

當抹手紙的數量增加，所產生的酒精分量亦增加。



數據分析：

以上數據指出酒精的產生是真的由纖維素導致，而非其他因素。

因此，我們可以正式結論：「利用抹手紙生產生質酒精」是明確可行。

2A. 公平測試 (二)

探究問題：	纖維素酶的分量對酒精的生產有甚麼影響？	
實驗假設：	纖維素酶增加，生產的酒精分量亦會相應增加	
控制因素：	唯一變項	纖維素酶的分量 (2 克、4 克、6 克、8 克)
	依變項	酒精的分量
	不變項	瓶子的樣式、大小及擺放的位置 抹手紙的數量 水的分量 纖維素酶的反應溫度及時間 糖化酶的分量、反應溫度及時間 酵素的分量、反應溫度及時間

實驗設計：

加入糖化酶酵素後的情況

實驗結果：

抹手紙的數量	10張 (18.4克)	10張 (18.4克)	10張 (18.4克)	10張 (18.4克)
水的分量	500mL	500mL	500mL	500mL
纖維素酶	2克 / 50°C / 1天	4克 / 50°C / 1天	6克 / 50°C / 1天	8克 / 50°C / 1天
糖化酶	2克 / 室溫 / 5天	2克 / 室溫 / 5天	2克 / 室溫 / 5天	2克 / 室溫 / 5天
酵素	2克 / 室溫 / 5天	2克 / 室溫 / 5天	2克 / 室溫 / 5天	2克 / 室溫 / 5天
酒精濃度	7%	7%	7%	7%
換算酒精分量	35mL	35mL	35mL	35mL

當纖維素酶由 2 克增加至 8 克，生產的酒精分量維持不變。

數據分析、挑戰及應對：

以上的數據說明我們的原有假設不成立。這似乎說明纖維素酶與生產的酒精分量沒有關係。但我們進一步思考及分析後，認為有機會是因纖維素酶的分量過多引致。假設 2 克的纖維素酶已多得足夠把所有纖維素「液化」。在再沒有纖維素可被「液化」的情況下，不論我們增加多少纖維素酶，亦不可能增加酒精分量的！因此我們決定做一個「**跟進的公平測試** 2B」: 把測試中的纖維素酶分量改為 0.2 克、0.5 克、0.7 克、1 克。

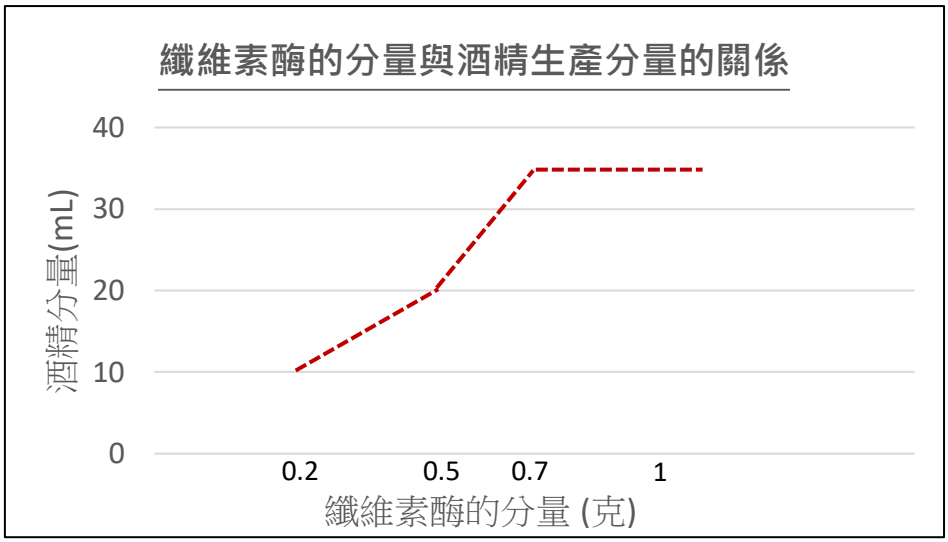
2B. 公平測試 (二) —— 跟進

探究問題：	纖維素酶的分量對酒精的生產有甚麼影響？	
實驗假設：	纖維素酶增加，生產的酒精分量亦會相應增加	
控制因素：	唯一變項	纖維素酶的分量 (0.2、0.5、0.7、1 克)
	依變項	酒精的分量
	不變項	瓶子的樣式、大小及擺放的位置 抹手紙的數量 水的分量 纖維素酶的反應溫度及時間 糖化酶的分量、反應溫度及時間 酵素的分量、反應溫度及時間

實驗結果：

抹手紙的數量	10張 (18.4克)	10張 (18.4克)	10張 (18.4克)	10張 (18.4克)
水的分量	500mL	500mL	500mL	500mL
纖維素酶	0.2克 / 50°C / 1天	0.5克 / 50°C / 1天	0.7克 / 50°C / 1天	1克 / 50°C / 1天
糖化酶	2克 / 室溫 / 5天	2克 / 室溫 / 5天	2克 / 室溫 / 5天	2克 / 室溫 / 5天
酵素	2克 / 室溫 / 5天	2克 / 室溫 / 5天	2克 / 室溫 / 5天	2克 / 室溫 / 5天
酒精濃度	2%	4%	7%	7%
換算酒精分量	10mL	20mL	35mL	35mL

纖維素酶的分量達到 0.7 克，生產的酒精分量開始維持不變。



數據分析：

以上的數據說明我們的假設成立。隨著纖維素酶增加，生產的酒精分量亦會相應增加；直至纖維素酶達至 0.7 克，所有纖維素已被液化，生產的酒精分量亦因此固定不變。

這樣說明，在處理 10 張抹手紙(18.4 克)的情況下，我們使用的這種纖維素酶需相應使用 0.7 克，將達到最佳效果，換算百分比為：

$$\frac{0.7}{18.4} \times 100\% = 3.8\%$$

3. 公平測試 (三)

探究問題：	酵素的反應時間對酒精的生產有甚麼影響？	
實驗假設：	酵素的反應時間增加，生產的酒精分量亦會相應增加	
控制因素：	唯一變項	酵素的反應時間 (1、3、5、7 天)
	依變項	酒精的分量
	不變項	瓶子的樣式、大小及擺放的位置 抹手紙的數量 水的分量 纖維素酶的分量、反應溫度及時間 糖化酶的分量、反應溫度及時間 酵素的分量、反應溫度及時間

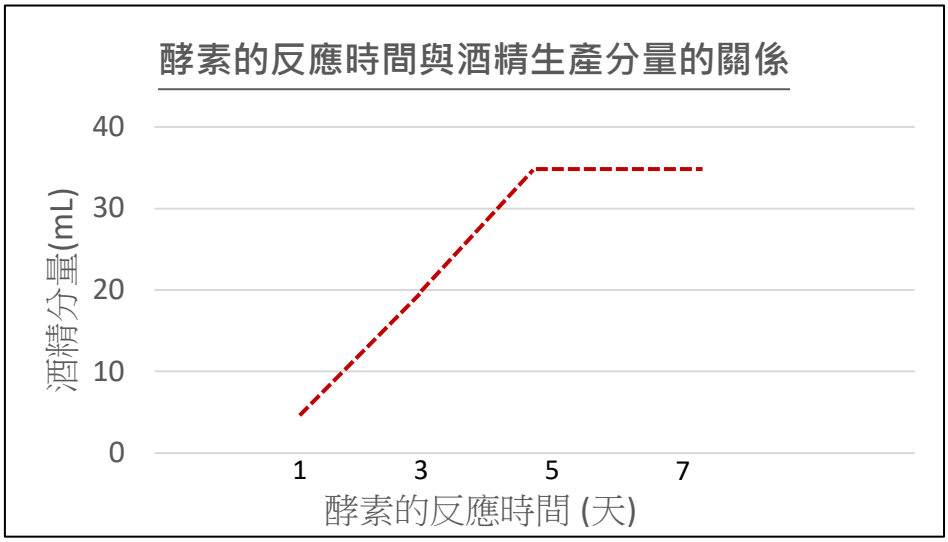
實驗設計：

分別於加入酵素後的第 1、3、5、7 天量度酒精分量

實驗結果：

抹手紙的數量	10張 (18.4克)	10張 (18.4克)	10張 (18.4克)	10張 (18.4克)
水的分量	500mL	500mL	500mL	500mL
纖維素酶	2克 / 50°C / 1天	2克 / 50°C / 1天	2克 / 50°C / 1天	2克 / 50°C / 1天
糖化酶	2克 / 室溫 / 5天	2克 / 室溫 / 5天	2克 / 室溫 / 5天	2克 / 室溫 / 5天
酵素	2克 / 室溫 / 1天	2克 / 室溫 / 3天	2克 / 室溫 / 5天	2克 / 室溫 / 7天
酒精濃度	1%	4%	7%	7%
換算酒精分量	5mL	20mL	35mL	35mL

酵素的反應時間達到第 5 天，生產的酒精分量開始維持不變。



數據分析、建議及改善：

跟公平測試(二)的情況相似，以上的數據說明我們原有的假設不成立。酵素的反應時間在一定日子後，生產的酒精分量有機會達到峰值，而不是會無限量增加。

這樣說明，在處理 10 張抹手紙(18.4 克)的情況下，我們使用的這種酵素需相應給予 5 天反應時間，將達到最佳效果。

由於時間關係，我們暫未能進一步進行實驗。但我們仍建議改變抹手紙數量並再次進行此測試，以了解當中的關係。

總結

通過以上的探究，我們發現利用抹手紙生產生質酒精確實可行；而利用「酶」的方式在效能上，1 張抹手紙大約能生產 3.5 毫升生質酒精。

一包 250 張的抹手紙，以全校共 16 個廁所、平均每 3 天需更換一次抹手紙計算，粗略估計每天耗用的抹手紙約有 1333 張 (250 × 16 ÷ 3)。若全數回收用作為生產原料，每天將能生產超過 4.6 公升的生質酒精。

根據 2019 年的統計數字，全港每日耗逾 6500 萬張抹手紙。若全數回收用作為生產原料，每天將能生產超過 227,500 公升的生質酒精。




雖以我們手上的科技，不可能與專業的科研部門比較，但我們認為，我們這次的創新嘗試及實驗成果，，亦為「生質能源」的發展編寫了新一篇序章。

我們建議科研部門按這個意念進行更專業的測試，以找出能把以上技術普及的條件。我們期望這個測試是讓世界改變的一個微小開始。

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指導老師: 温家軒、蔡詠霞、何頌言

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「未來世界難題／現實難題」-香港的海洋污染

題目：回收發泡膠

指導老師：李麗冰、賴俊彥、黃俞曼

參賽學生：林巧澄、梁舜堯、徐琬茜、張凱晴、林彥泰

一、 探究意念

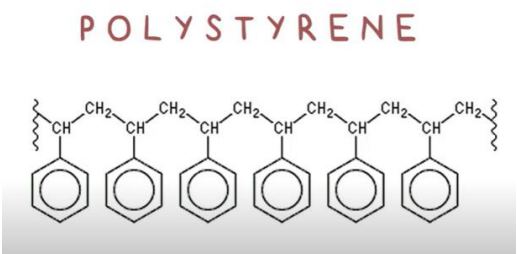
根據WWF 2015年「育養海岸」於鶴咀垃圾灣調查報告，海洋常見的垃圾有68.3%是發泡膠碎片。而香港每日產生30噸發泡膠廢料，過往一直依賴內地回收處理，但在疫情影響回收鏈後，出現「膠箱圍城」的危機，全港近七成發泡膠箱都被堆填。發泡膠廢料為海洋和陸地都帶來沉重的負擔，有見及此，本研究希望從循環再造的角度出發，希望發現到哪一種溶劑能有效回收發泡膠以及可使用回收物再作其他用途，從而解決海洋塑膠污染的問題。

二、 科學原理及探究方向

發泡膠（Styrofoam）是聚苯乙烯的其中一種形態，苯乙烯經過聚合反應之後，變成了透明又質脆的聚苯乙烯，繼續加入發泡劑，施以大量攪拌，它將在體積膨脹的同時變成白色而柔韌的泡沫塑料。

對於有機化合物而言，一種物質（溶質）能否溶於另一種物質（溶劑），一般遵循著「相似相溶」的原理。「相似」指的是物質的分子極性相似。水是（強）極性溶劑的代表，強極性的物質易溶於水，一般稱它們具有「水溶性」。非（弱）極性的物質因為更容易溶於油，而稱它們具有「脂溶性」。苯乙烯本身是弱極性分子，聚合而成的聚苯乙烯很容易就被丙酮之類有機溶劑所溶解。

本研究的目的，就是研究哪一種最適合回收發泡膠的溶劑，分別比較溶解速度是否最快、溶解份量是否最多、溶解後凝固的時間最短，再繼而比較凝固後的物料的重量、黏性、防水性、密度、堅固度和耐熱性，找出發泡膠的回收物可作哪些用途。



三、探究過程及測試結果

1. 研究哪一種溶劑最適合回收發泡膠。

以相同份量的溶劑(20mL)溶解相同體積的發泡膠(4x8x3cm)。首先以計時器計算發泡膠放進溶劑後的溶解速度、呈飽和狀態所需發泡膠數量以及觀察其溶解後的狀態。然後量度由液體變成固體時間以及觀察其形成固體的狀態。

測試結果

測試溶劑種類	主要化學成份	溶解速度	呈飽和狀態所需發泡膠數量	溶解後飽和狀態	凝固時間	固體狀態
洗甲水	丙酮	10秒	17塊	糯米糍狀白色 	19分8秒	硬, 厚粒狀, 沒有味道 
佛手柑油	檸檬烯、沉香酯、沉香醇、呋喃香豆素	24秒	5塊	膠水狀透明 	2天`	表面粗糙, 形成最薄的膜, 十分脆 
甜橙油	檸檬烯、檸檬醛、芳樟醇、橙花醇、辛醛、葵醛	1分30秒	7塊	蜜糖狀鮮橙色 	4天	平滑,形成較硬的薄膜, 較深色 
尤加利油	桉油醇、芳樟醇、樟腦烯、茴香萜、柚油萜	3分25秒	4塊	膠水狀透明 	2天	平滑但有較多泡, 形成硬的薄膜 
葡萄柚油	松萜或蒎烯、月桂烯、檸檬烯、香葉醇、芳樟醇、香茅醛、乙酸葵酯和萜品烯	40秒	9塊	膠水狀橙黃色 	4.5天	表面粗糙, 形成薄膜, 周邊呈網狀及較脆 

測試結果（續）

測試溶劑種類	主要化學成份	溶解速度	呈飽和狀態所需發泡膠數量	溶解後飽和狀態	凝固時間	固體狀態
牛油	碳氫化合物鏈子脂肪酸，脂肪，水	/	/	未能溶解	/	/
BB油	含輕質礦物油、羊毛脂及基衍生物、植物油以及抗氧化劑	/	/	未能溶解	/	/
橄欖油	飽和脂肪酸、亞油酸、亞麻油酸和正十七碳烯酸	/	/	未能溶解	/	/
麻油	蓖麻油酸、甘油酯	/	/	未能溶解	/	/
葡萄籽油	亞油酸、油酸、植物甾醇、多酚、角鯊烯和類胡蘿蔔素	/	/	未能溶解	/	/
檸檬草油	香葉烯、月桂烯、檸檬烯、甲基庚烯醇、香茅醛、香葉醇、橙花醇、蒎烯、樟腦烯	2分12秒	5塊	白膠漿狀 	5天	平滑但有泡, 薄及柔軟 
薰衣草油	乙酸芳樟酯、薰衣草醇、芳樟醇、香葉醇、橙花醇、樟腦烯、龍腦、乙酸松油酯、乙酸薰衣草酯、蒎烯、月桂烯等	4分9秒	5塊	泡沫狀白色 	放置超過兩星期都未能凝固	表面濕潤, 仍未完全凝固, 味道最濃烈 

小結

在測試的溶劑中，牛油、米糠油、橄欖油、麻油、葡萄籽油、BB油均未能溶解發泡膠；而洗甲水含有98%丙酮，它的溶解發泡膠的速度最快以及能溶解最多份量發泡膠，溶解速度最快其次是佛手柑油、葡萄柚油、甜橙油、檸檬草油，這些溶劑都是含有較多比例的檸檬烯。而尤加利油、薰衣草油都能溶解發泡膠，但相對溶解速度較慢及份量較少。而薰衣草油雖然能溶解發泡膠，但放置多時都未能凝固，因此也不合適進行發泡膠回收。

2.測試凝固物料的重量、黏性、防水性、堅固度和耐熱性，找出發泡膠的回收物可作哪些用途。

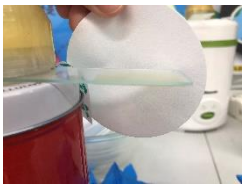
重量

用電子磅量度相同份量的發泡膠(5g)於混合不同溶劑(20mL)後凝固物的重量。

	洗甲水	佛手柑油	甜橙油	尤加利油	葡萄柚油	檸檬草油
凝固前(克)	14	16	16	16	16	16
凝固後(克)	1.47	0.8	0.286	0.5	1.44	2.2

黏性

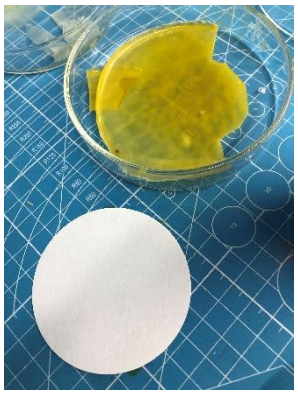
將凝固物貼在玻璃片, 倒置玻璃片放置30分鐘後觀察凝固物狀態。

	洗甲水	佛手柑油	甜橙油	尤加利油	葡萄柚油	檸檬草油
凝固物在玻璃片的狀態	一倒置就馬上脫落	一倒置就馬上脫落	一倒置就馬上脫落	30分鐘後脫落一半 	30分鐘後沒有任何脫落 	30分鐘後脫落四分之一 

防水性

用濾紙放在凝固物下面, 在凝固物上滴5mL水放置30分鐘, 觀察濾紙有沒有濕、凝固物濕之後的狀態。

	洗甲水	佛手柑油	甜橙油	尤加利油	葡萄柚油	檸檬草油
濾紙狀態	乾	乾	乾	乾	乾	乾
凝固物濕之後的狀態	沒有改變	變得柔韌	沒有改變	沒有改變	沒有改變	變軟



堅固度

將相同大小的物料用電線夾固定在彈簧秤的鐵勾上，水平拉扯物料，直到物料斷裂並紀錄斷裂時測力計的數值。

	洗甲水	佛手柑油	甜橙油	尤加利油	葡萄柚油	檸檬草油
水平拉力尺(N)	>20	10	1.3	6	0.2	12

耐熱性

使用水浴加熱法, 放在100度攝氏水上隔著玻璃杯放置3分鐘, 用食物探熱針量度凝固物內裡溫度、用紅外線探熱針量度凝固物表面溫度及觀察狀態有沒有改變。

	洗甲水	佛手柑油	甜橙油	尤加利油	葡萄柚油	檸檬草油
放置熱水前的內裡溫度(攝氏度)	25.2	25.6	24.8	24.8	24.9	25.9
放置熱水前的內裡表面溫度(攝氏度)	25	25	25	25	25	25
放置熱水後的溫度(攝氏度)	38.5	42.3	44.9	38.2	41.9	39.3
放置熱水後的狀態	變少許軟及透明	有香味散發, 變軟及透明成啫喱狀	四周卷起, 有香味散發, 變啡色	變軟及透明,貼住底部	變少許軟及牢牢貼住底部	有香味散發, 變軟及貼住底部

四、結論及反思

	洗甲水	佛手柑油	甜橙油	尤加利油	葡萄柚油	檸檬草油
重量	**	****	****** 最輕	*****	***	* 最重
黏性	沒有黏性	沒有黏性	沒有黏性	**	*** 黏性最強	*
防水性	*** 最防水	**	*** 最防水	***	*** 最防水	*
堅固度	****** 最堅固	****	**	***	* 最脆弱	*****
耐熱性	**	*****	****** 最耐熱	*	****	***

透過不同測試，我們發覺使用甜橙油回收的發泡膠物料在重量最輕，而且最防水和耐熱，因此較合適製作輕包裝，例如包裝膠膜，但洗甲水回收的發泡膠物料雖然較重，但相對最堅固，可以用作製作硬的膠盒或需要牢固包裝的膠箱。疫情間街市棄置大量發泡膠箱原本用來盛載海鮮及蔬果，如回收發泡膠箱之後，也可製作可防水的循環再造膠箱。而葡萄柚油回收的發泡膠物料雖然比較脆弱，但黏性最強，可以用作製作膠水、膠紙等黏合物。因此，不同回收物料可按照其優點和特性，去應用製作不同的物品。

這些回收物料雖然都有一定的耐熱性，但是當加熱到一定程度及長時間加熱，仍會軟化，而且人體如吸入過多丙酮，也會出現身體不適。基於食物安全，因此以上溶劑所回收的物料並不合適使用製作食物盒。而我們進行測試的溶劑都是複合物，混合不同種類成分。如果我們能抽取到當中主要的成分，例如丙酮、檸檬烯，再重覆以上測試，就可發現最有效回收發泡膠的原料，也讓回收的過程可簡化，令成本效益大大提高，用家也自然會更願意協助回收。

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科學家報告書獎

第十六屆香港科學青苗獎

科學家專訪報告

盧君宇博士

參賽學校：海壩街官立小學
參賽學生：王子銘
梁曉臻
蕭雋軒
呂璟業
陳浩宇

簡介

盧君宇教授現於香港理工大學時裝及紡織學院任教。他主力從事環境及人與健康相關的研究。最近在研究可殺滅新冠病毒三維打印物料，並於本年度的第四十八屆瑞士日內瓦「國際發明展」取得金獎。現時，這項物料已廣泛地應用在理工大學，包括：洗手間廁格、電梯的按鈕及課室的門把。

盧教授的探究和奮鬥過程

盧教授表示雖然自己在大學不是修讀環境相關的科目，但在中學時已對這方面感到興趣。而他在時裝及紡織學院任教可令他把自己的研究與興趣結合，因為他觀察和發現到生產時裝的過程對環境做成污染。

在訪問期間，盧教授分享自己最難忘的研究是可殺滅新冠病毒三維打印物料。他表示自己是讀管理研究的出身的，因此很多研究都是關於如何鼓勵企業做好環保。盧教授分享這項研究其實經歷了多次的失敗，研究團隊嘗試了超過二百項比例配方，才得出現是的最終版本，之前的版本不是太軟就是顏色不理想，甚至出現氣泡的問題。但這些失敗的經驗都令他不斷成長。

盧教授認為成功的科學家需要具備專注及努力不懈的特質。進行研究涉及科學實驗及收集數據，過程繁複而且花費大量時間，需要專注及努力不懈，才能取得成果。但當中的成功感及滿足感能鼓勵及推動自己繼續從事研究。

盧教授對海洋垃圾污染的看法

盧教授認為香港海洋垃圾污染的情況有很多改善空間，但部分垃圾未必是香港製造的，而是從外地漂浮過來。所以著眼點不應該只集中於香港，反而是地球的海洋垃圾問題，因為水流會把垃圾從外地帶到香港。

盧教授認為市民對海洋垃圾問題亦有責任。購買產品時應選購一些對海洋污染較少的產品，如：避免選購由人造纖維製成的衣物，人造纖維經常清洗後會變成微塑膠，不知不覺間污染海洋。

而香港市民對海洋垃圾的關注度及意識，盧教授認為仍有待提高。他分享其中一次的研究是訪問香港市民對環保議題的重視程度，他們最重視是能源及堆填的議題，而不是海洋垃圾。

盧教授評價探究作品：「海洋垃圾機械人」

對於同學們探究作品：「海洋垃圾機械人」，盧教授提出了三點的建議。

首先，他認為要考慮怎樣控制機械人順利往來指定地點，如果機械人失控就會變成垃圾在海洋飄浮，即使收拾集到更多的垃圾亦不能將其帶回岸上處理。

第二，他建議可加設感應器以追蹤垃圾，如：使用聲納偵測海上最多垃圾的位置，以增加垃圾收集量。

第三，盧教授建議同學先研究哪一類型的海洋垃圾最多，並按垃圾的特性設計收集垃圾的機械臂或入口。如果想收集大型的垃圾，便需較寬闊的設計。他又建議可用三維打印製作機械臂，三維打印技術輕易製作出空心而又帶有幾何結構的機械臂，減輕機械人的重量之餘亦不會犧牲其堅硬程度。

學生的反思

同學們非常感謝盧教授在百忙之中抽空接受訪問。他除了分享了他在科學研究的一些經歷外，還對於同學們的探究作品：「海洋垃圾機械人」，提供了寶貴的意見。

透過這次訪問，同學們明白到要成為一個成功的科學家，並不容易，要靠自己不斷的嘗試，而且不能放棄。當盧教授告訴大家：他在發明防菌測試過程當中，便把相同的步驟重複了超過二百次，大家都非常驚訝和欣賞盧教授堅毅的探究精神。

盧教授勸勉有意從事科學研究的同學首要是有廣闊科學基礎知識，尤其是物理及化學原理。另外，很多研究亦涉及數學，因此中學的應用數學知識亦是十分重要的。這對有意將來從事科學研究的同學們都是很重要的建議。

同學們對於盧教授所研發可殺滅新冠病毒的三維打印物料感到很好奇。得知這項物料已廣泛地應用在理工大學，在訪問環節結束後，同學們在理工大學四處尋找並嘗試觸摸這種物料，結成功在洗手間、課室的門把和電梯的按鈕有所發現，大家都非常雀躍呢！

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同學們在訪問前認真商討和擬定訪問的問題。</td>
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同學們與盧教授的大合照，這真是一次寶貴的訪問經驗！</td>
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<td colspan="2">同學們都認真聆聽和記錄盧教授的分享。</td>
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第十六屆香港科學青苗獎

科學家專訪報告

聖保羅男女中學附屬小學

參賽學生： 陳皆攸、張智南、莊梓麟、何沐珈、田澤沛

指導老師： 陳穗雯老師、黃旭霖老師

受訪科學家： 周鴻奇教授

職銜： 香港教育大學健康與運動科學講座教授

博文及社會科學學院副院長（研究及研究課程）

香港教育大學基督教信仰與發展中心總監

香港工程師學會生物醫學分部前任主席

《International Journal of Industrial Ergonomics》及《Journal of Healthcare Engineering》的編輯委員會成員

研究範圍： 運動分析、運動生物力學、人體工學、運動表現與評估等（尤其是應用於學童及青少年的範疇）

周教授的讀書經歷

周鴻奇教授
香港教育大學健康與運動科學講座教授[1]

周鴻奇教授在中三時已有夢想，想完成博士學位，為何會有志於生物醫學工程呢？原來當他在香港大學修讀第二年機械工程系的時候，認識了一位患上腎病的師姐。這位師姐向他分享了腎病帶來的生活不便和問題，周教授聽完師姐的分享後感到很痛心，想幫忙卻不知所措。

正當周教授畢業之際，他本來對未來感到迷惘，但受修讀醫學的宿舍室友影響，加上想起師姐的病患，令他想當醫生，不過他申請報讀醫學院後卻遭到拒絕。周教授沒有放下想幫助病患者的心志，他和學院導師討論後，被推薦到醫學院參與研究人體器官的工作。最後，他成為了第一位由香港大學醫學院和工程學院培訓，專注研究生物醫學工程的人。而為了更善用他機械工程學士的知識及發展他研究的範圍，他遠赴英國深造生物醫學工程中的生物力學。

周教授過往的研究和靈感來源

周教授研究的生物醫學工程與我們的生活息息相關。在數十年前進行脊骨研究時，周教授留意到書包價格比以往大幅提升，而他又觀察到香港的小孩子常常都背着大書包，於是他便了靈機一動，研究「背書包會否影響脊骨發育」這個課題，此後便研究了十多年，成為這個範疇最多論文的學者。周教授曾訪問了著名的護脊書包品牌公司，以了解護脊書包如何能保護脊椎，其後周教授還設計了幾種具不同護脊功效的書包，例如減少腰背痛程度的、為骨質疏鬆者減少痛楚的、為脊柱側彎者改善姿勢的等等，原來只要不過重，背書包不一定是壞事，甚至經過設計後可改善人們的生活。

周教授最新研究方向

周教授經常觀察人們日常生活遇到的問題，從而制訂研究範圍，最近他研究如何減低跑步受傷的機率及程度。周教授指出近年很多人愛上跑步，但同時不少人出現膝蓋、髖關節、踝關節等位置的受傷，於是他便研究跑步姿勢和關節勞損之間的關係。

周教授的研究發現如果每次跑步用同一跑姿，會令某些關節比其他關節長時間承受較多的力，受力較多的關節會變得較脆弱，引致這些關節能承受力量的上限大幅下降，並造成輕微受損，例如微型裂縫。若果情況惡化的話，微型裂縫有機會逐漸變成大裂縫，令關節永久受損，難以修復，就如金屬疲勞一樣。

周教授的研究範圍包括運動分析、運動生物力學、人體工學、運動表現與評估[2]

周教授亦關注運動員的脊柱健康。運動員在運動時容易受傷，而脊髓受損造成的後果更是嚴重。脊髓受損可以是偶發性，例如跳水運動員發生意外，傷害到脊柱，繼而令神經線受損，有機會產生不同程度的癱瘓；也可以是長期積累而成的，如跑步及體操選手因為運動姿勢長期不當而令脊髓受損。周教授指出雖然保持同一良好姿勢有助保持最佳成績，但偶然也要改用一些不常用的姿勢，多休息，減低關節疲勞，防止骨骼受太大的壓力。

人工智能與周教授的研究

周教授認為人工智能對他的研究有重大幫助，例如他可運用人工智能作分析並預測跑步運動員在什麼時候會受傷、估計洗腎的人會在什麼時候感到不適、估計脊骨受力程度、估計跑步運動員的腿如何活動等。周教授相信人工智能在未來可對科學研究帶來更大的幫助。

周教授最深刻的研究經歷

為研究人體脊骨，周教授曾一個人到殮房解剖超過 100 具屍體，由於這些屍體都十分「新鮮」，部分屍體剖開後，會有血從屍體噴出來。周教授曾發過不少與屍體有關的夢，例如在夢中看見一個無頭的死屍想取回自己的頭，這些夢境令他相當難忘。回顧那段和「大體老師」共渡的日子，周教授說他並不懼怕，他是抱着尊重的態度去看待每一位「老師」，而從這些「老師」身上他了解到人體的結構，例如人體脊椎之間有條短短的黃韌帶，具有很大的彈性，在我們直立時保持拉緊，這是為了保護我們的脊髓免被擠壓……認識這些結構令他體會到上帝設計的人體的奧妙。

周教授的心得分享和勸勉

周教授作為科學家，他認為從事科學工作必須具備好奇心、堅毅及誠實——有好奇心才能觀察到日常生活上的問題及需要，然後會想尋求答案或解決方法；在科學研究的過程中，會時常遇到挫折，堅毅特質有助推動科學家繼續研究；實驗中的數據應當是從客觀及公平的實驗中獲取的，科學家應保持誠實，不應惡意修改實驗設計或參數、偽造或剽竊數據。

周教授示範如何運用機械和電腦進行運動科學研究

周教授的科學研究生涯也遇過不少挫敗，他會藉著祈禱，求神為他加添力量、信心和決心，使他放下失敗經歷並繼續不斷嘗試。他閱讀《聖經》多年得到當中最重要的信息，就是凡事要以「愛神愛人」為原則，這個原則時常提醒他進行科學研究是以提升人類的生活質素為本。

我們的反思

從整個訪談中，我們感受到周教授對人的愛。無論是對他師姐、運動員、各種病患者或兒童，他都很關心。他希望減輕師姐因腎病所承受的困苦，希望協助運動員在保持佳績的同時減低受傷風險，希望他的設計能幫助不同脊椎傷患的人，也希望幫助孩童能健康地發育成長。這種人文關懷，或許是科學家應有的初心!

相片來源：

1. 教育大學網站
   https://www.eduhk.hk/zht/experts/professor-chow-hung-kay-daniel

2. 教育大學網站
   https://www.eduhk.hk/flass/tc/About-Flass/Faculty-Members.html

科學家報告書獎

優才(楊殷有娣)書院 - 小學部

第十六屆香港科學青苗獎

科學家專訪報告 – 周超博士

指導老師：陳漢翹老師、高嘉淇老師

參賽學生：葉澔洋、袁梓嫣、史瀅晞、康野行、郭子鋒

專訪教授簡介

受訪科學家：周超博士
工作機構：香港理工大學
職銜：香港理工大學土木及環境工程學系助理教授
研究範圍：致力於研究熱、水、力多相偶合的非飽和土力學、土體本構模型和數值模擬、從而提高基礎設施的安全性和功能性，尤其針對樁基和路基等。

研究成就及方向

周超博士現職香港理工大學土木及環境工程學系助理教授；2009年獲清華大學頒授水利工程學士學位，2014年獲香港科技大學頒授岩土工程博士學位。加入理大的大家庭前，曾於2014至2018年間擔任香港科技大學研究助理教授。他已經發表了過百篇學術論文，其中六十餘篇發表在國際權威的岩土工SCI期刊。

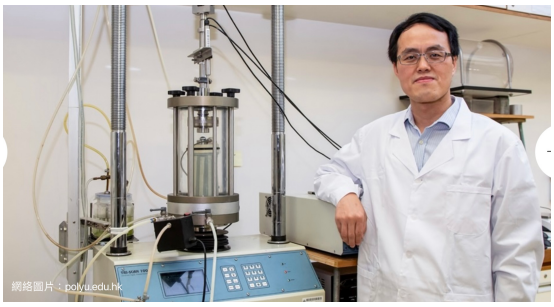
鑑於他突出的研究成果和潛力，周博士於2020年獲國家優秀青年基金項目(港澳)，以支持其未來的科研工作。周博士亦曾獲得多個權威獎項，包括國家自然科學二等獎，以及獲國際土力學及岩土工程學會非飽和土力學專業委員會頒發 Bright Spark Lecture Award。他同時服務多個權威學術組織及期刊編委會，包括國際力學及岩土工程學會、Canadian Geotechnical Journal 等，貢獻良多。

周博士主要研究土木工程，**負責研究泥土和石頭在土木工程的影響。**土木工程是基礎建設的最基本，無論大廈地基、斜坡、交通運輸都涉及到的安全問題，加上香港最年不斷發展，土木工程的研究對香港或世界都有着重要的責任。周博士說：**「做土木工程師最主要的意義，便是設計和製造一些東西，令市民安全。」**土木工程學和日常生活緊緊相連，就算是一些微不足道的發現或者是研究，也可以對社會，人民有大大的幫助，節省很多時間，不必要的風險。

周博士說:「因為人類有很多未知的東西，所以他希望可以創造知識。他希望通過科學，去改善現在的做法，這樣對社會會有更好的貢獻。」他未來的發展方向是希望可以解決因氣候變化所帶出的問題:

- 研究新的能源 - 地熱源。因為地熱比較清潔，亦可減少碳排放。
- 希望可以利用地熱做到空調的冷／熱轉換變化。例如夏天時，泥土會吸收陽光的熱力，到冬天時，泥土裡有熱氣，然後在泥土裡注入冷水，使泥土裡的熱氣上升，造成循環，調節温度。

成為土木及環境工程學家的深刻經歷



周博士有一次到陝西考察，出發前已經知道這個地方降雨量非常少，非常缺水，因此人民生活出現很多問題。而印象最深的是，到達後發現陝西乾旱程度基本上是所有河流都是乾的，幾乎看不到水。當地有學生還說他們從小到中學都沒看過「雨」這東西。博士說香港人可能感受不到亦不會相信，但這事令到博士明白水是很重要的，一定要保護水源及節約用水。而作為科研人員，一個非常重要的責任及承擔就是希望可以將水帶到這個乾旱的地方，當時他和研究人員經歷了很長時間的研究，亦面對了很多困難。

科學研究的艱辛旅途:「反思」才是成功之母

做科研遇到困難很常見，挫折亦很多。例如他和團隊有一次要研究一個新儀器，他們失敗過很多次，最嚴重的一次是實驗時機器有水流了出來，並把整個實驗室淹掉了。當時他們面對著不少的困難及問題，最後用了兩個月去想怎樣去解決問題，所以令他覺得心態非常重要，保持積極態度，願意不斷嘗試，不要給失敗嚇走。最後研究成功的原因，是每次失敗後都要作出總結，找出為什麼會失敗，並且跟其他人一起討論，提高自己知識和想法。

科學家的特質

周博士覺得科學家要有「3C」:

1. Curiosity - 要有好奇心，要多問;
2. Creative - 要具創意力，有創意就會產生想法，多思考，多討論;
3. Critical Thinking - 要有批判性思維，要真正理解問題所在。

除了這三元素外，還需要知識深而廣。即是既要對自已專業有深厚認識，更要知識廣博，以致可以將自己專業運用在其他科技上或將其他科技運用於自己專業之上。例如:博士將光纖廣泛運用於土木工程項目裏面。

周博士以他的座右銘:「有志者立長志，無志者常立志」這句話去建議學生要有志向(即目標)。這句話的意思是，如果有遠大目標的人，是會很長時間去堅持去實踐理想;但如果沒有志向的話，就會今天立一個理想，明天立一個目標，後天又立一個志向，事實上就是沒有想法了。所以我們一旦找到了目標，即使面對了挫折，並不是要馬上找下一個目標，而是重新進行整個過程，再從中分析問題的成因，堅持當初定立的研究目標，不斷反思、不斷改進，是科學研究的唯一道路。

我們的反思

在訪問的過程中，除了學到要成為科學家所要有的特質之外，最令我們感受到周博士一顆對生命尊重的心。整個訪問，不時聽到博士常常提及安全的問題，地基的安全、斜坡的安全等等。他揀選土木工程作為他的研究，這是因為土木工程是為人類建立安全的基本。作為成功的科學家，不就是要想別人未想到的東西，去創造知識，貢獻社會，改變人類生活嗎？

最感動我們的，是周博士的一句說話:「我們要了解泥土、了解身邊的環境、了解這個世界。」很多科學家都希望用知識改變這個世界，但是這份改變很不容易，甚至要令地球付出很大代價。周博士除了尊重生命，亦很愛護自然環境。我們也希望將來能成為科學家，為了能幫助更多的人，也希望人類和自然環境能夠和平共處。知識故然重要，但唯有愛心，才能將科學造成一條連繫人、地球、未來的橋樑。

另一方面，他特別提到我們要注意學習的習慣，要將不好的習慣改掉，才能令我們有更好的學習成就，邁向成為科學家的路。這個提議對我們有很大的啟發，希望我們可以有一天成為一個成功的科研人員。

最後他向我們問了一個問題：團結合作重要一些還是自己一個做事比較好？根據周博士解釋，因為現今做科研跟幾百年前例如牛頓、愛迪生獨自埋首做研究不一樣，現在科研都涉及多方面的知識，困難及問題亦較多及複雜，所以團隊合作是很重要的，亦藉此帶出良好溝通的重要性，以致可以將自己專業運用在其他科技上或將其他科技運用於自己專業之上。例如：教授將光纖廣泛運用於土木工程項目裏面。

這令我們聯想到這次科學青苗獎都遇到過很多困難，例如題目的定立、實驗的失敗，我們都有感到氣餒想放棄的時候，但憑着我們幾位同學的團結合作，大家彼此商量，最後都能夠把實驗成功完成。

在這次的訪問中，我們明白了其實科學家的道路並不容易走，要經歷多次失敗才能成功，也要學會怎樣平衡資源和設計意念，才能達到理想的效果。雖然這很困難，但我們不會放棄，努力做到一位成功的科學家。

中學組:

冠軍

The 16th Hong Kong Budding Scientists Award 2022-2023

Topic 1 - Sports Science

Investigation on the Effect of Vertical Oscillation on Running Efficiency: A Distance Running Analysis

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1. Abstract

In the world of distance running, athletes employ various techniques to run faster and be more efficient. This study aims to investigate the impact of reducing vertical oscillation on running efficiency (defined as the energy consumption per step) in distance running. Ten adolescent distance runners were recruited and asked to run using both bouncing and reduced bouncing running methods. Video recordings of the participants running at a frequency of 180 strides per minute were captured, and an AI algorithm was used to extract the vertical and horizontal coordinates of their movements. The study measured three key variables related to running efficiency: vertical oscillation, stride length, and horizontal movement. The ratio between the vertical oscillation and the horizontal movement was calculated to determine the efficiency of running.

2. Introduction

Distance running, often defined as any running event longer than 5 kilometers, is a highly technical and physically demanding sport that requires athletes to continuously optimize their running form and technique to improve their performance. According to a study by Tartaruga et al. (2012) in the Journal of Human Kinetics, several factors can impact running efficiency, such as stride length, stride frequency, and vertical oscillation[1]. One factor that can impact running efficiency is vertical oscillation, which refers to the levels of vertical motion of the body during running. Some athletes utilize a bouncing technique that involves a higher degree of vertical oscillation,[2] which they believe can improve the running efficiency. However, it was observed that an elite distance runner and P.E. teacher, Mr. Ho Hoi To, who has received multiple running awards in distance running, runs with little to no vertical oscillation (Fig.1) , which contradicts

[1]Tartaruga, M. P., Brisswalter, J., Peyré-Tartaruga, L. A., Ávila, A. O., Alberton, C. L., Coertjens, M., & Kruel, L. F. (2012). The relationship between running economy and biomechanical variables in distance runners. Journal of Human Kinetics, 34, 5-14.

[2] Heiderscheit BC, Chumanov ES, Michalski MP, Wille CM, Ryan MB. Effects of step rate manipulation on joint mechanics during running. Med Sci Sports Exerc. 2011;43(2):296-302. doi: 10.1249/MSS.0b013e3181ebedf4. PMID: 20581722.

the common belief. This observation was a primary motivation for conducting an investigation into the effect of vertical oscillation on running efficiency in adolescent distance runners.

Fig.1: Illustration of the method running with low vertical oscillation (Demonstrated by Mr. Ho Hoi To)

Previous research has examined the relationship between vertical oscillation and running efficiency in distance runners. Saunders et al. (2004)[3] found that a lower degree of vertical oscillation was associated with better running efficiency in distance runners. However, the impact of vertical oscillation on running efficiency has not been thoroughly investigated.

To address this gap in knowledge, this study will use artificial intelligence (AI) to analyze the track of the movement of 10 male secondary students aged 12-15 in videos and computer vision algorithm to detect and track the motion of the subjects for further analysis.

The study will compare the ratio of vertical oscillation divided by horizontal movement between athletes running with high vertical oscillation and low vertical oscillation respectively. a difference in the ratio can show which running method is more efficient in terms of energy consumption.

[3]Saunders, P. U., Pyne, D. B., Telford, R. D., & Hawley, J. A. (2004). Factors affecting running economy in trained distance runners. Sports Medicine, 34(7), 465-485.

Overall, this investigation aims to contribute to the current body of knowledge on running efficiency and provide insights into an optimal running technique for distance runners, the role of vertical oscillation.

3. Theory

3.1 Experiment

3.1.1 Centre of Mass of Human

The pelvis was considered the center of mass in running[4] (Fig.2) , and its movement plays a crucial role in determining the athlete's overall running speed. The pelvis acts as a lever arm that facilitates the transfer of energy from the legs to the upper body, and its movement during running can affect the stability and effectiveness of the athlete's stride.

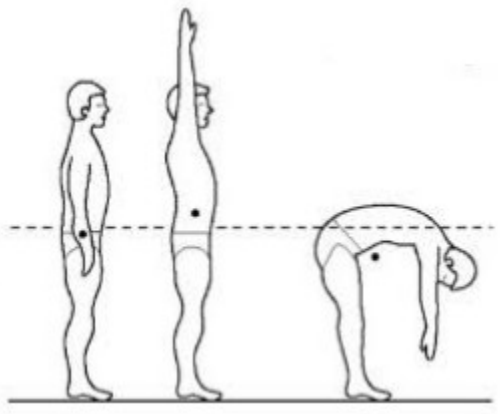


Fig.2: Illustration of position of the center of mass of human

Fig.2 Pic credit: https://physics.stackexchange.com/questions/673369/how-can-we-change-the-centre-of-mass-of-our-own-body

3.1.2 Vertical Oscillation of Human

Vertical oscillation is influenced by the movement of the pelvis.[1] In general, a higher degree of vertical oscillation will consume more energy, which will result in a higher energy cost

[4]How can we change the center of mass of our own body? (2021, October 24). Physics Stack Exchange. Retrieved May 11, 2023, from https://physics.stackexchange.com/questions/673369/how-can-we-change-the-centre-of-mass-of-our-own-body

of running and reduced running efficiency[1]. In contrast, a lower degree of vertical oscillation has been associated with a better running efficiency[2].

3.1.3 Stride Length of Human

Stride length is another important factor in running efficiency, and is defined as the distance traveled in the horizontal direction during each stride. Longer stride lengths can allow athletes to cover greater distances per stride. Stride length is influenced by the velocity of the athlete.

3.1.4 Pace Setter

A pace setter was employed using a constant beat of 180 beats per minute to suit the human running rate, and to limit power output of the runners. In distance running, a constant beat of 180 beats per minute has been found to be effective in helping runners maintain a consistent pace and stride frequency[5]. This is because 180 beats per minute is believed to be the optimal cadence for distance running, as it matches the natural running rate of most individuals[6]. The pace setter served as a valuable tool to help runners maintain a consistent pace and stride frequency which fostered the calculation of running velocity.

3.1.5 Ratio between vertical oscillation and length of each stride

This study aimed to investigate the relationship between vertical oscillation and horizontal movement in distance runners, and compare the performance of athletes running with bouncing and reduced bouncing methods. To investigate these relationships, this study used artificial intelligence (AI) to analyze the x and y coordinates of the movement of human subjects in videos. The movement ratio was calculated by dividing the vertical oscillation (measured in pixels)(Δy) by the stride length (measured in pixels)(Δx), and then expressing the result as a ratio. The AI algorithm used for this study(YOLOv8) will be based on deep learning techniques, which have been shown to be effective in analyzing human motion data from videos. When the ratio is greater, it means Δy is greater and/or Δx is smaller, vice versa. if the ratio becomes smaller, the energy used to increase the height of the runner is reduced, or the energy used to increase the height is transferred to increase the horizontal distance.

[5]Edwards, S. (1993). Running to the beat. The Science Teacher, 60(1), 42-47.
[6]Reel, J. J., & Gill, D. L. (1996). Optimal cadence for running: a computer simulation. Journal of Applied Biomechanics, 12(3), 490-496.

3.1.6 Target Group in the Test

The target participants for this study are adolescent distance runners with a minimum of two years of running experience, aged between 13-18 years old, and no history of musculoskeletal injuries within the past six months. This specific population was chosen because they are in a critical period of developing their running performance, and understanding the factors that influence running efficiency during adolescence can have long-term implications for athletic success and overall health.

3.2 Objectives

The objective of this study is to investigate the effect of vertical oscillation on running velocity in distance runners. Specifically, we aim to:

1. Determine the relationship between vertical oscillation and running efficiency in distance running.
2. Compare the ratio between the vertical oscillation and length of each stride to the front between athletes using bouncing and reduced bouncing techniques.

3.3 Hypothesis

- Lower vertical oscillation is associated with improved running efficiency in distance running.

4. Methodology

Participants: The present study recruited 10 adolescent distance runners who met the specific inclusion criterias, and each participant was required to run in both bouncing and reduced bouncing methods.

Data Collection: The study utilized cameras to capture video recordings of participants running at a frequency of 180 beats per minute, which we found out after some trial-and-error to be the best running frequency for the test as it is close to most people's running frequency, with the runner doing one stride per beat. An AI algorithm based on deep learning techniques was developed to extract the vertical and horizontal coordinates of the participants' movements.

Variables: The study measured three key variables related to running efficiency: vertical oscillation, stride length, and horizontal movement to the front.

Vertical oscillation: the peak-to-trough displacement of the center of mass in the vertical direction during each stride.

Stride length: the distance traveled in the forward direction during each stride.

*Horizontal movement :*the distance traveled horizontally between each measured coordinate.

The ratio between the vertical oscillation and the stride length: calculated by dividing the vertical oscillation (measured in pixels) by the horizontal movement (measured in pixels). It was chosen for calculations as it eliminates a lot of unnecessary variables (effort put in by each runner, physical capability of each runner, etc.)

Data Analysis: The study utilized artificial intelligence to summarize the data for each variable. COCO keypoints is a dataset used for human pose estimation. It provides labeled key points for humans in natural images, which includes 17 key points such as the hip, knees and feet etc. (Fig. 3) These key points were used quantitatively to find the difference between the vertical and horizontal coordinates, denoted as Δx and Δy respectively, and therefore the ratio between them.

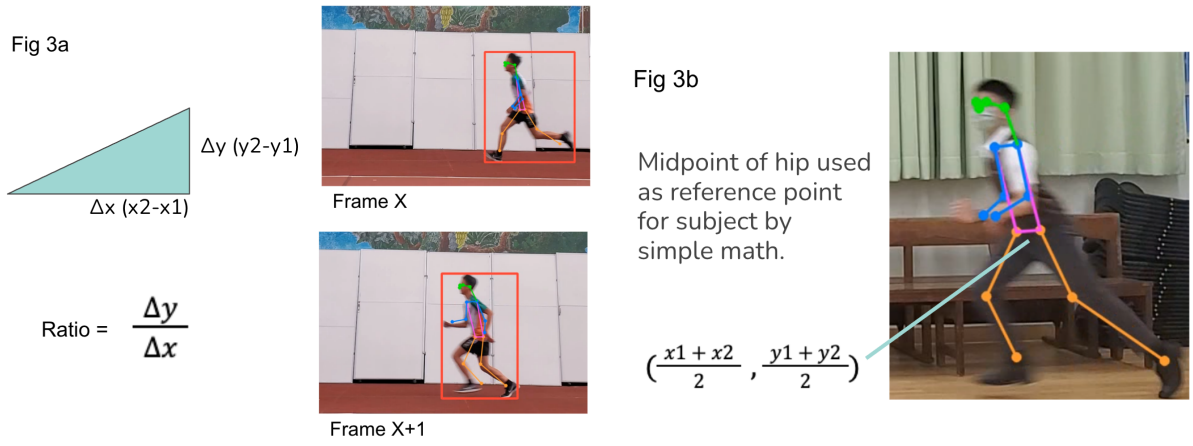


Fig.3: Illustration of the key points found by AI and point used to for reference in movement

It is widely used in computer vision research for developing algorithms for human pose estimation, action recognition, and gesture recognition, which is what we need. YOLOv8 pose, which uses the object detection tech in deep machine learning, was used to compare the bouncing and reduced bouncing groups.

Overall, the study used video recordings and AI algorithms to measure and analyze the

key variables related to running efficiency in distance runners. The data was then analyzed using statistical techniques and turned into ratios to eliminate variables, and in turn explore the relationships between the variables and compare the performance of bouncing and reduced bouncing athletes.

5. Experiment

5.1 Objective

1. Determine the relationship between vertical oscillation and horizontal movement to the front in distance runners.
2. Compare the vertical and horizontal movement to the front between bouncing and reduced bouncing athletes.

5.2 Hypothesis

- Lower vertical oscillation is associated with improved running efficiency in distance running.

5.3 Experiments

Instruments:

1. A camera was used to capture video recordings of the runners' movements (Frame rate: 60 fps; Resolution: 1920x1080; Aperture: f/1.5; Focal length: 26mm), mounted on a tripod for stabilization during recording.
2. White background board was placed behind the running area to provide a contrast for video analysis.
3. A metronome was used to maintain a consistent running cadence.
4. A speaker was used to provide auditory cues for the runners.

Preparation Procedures:

1. The camera was positioned at a stable location perpendicular to the running direction.
2. The metronome was set to a frequency of 180 beats per minute, and the speaker was placed at a consistent distance from the runners.
3. The white background board was mounted behind the running area to provide a contrast for video analysis.
4. The runners were informed about the bouncing and reduced bouncing running techniques and given time to practice each technique.

Experiment 1 - Bouncing:

Procedures:

1. The runners were instructed to perform the bouncing running technique, defined as running with vertical oscillations of at least 5 cm during each stride.
2. The runners were lined up at the starting position and given a brief period to prepare.
3. A countdown was initiated, and the recording was started by the experimenters.
4. The runners began running at the specified frequency.
5. The recording was ended by the experimenters after the runners completed the trial.

Experiment 2 - reduced bouncing:

Procedures:

1. The runners were instructed to maintain a reduced bouncing running style, with minimal vertical oscillations.
2. The runners were lined up at the starting position and given a brief period to prepare.
3. A countdown was initiated, and the recording was started by the experimenters.
4. The runners began running at the specified frequency.
5. The recording was ended by the experimenters after the runners completed the trial.

Assumptions of the experiment:

1. The bouncing and reduced bouncing running styles were able to be performed by all athletes as instructed.

2. The camera and other instruments used in the experiment were functioning properly and accurately captured the runners' movements.
3. The running conditions, including the temperature, humidity, and surface texture, were consistent across both experiments.
4. The data collected from the experiment was analyzed using appropriate statistical techniques to determine the significance of the differences between the bouncing and reduced bouncing running styles.

Table 1-- Details of procedures of data collection

6. Observations and Analysis

6.1 Experimental Results

6.1.1 Results of Experiment 1 – Running with bouncing

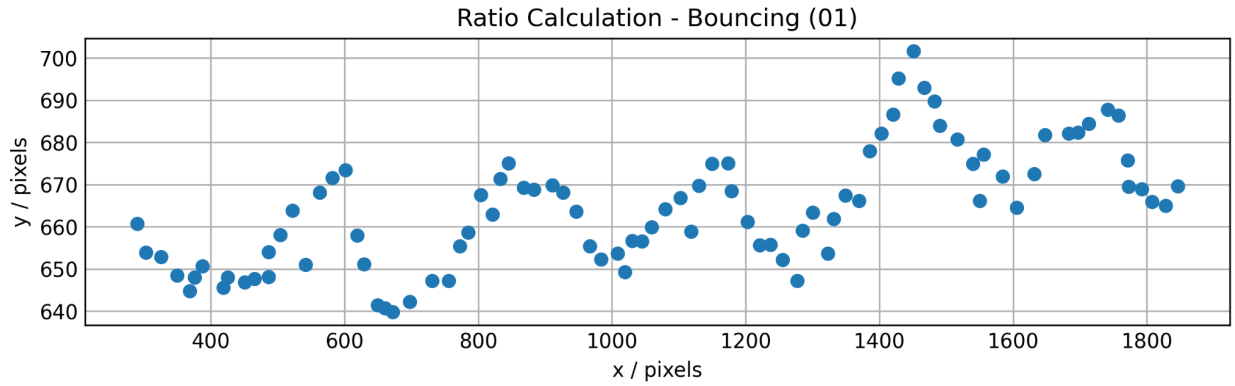


Fig.4: Results of sample Bouncing(01) of Experiment 1 – Running with bouncing

(Video: https://drive.google.com/file/d/1wRYkOrAzheTRBAgKS5kgsvo_NbuDQcbm/view?usp=share_link)

6.1.2 Results of Experiment 2 – Running with reduced bouncing

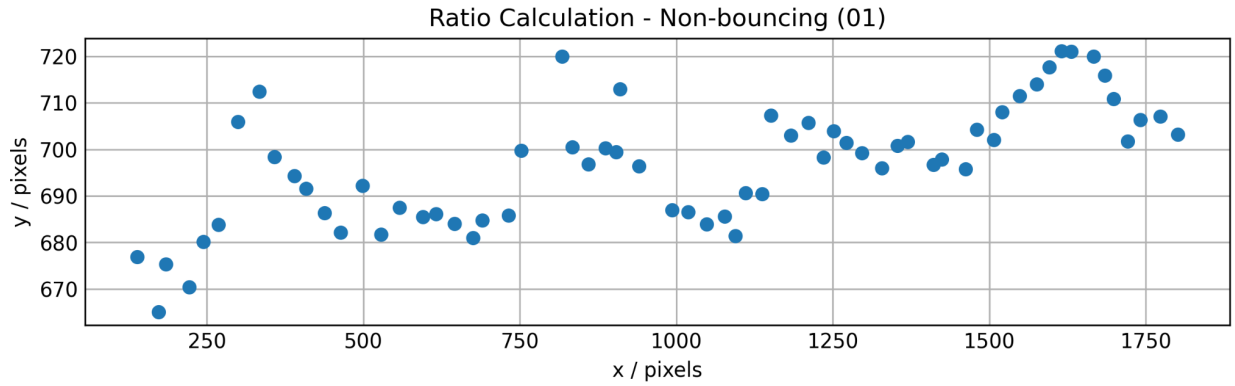


Fig.5: Results of sample Non-bouncing(01) of Experiment 2 – Running with reduced bouncing

(Video: https://drive.google.com/file/d/1E55FybLASkX9gAFCHQr3BalwpTzWd6-G/view?usp=share_link)

6.1.3 Results of the Rate of Movement

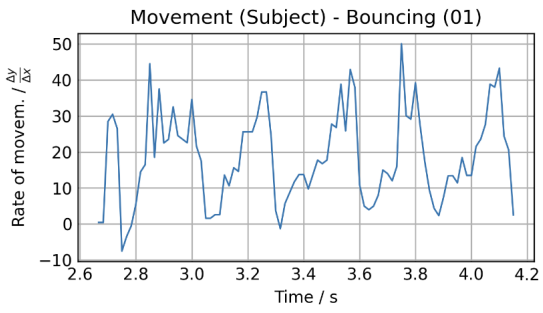


Fig 6a - Bouncing Method

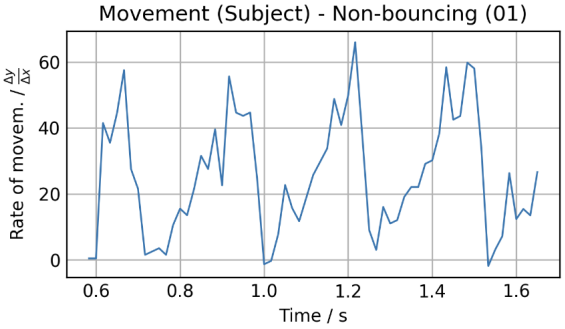


Fig 6b - Non-bouncing Method

Fig.6: Movement of subject in bouncing and non-bouncing method

6.1.4 Results of the Speed and Ratio (Δy/Δx)

Sample No.	Bouncing		Non-bouncing	
	Speed $(m\,s^{-1})$	Ratio	Speed $(m\,s^{-1})$	Ratio
1	4.6391753	0.1022487	7.0422535	0.0524993
2	4.8387097	0.0851164	5.4545455	0.0517519
3	5.2295177	0.0862335	6.4285714	0.0655156
4	4.8648649	0.0748899	5.0561798	0.0488862
5	6.7014147	0.0625278	7.4380165	0.0311127
6	4.8648649	0.1172794	4.1284404	0.0321681
7	4.3902439	0.0636042	5.2023121	0.1140858
8	3.4883721	0.0539507	6.4285714	0.0421712
9	4.5454545	0.0363984	5.6603774	0.0388868
10	5.0279330	0.0615230	5.2023121	0.0838898

Fig.7: Speed and Ratio of both method with all samples

6.2 Observations of data

Comparing the two sets of data (bouncing and reduced bouncing), it was observed that the ratio of vertical oscillation divided by the horizontal distance of the reduced bouncing technique was smaller than that of using the bouncing technique. This finding suggested that the efficiency of running with the reduced bouncing technique was superior. The reduced ratio implies a reduction in the vertical oscillation numerator and/or an increase in the horizontal displacement denominator, indicating a decreased energy expenditure for covering the same distance, thereby resulting in a more efficient running process.

6.3 Analysis of data

6.3.1 Reasons for increasing the running efficiency

Reducing vertical oscillation can improve running efficiency for several reasons. Firstly, as shown in the above analysis of data, by reducing vertical oscillation, runners can conserve energy, which can then be used to improve horizontal movement. This leads to improved running efficiency, as less energy is expended on vertical movement and more on horizontal movement.

This finding is in agreement with our hypothesis that lower vertical oscillation is associated with improved running efficiency in distance running.

Secondly, a smaller movement ratio (vertical oscillation divided by the horizontal distance) indicates that either solely the vertical movement is reduced, or the vertical movement reduced and the horizontal movement increased simultaneously. This shows that by reducing vertical oscillation, the runner can conserve energy for vertical movement, or use more energy in horizontal movement instead of vertical movement. This supports the notion that reducing vertical oscillation can improve running efficiency.

Lastly, reducing vertical oscillation may lead to improvements in distance running performance. By reducing energy wasted in vertical movements, runners can conserve energy and maintain a steady pace over longer distances, improving running efficiency and overall performance.

The results of the experiment suggest that reducing vertical oscillation can improve running efficiency. This finding is consistent with previous research that has linked reduced vertical oscillation to improved running efficiency.

6.4 Experiment conclusion

The experiment results showed that reducing vertical oscillation can improve running efficiency, as indicated by the smaller ratio output. The ratio, calculated by dividing Δy by Δx, becomes smaller when Δy decreases and/or Δx increases, indicating a more efficient running process. Therefore, the hypothesis that reducing vertical oscillation can improve running efficiency stands. Optimizing running form to reduce vertical oscillation could be an effective strategy to improve running efficiency and performance.

7. Discussion

7.1 Possible Errors

1) Calibration errors: The use of cameras and AI algorithms may have introduced errors in the measurement of the key variables, such as inaccuracies in the tracking of the center of mass or errors in the extraction of the vertical and horizontal coordinates.

2) External factors: External factors such as air resistance, terrain, and temperature could have affected the running efficiency of the participants in ways that were not accounted for in the study.
3) Inter-rater reliability: The AI algorithm used for data extraction may not have been 100% accurate, and there may have been some variability in the way that different researchers interpreted the video recordings and extracted the key variables. This could have introduced errors and reduced the reliability of the findings.

7.2 Limitations

1) Learning effects: The participants may have exhibited learning effects over the course of the study, as they were required to run in both bouncing and reduced bouncing conditions. This could have affected the results, as the participants may have adapted their running style based on their previous experiences.
2) Control conditions: The study utilized a pace setter to control the frequency of running and required participants to run in both bouncing and reduced bouncing conditions, which may not fully capture the range of running styles that distance runners employ in the real world.

7.3 Suggestions for Improvements

1) More comprehensive measurement: Future studies could measure a wider range of variables related to running performance, such as foot strike patterns, joint angles, and muscle activation patterns, to gain a more comprehensive understanding of the factors that influence running efficiency.

7.4 Further Investigations

1) Optimal vertical oscillation-to-stride length ratio: Future studies could investigate the optimal ratio between the vertical oscillation and stride length that maximizes running efficiency, as we found out during investigation that extremely small vertical oscillation instead reduces running efficiency.
2) Sex-related differences: Future studies could investigate sex-related differences in running efficiency, such as differences in gait patterns and muscle activation patterns between male and female distance runners.

8. Conclusion

After a series of experiments and analysis, reducing vertical oscillation can improve running efficiency in distance runners by conserving energy, promoting more efficient horizontal movement. These findings have important implications for developing more effective running techniques.

9. Reference

(1) Tartaruga, M. P., Brisswalter, J., Peyré-Tartaruga, L. A., Ávila, A. O., Alberton, C. L., Coertjens, M., & Kruel, L. F. (2012). The relationship between running economy and biomechanical variables in distance runners. Journal of Human Kinetics, 34, 5-14.

(2) Heiderscheit BC, Chumanov ES, Michalski MP, Wille CM, Ryan MB. Effects of step rate manipulation on joint mechanics during running. Med Sci Sports Exerc. 2011;43(2):296-302. doi: 10.1249/MSS.0b013e3181ebedf4. PMID: 20581722.

(3) Saunders, P. U., Pyne, D. B., Telford, R. D., & Hawley, J. A. (2004). Factors affecting running economy in trained distance runners. Sports Medicine, 34(7), 465-485.

(4) How can we change the center of mass of our own body? (2021, October 24). Physics Stack Exchange. Retrieved May 11, 2023, from https://physics.stackexchange.com/questions/673369/how-can-we-change-the-centre-of-mass-of-our-own-body

10. Appendix

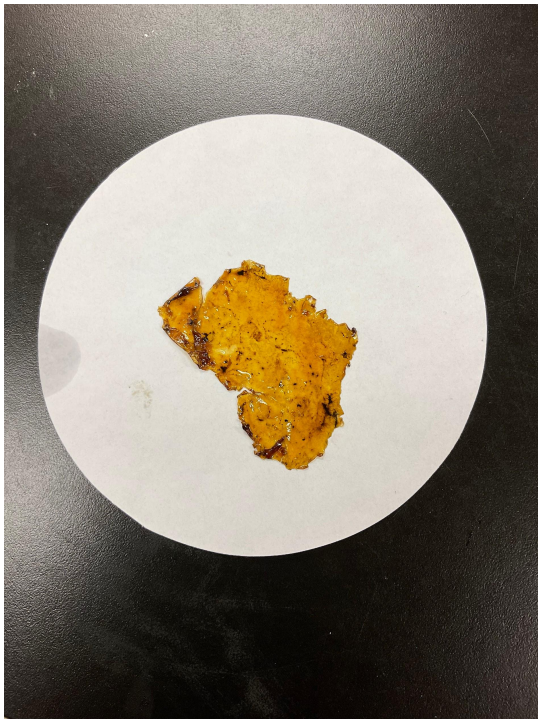
1. Video analysis program in Python with Yolov8

```
from ultralytics import YOLO
model = YOLO('/content/drive/MyDrive/Colab Notebooks/yolov8n-pose.pt')
a_source = '/content/drive/MyDrive/'+source+'.mp4'
results = model(a_source)

vidVar = [0,0]
displacementVidVar = [0,0]
print('\n\n')
vidVar[0] = int(input('Analysis starting frame'))
vidVar[1] = int(input('Analysis ending frame'))

def ratioCal():
        res = []
        res_x = []
        res_y = []
        res_diff = []
        time = []
        ratio = []

        for i in range(vidVar[0],vidVar[1]):
          tmp = results[i].keypoints[0].tolist()
         coor  =  [(tmp[11][0]+tmp[12][0])/2,(tmp[11][1]+tmp[12][1])/2]  #midpt  coor  =
[tmp[0][0],tmp[0][1]]
          res.append(coor)
          res_x.append(coor[0])
          res_y.append(coor[1])
          res_diff.append([coor[0]-res[i-vidVar[0]-1][0],coor[1]-res[i-vidVar[0]-1][1]
])#x,y
        ratio.append((coor[0]-res[i-vidVar[0]-1][1]/coor[0]-res[i-vidVar[0]-1][0]))
#-(dy/dx)
          time.append(i/60)
        print(ratio)

        plt.style.use('_mpl-gallery')

        x = res_x
        y = res_y
```

```
 dict = {'Time/s': time, 'X': res_x , 'Y': res_y, 'Change of position':
res_diff}
 df = pd.DataFrame(dict)
 df.to_csv(name+'/coordinate.csv')

 # plot
 fig, ax = plt.subplots(figsize=(8,2))
 ax.scatter(x, y, linewidth=1.0)
 plt.ylabel(r'y / pixels')
 plt.xlabel('x / pixels')
 plt.title('Ratio Calculation - ' + name)
 plt.savefig(name+'/'+source+'_ratio_xy.png',bbox_inches='tight',dpi=300)
 plt.show()

 print('\n\n\n')

 x_change = []
 y_change = []
 humanCoor = []

 rra = int(input('Enter steps (Complete upward slope)'))

 for i in range(0,rra):
   x_change.append([int(input('Lower '+str(i+1)+' point'))])
   y_change.append([int(input('Upper '+str(i+1)+' point'))])

humanCoor.append([[x_change[i][0],vlookup(x_change[i][0],res)],[y_change[i][0],
vlookup(y_change[i][0],res)]]) #[[lower pt coor][upper pt coor],]

 x_diff = []
 y_diff = []
 d_ratio = []

 for i in range(0,rra):
   x_diff.append(humanCoor[i][0][0])
   y_diff.append(humanCoor[i][0][1]-humanCoor[i][1][1])

 for i in range(0,len(x_diff)-1):
   d_ratio.append(y_diff[i]/(x_diff[i]-x_diff[i+1]))

 print('Ratio: '+ str(listavg(d_ratio)))
```

亞軍

Investigation on properties of SCOBY kombucha tea leather in comparison to kinesiology tape



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Aelita Chan

Cheuk Nim Yan

Isabel Chung

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Phoenix Li

Content

Abstract

There has been a global movement to use sustainable materials in sports equipment and tools. Studies show that materials commonly used to make sports tapes are not environmentally friendly and can have adverse effects on athletes' health. In response to this problem, we are determined to develop an environmentally-friendly sports tape, with the benefits of traditional sports tape without the use of harsh chemicals. We have looked into the possibility of creating a biodegradable kinesiology tape with medical properties, which is a kombucha tea leather. We conducted a scientific investigation on the kombucha yield of different kinds of tea products as well as its properties.

1. Introduction

1.1 Sports tape (kinesiology tape)

Sports tape is an essential item for athletes. It is a thin and elastic tape with a hypoallergenic acrylic adhesive. It can provide support to joints, which in turn relieves pain, reduces inflammation and improves overall performance. However, a case study performed by Mikołajewska in 2010 [1] showed that patients develop skin allergies to the acrylate in glue on the kinesiology tape, which indicates an important medical concern in using traditional athletic tape because skin irritations can lead to severe cutaneous lesions and wounds [2].

1.2 Background and problem analysis

Leather is a strong material that is used in a wide range of consumer goods. Nevertheless, leather processing produces waste, debris and exhaust gases. Recently, the increasing price of leather and the constant pressure from animal rights groups has led to strict regulations on leather preparation and products. Among efforts to solve related difficulties of the leather industry, the reuse approach of bio-waste has shown promise in developing the eco-friendly and animal-free alternative leathers, such as mushroom-derived leathers and bacterial cellulose-derived leathers. Kombucha leather is a bacterial cellulose-derived leather that is not made from animal skin. It can be applied in footwear and decoration. It is prepared by culturing cellulose-synthesising bacterial strains in the fermented media.

1.3 Fermentation of Tea

Fermentation of tea is a chemical process that requires carbohydrates to be present. In our experiment, sugar, water and a SCOBY are used [3]. When yeasts consume the sugar in the tea, they break down the sucrose into glucose and fructose through anaerobic respiration. Ethanol and carbon dioxide are produced. The good bacteria will then ingest the ethanol and produce acetic acid, also known as vinegar, which helps protect the culture against invading organisms. The bacteria will create a biofilm (protein and polysaccharide) that houses the yeast and bacteria. This biofilm serves as physical protection against external organisms and stores resources to ensure long-term symbiosis. In addition, bacteria produce enzymes that break down complex molecules in order to use the glucose for energy and to sustain the SCOBY.

Fermentation equation:

$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$

(Glucose) → (Ethanol) (Carbon Dioxide)

Kombucha is composed of different substances as shown in Fig1.1 and 1.2. Bacteria in SCOBY perform fermentation of their own, converting alcohols from yeast into organic acids. Bacteria strains like acetobacter and gluconobacter convert the remaining sugar and alcohols from yeast into acetic acid, gluconic acid, and other desirable acids in kombucha.

Microbial Strain	Type	Common Source
Lactobacillus nagelii (Lactic acid bacteria)	Bacteria	Milk, sugary food
***Gluconacetobacter* (Acetobacter)**	Bacteria	Sour juices, ripe fruits
Gluconobacter	Bacteria	Flowers,fruits
Komagataeibacter	Bacteria	Vinegar, sugary food
Brettanomyces bruxellensis	Yeast	Wineries
Candida stellata	Yeast	Overripe grapes
Schizosaccharomyces pombe	Yeast	Soil, sugary/alcoholic drinks
Torulaspora delbrueckii	Yeast	Grapefruits, berries
Zygosaccharomyces bailii	Yeast	Wine, tea, vinegar

Fig 1.1

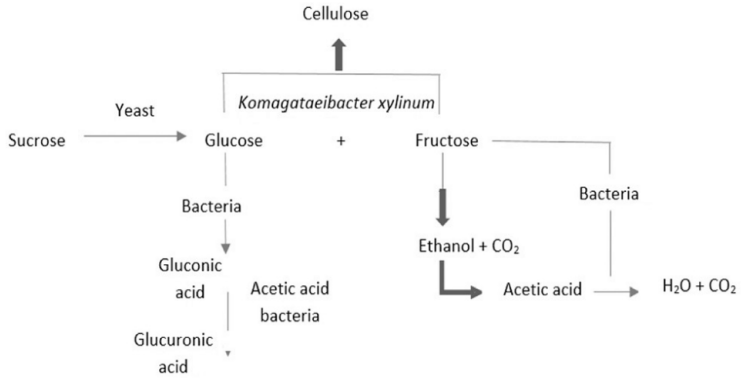
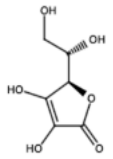


Fig 1.2

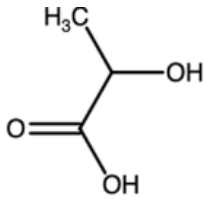
Chemical	Compound Type	Source
Acetic acid	Organic acid	Bacteria
Gluconic acid	Organic acid	Bacteria
Glucuronic acid	Organic acid	Bacteria
Citric acid	Organic acid	Bacteria
Lactic acid	Organic acid	Bacteria
Malic acid	Organic acid	Fruit
Tartaric acid	Organic acid	Fruit
Malonic acid	Organic acid	Bacteria
Oxalic acid	Organic acid	Fruit
Succinic acid	Organic acid	Bacteria
Pyruvic acid	Organic acid	Bacteria
Usnic acid	Organic acid	Bacteria
Sucrose	Sugar	Additive
Glucose	Sugar	Yeast
Fructose	Sugar	Yeast
Ethanol	Alcohol	Yeast
Glycerol	Alcohol	Yeast
Methanol	Alcohol	Yeast
Vitamin B	Vitamin	Tea leaves
Vitamin C	Vitamin	Tea leaves
Proteins	Amino acids	Unknown
Purines	Organic compound	Unknown
Pigments	Organic compound	Unknown
Enzymes	Enzyme	SCOBY
Tea polyphenols	Organic compound	Tea leaves

Fig 1.3 Chemical composition of kombucha

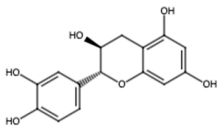
Vitamin C



Lactic Acid



β-catechin



Ethanol

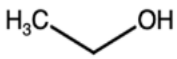


Fig 1.4

2. Experimental Details

2.1 Making the kombucha tape

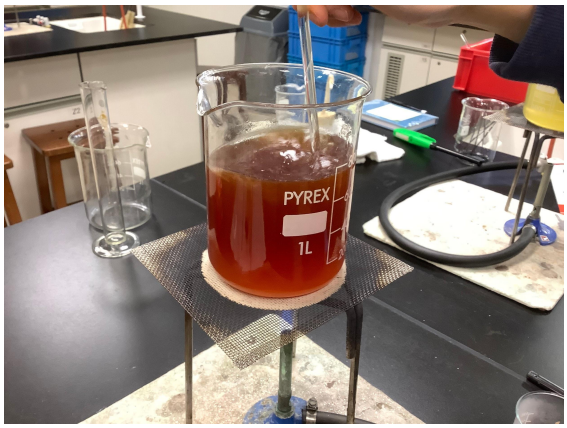
Objective: To create a kombucha leather that would be used for sports tape.

Preparation of kombucha tape

1. 630mL of distilled water is boiled and cooled to room temperature.
2. 1 green tea bag is brewed.
3. The tea bag is removed and sugar is added to the tea; vinegar is added to some of the mixture.
4. The mixture is stirred with a glass rod until the sugar is completely dissolved.
5. The mixture is poured into a cuboid container, covered with a cling wrap and another container, providing a dark environment for the SCOBY to grow.

Drying of kombucha tape

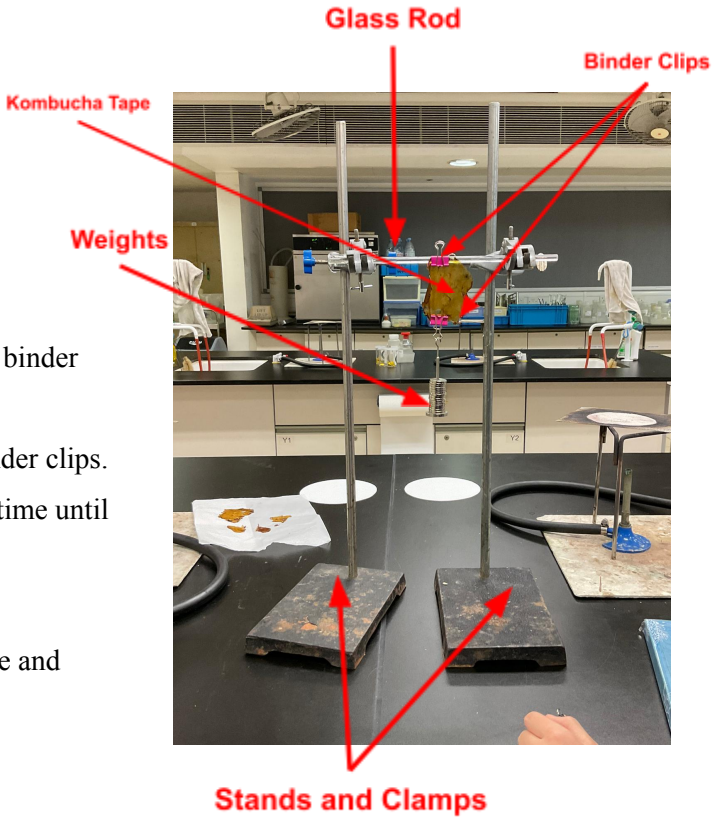
1. The solution was poured onto a flat surface lined with parchment paper and placed in the oven until it was thoroughly dried.
2. The film was peeled off the parchment paper with a spatula and tested for results.



2.2 Tensile strength test

Objective:

To test the tensile strength of the kombucha leather.



Procedures:

1. Clip the kombucha leather to the glass rod with binder clips.
2. Attach the hook of the weights to one of the binder clips.
3. Increase the force by adding weights of 5g at a time until the leather breaks.
4. Record the total mass of weights used.
5. Repeat Steps 1-4 with PARZT Kinesiology Tape and Cohesive Bandage.

2.3 Water permeability test

Objective:

To test the water resistance, waterproof ability of the kombucha leather.

Procedures:

1. Place the kombucha leather on a piece of filter paper.
2. Add 3 drops of water onto the leather with a dropper.
3. Lift up the filter paper and observe whether there is water on it.
4. Repeat Steps 1-3 with PARZT Kinesiology Tape and Cohesive Bandage.

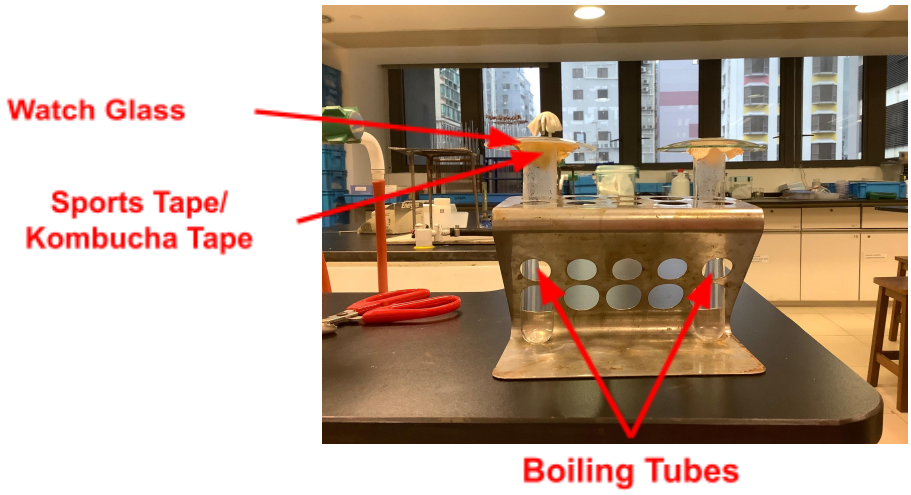
2.4 Water vapour permeability test

Objective:

To test the water vapour permeability of the kombucha leather.

1. Boil 20mL of water and pour it into a boiling tube.
2. Dry the leather and place it on top of the mouth of the test tube. Make sure it covers the whole mouth.
3. Place an inverted watch glass on top of the test tube.
4. Observe whether water droplets are formed on the watch glass.
5. Repeat Steps 1-4 with PARZT Kinesiology Tape and Cohesive Bandage.

Water permeability test



3. Results and Analysis

Making of Kombucha Tape

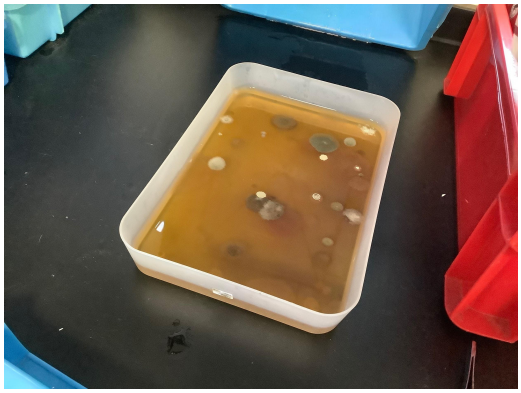
We have used different types of tea and amounts of ingredients according to the recipes. After trial and error, we have successfully synthesised and identified the best combination for creating the kombucha leather, which is batch A. Hence, we reproduced a few of batch A to obtain a more reliable result[.

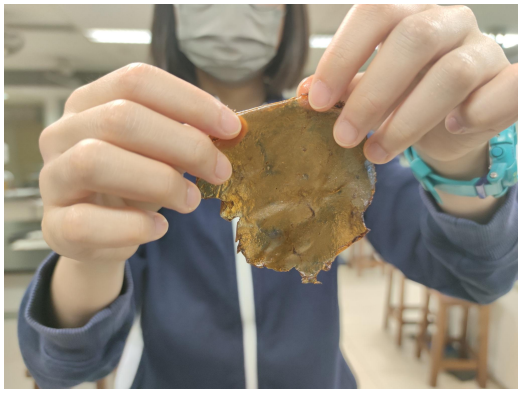
Results of kombucha leather trials

	Ingredients					
Batch	Type (brand) of tea	No. of teabag/ tea (mL)	Granulated sugar (g)	Distilled water (mL)	Vinegar (mL)	SCOBY
A1	Green Tea	1	34	630	/	/
A2	Green Tea	1	30	630	/	/
A3	Green Tea	1	30	630	30	/
A4	伊藤園 - 日本綠茶茶包	1	30	630	/	/
B	Yogi green tea kombucha	2	34	630	/	/
C	Green Tea	1	34	630	30	Dried kombucha starter culture (12 g)
D	Black Tea	1	34	630	30	Dried kombucha starter culture (12 g)
E	Kombucha Tea	250 mL	7.5	125	/	/
F	Black Tea Kombucha Tea	2 500 mL	160	2520	260	Dried kombucha starter culture (10g)

3.1.1 Images of results:

A1:





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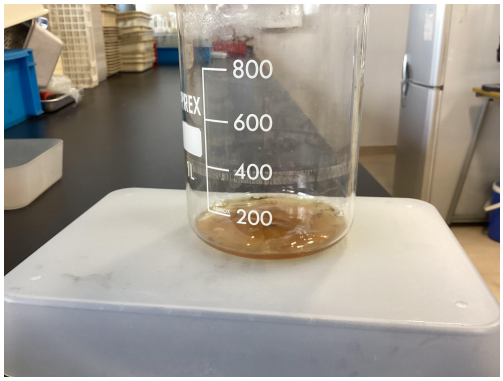

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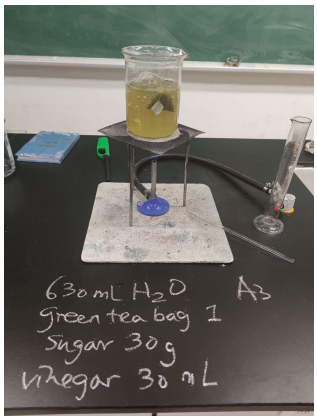

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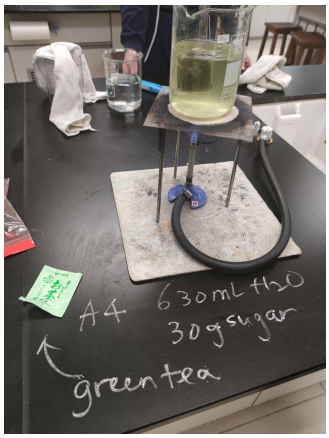

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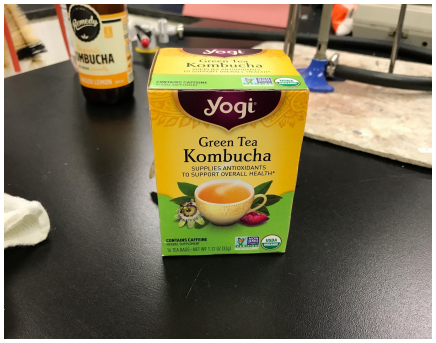

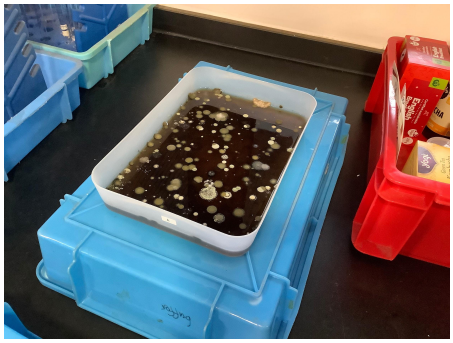

Turns dark and mouldy

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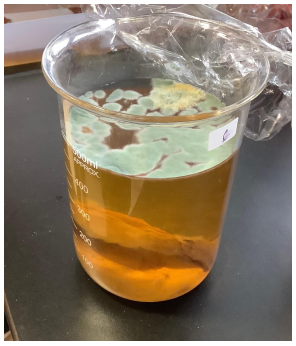

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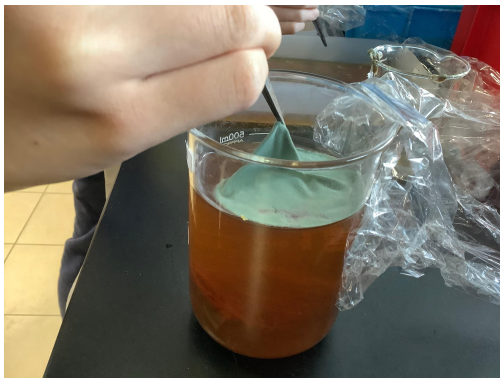

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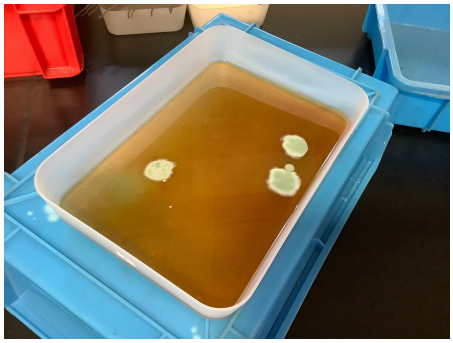

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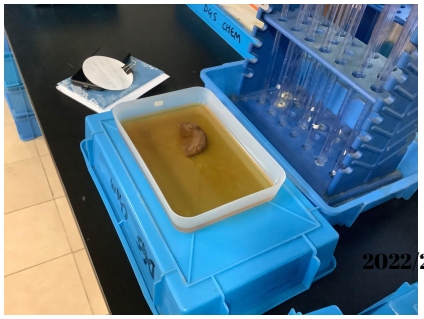

3.1.2 Appearance of Kombucha leather

The leather appears brown as this is the natural colour of kombucha. There is a thin layer of oil on the kombucha leather which makes it sticky and water-resistant. The texture is delicate and gelatinous, soft and slimy. The older the leather gets as time passes, the darker the shade of brown observed. The surface is mildly rough and uneven.

3.1.3 Biodegradability of Kombucha Tape

kombucha produced using green tea extracted is 100% biodegradable as kombucha decomposes in about 6 months with the help of catalysts such as insects, additional sugars, bacteria, sunlight and rain according to previous research [5]. The materials use only organic materials with only small amounts of thermal and chemical energy needed while being fully compostable once grown.

3.2 Tensile Strength of Kombucha Tape

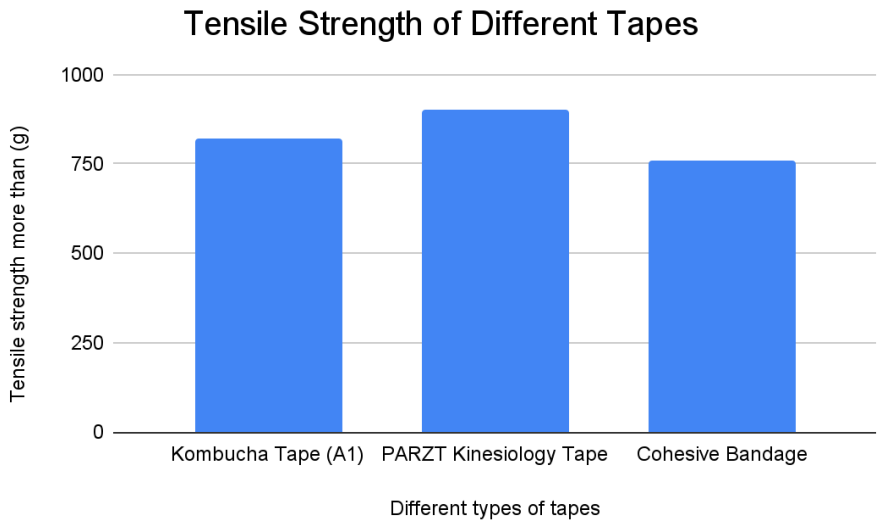

Fig 3.2

The experimental results from the table below show that our kombucha tape has excellent tensile strength compared to sports tape used by athletes. This is important for sports tape because the pressure it gives to the athletes facilitates muscle contraction and supports muscle building. It is tested to be sufficiently strong and can hold weights amounting to 750g+, equivalent to the strength of professional athletic tapes. We deduce that our kombucha tape has high tensile strength since it is made from cellulose, a stretchy material. The kombucha leather is a layer of cellulose on the surface of the sweetened tea mixture. Cellulose is a flexible natural polymer made up of repeating units of glucose. Cellulose fibres in kombucha leather are arranged in such a unique way that allows the material to be stretched and bent without breaking, giving the kinesiology tape strength and flexibility. In addition, sealing the leather with additional materials like natural essential oils can help strengthen the tape. Research has also shown that

adding higher concentrations of sugars to the leather can significantly increase its durability and flexibility [7]. Therefore, it shows that our Kombucha Tape has similar abilities to professional kinesiology tape.

3.3 Water permeability of Kombucha Tape

Type of tape	Water permeability
Kombucha Tape	***No***
PARZT Kinesiology Tape	***No***
Cohesive Bandage	Yes

Fig 3.3

Water resistance

Kombucha leather has excellent water resistance. This allows for higher durability, since sports tapes may be frequently in contact with liquids such as perspiration. However, the kombucha leather film softens in moisture and becomes less durable. From the above conclusion and Fig. 3.4, we can infer that PARTZ Kinesiology Tape > Kombucha tape > cohesive bandage.

3.4 Water vapour permeability of Kombucha Tape

Type of tape	Water vapour permeability
Kombucha Tape	***Yes***
PARZT Kinesiology Tape	***Yes***
Cohesive Bandage	***Yes***

Fig 3.4

Breathability

Kombucha leather is highly breathable as it allows air to flow through, enabling it to regulate temperature and moisture, making it a comfortable material to be worn for extended periods of time. Kombucha tape is made up of a network of interlocking cellulose fibres, creating tiny pores that allow air and moisture to pass through. This structure also helps wick moisture, preventing the buildup of sweat and odour. This breathability poses a contrast to traditional leather, which is less breathable due to its dense structure and lack of pores. Additionally, the breathability of kombucha leather can help to prevent the growth of bacteria and fungi, which can cause odours and other problems.

Left: Kombucha leather on filter paper. Right: Cohesive tape on filter paper

4. Discussion

4.1 Effects of temperature on kombucha growth

Kombucha is fermented at temperatures ranging around 75-85°F, since warm weather tends to accelerate fermentation. Our kombucha has been brewing for only 2-3 months under fluctuating temperatures throughout winter and early spring in Hong Kong. The lower the temperature, the longer the time it takes for fermentation. This explains why the leather appears to be relatively weak and only a small piece of fabric can be obtained. However, if the temperature of the tea added to kombucha is too high, the SCOBY might be damaged or killed [6]. To maintain a consistent temperature to maximise the chances of successful formation of kombucha, an incubator can be used instead of leaving the leathers in room temperature. Adding a larger volume of starter tea can also aid in increasing the speed of fermentation under relatively cooler temperatures.

4.2 Properties

4.2.1 Application

Due to its adhesive, breathable and water resistant properties, our Kombucha Tape is suitable for creating biodegradable kinesiology tape. It can be worn in rain and prevents the building up of sweat, which allows higher comfortability during intense exercise.

4.2.2 Comparison between kombucha leather and animal leather

Animal-based leather is more durable compared to Kombucha leather since it has stronger bonds and is more robust than Kombucha leather. Animal-based leather is also considered to be fully waterproof. However, Kombucha leather can undergo treatments to make it waterproof with sealants. Kombucha leather does not require chemical-based tanning, unlike traditional leather. These chemicals are not biodegradable and the tanning process emits effluent as well as toxic gases. The leather tanning process also requires vast amounts of water and energy making it unsustainable, destroying ecosystems. Moreover, Kombuchaleather is soft even when dry, making it perfect for making kinesiology tape. In fact, Kombucha leather offers more comfort due to its softer texture.

4.3 Major challenges

4.3.1 Adhesive structure and versatility

Adding the adhesive characteristic of traditional plastic tape to biodegradable tape is extremely time-consuming. We have to do many tryouts and experimental analyses to create an adhesive tape that benefits athletic performance while possessing waterproof and medical properties. However, Kombucha leather is more versatile compared to animal leather. Kombucha leather can be produced in any shape and does not require any sewing process as the pieces will stick together and dry as one. Wet and dyed Kombucha leather can be cut and naturally sealed together during the drying process.

4.3.2 Production

Producing high-quality biodegradable athletic tape requires specialised equipment and standardised experimental procedures that are not attainable at our level, causing it to be challenging to find the most suitable way in production, considering our limited time and resources. Knowledge regarding material science, engineering and chemistry has to be further developed.

4.3.3 Cost

Although biodegradable materials are more expensive than synthetic materials, Kombucha leather only requires freshly sweetened tea to grow, making it considerably cheaper to produce than animal hide. Kombucha grows rapidly and reproduces more SCOBYs during the fermentation process. Hence, it does not require large-scale production and can be created by household methods. Only a small number of ingredients are required which makes the economic return of kombucha tape even higher.

4.4 Areas of improvement

4.4.1 Limitations

One limitation of our experiment is the limited variety of tea types. To improve, we can expose the experiment to a wider range of tea types such as white tea, yellow tea and red tea. We can even mix tea breeds to find the optimal combination in producing kombucha leather. If time allowed, we could add Chinese medicine to the kombucha leather. In late April, we made a new set up by adding asiatic wormwood to the original ingredients. Asiatic wormwood contains compounds that have anti-inflammatory properties which can help reduce inflammation and pain in athletes' bodies. More time is needed for results to be observed.

4.4.2 Further tests

Biodegradability Test

The kombucha leather will be placed inside a soil sample, along with a piece of PARZT kinesiology tape and cohesive bandage to act as control. The set-up will be placed under a controlled environment with a temperature of 24°C to simulate the landfill environment. After 30 days, we will measure the mass of the remaining pieces of tape. The final mass will be compared with the initial mass of the tapes to compare the rate of degradation of the tapes.

5. Conclusion

We have found out that a mixture of green tea, sugar, and SCOBY can be fermented to produce the best yield of kombucha leather, which is fully biodegradable and can help reduce the negative impacts on the environment produced by traditional animal leather. It is tested to have a high tensile strength, breathability and water resistance. It is also softer in texture in comparison to traditional leather, making it an environment-friendly and cost-effective choice for making kinesiology tape.

6. References

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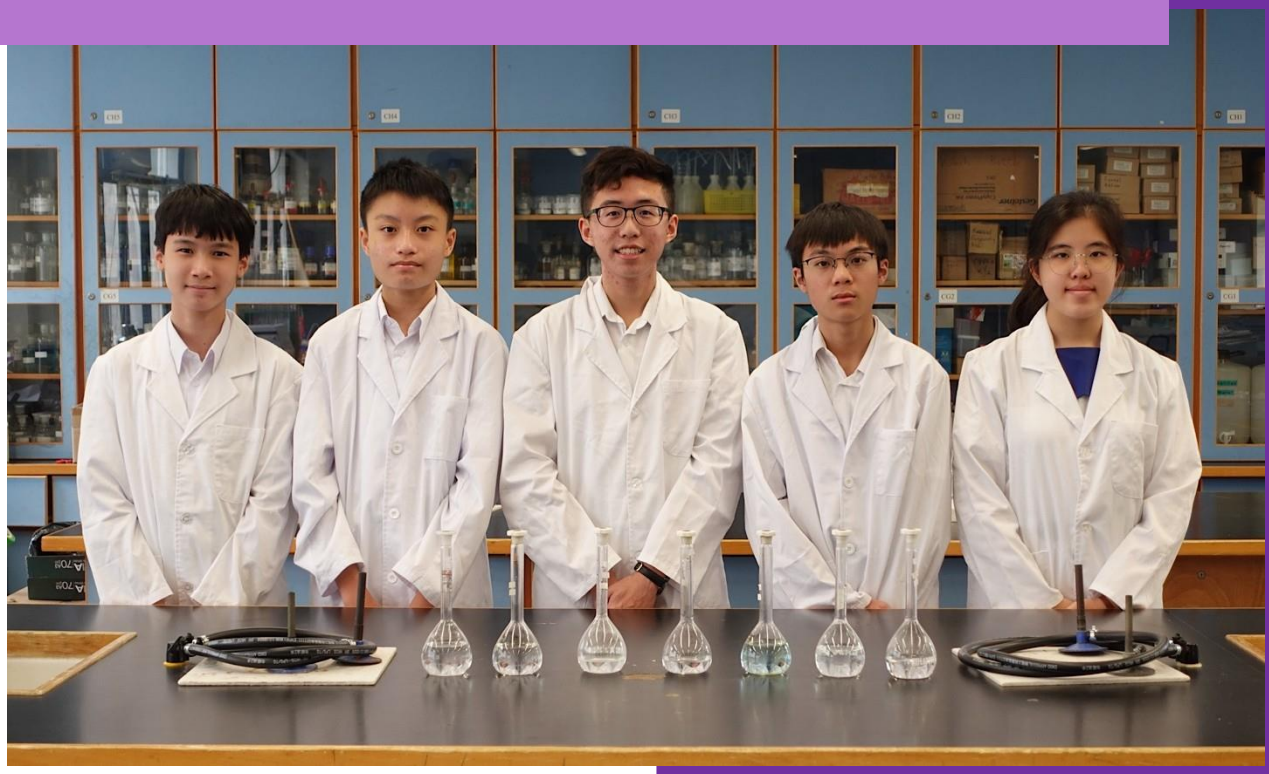
Waste vs. Waste –
Investigation of Chitosan in Removing Heavy Metal Ions in Water



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Abstract

Heavy metal pollution in seawater is a growing concern, particularly in Hong Kong. Marine ecology has been greatly damaged due to the excess amount of heavy metal in seawater, which can be toxic for sea creatures. Thus, the following report investigates the use of chitosan as a potential solution for removing heavy metal ions from water. Through a series of experiments, we examine the effectiveness of chitosan in removing heavy metal ions. Our findings demonstrate that chitosan is a promising material for heavy metal ion removal and can be used as a cost-effective, eco-friendly, and sustainable solution to remove heavy metal pollution in seawater. Hence, contributing to the future society.

1. BACKGROUND

1.1 Heavy Metal Pollution in Drinking Water in Hong Kong

Heavy Metal Contamination in Hong Kong's Seawater: A Pressing Environmental Challenge

Water pollution is a critical issue in Hong Kong, and recent research has highlighted the severity of the problem. In 2017, Professor Leung Kwok Hi from City University conducted a study in which he collected seawater and sea mud samples from four locations near the docks in Aberdeen Typhoon Shelter to assess heavy metal contamination. The results indicated that two of the seawater samples recorded 15.1 micrograms per litre of heavy metals, exceeding the second level of the national sea water quality standard of no more than 10 micrograms per litre. Such high levels of contamination render the water unsuitable for aquaculture, swimming, or marine sports.

In addition to this, Hong Kong generates approximately 2.8 million cubic metres of sewage per day, further compounding the water pollution problem. The seawater in Hong Kong is also contaminated with various harmful heavy metals, including Arsenic, Barium, Beryllium, Cadmium, Copper, Mercury, Selenium, Silver, Thallium, Tin, and Zinc. These sources of contamination highlight the prevalence of heavy metal pollutants in Hong Kong's water.

Therefore, it is evident that water pollution is a major concern in Hong Kong, with heavy metal contamination being a significant contributor to the problem. Addressing this issue is of utmost importance to protect public health and the environment.

Health Risks of Heavy Metal Pollution Drinking Water: Insights from Research and Past Incidents in Hong Kong

Heavy metals pollutants in water pose a high health risk to human beings. Research from the United States National Library of Medicine (NLM) has shown that chronic exposure to environmental pollutants can have serious health consequences, including cancer, weakened immunity, diminished white blood cells, and birth defects. Cadmium (Cd) is one of the common heavy metal pollutants found in water, and high levels of this metal in drinking water can lead to chronic kidney disease and other short- and long-term disorders, particularly in older adults.

The 2015 Lead in Drinking Water Incidents in Hong Kong further demonstrate the detrimental effects of significant water pollution on citizens. In more than 20 housing estates and 15 educational institutions, lead and other heavy metals were found to have contaminated drinking water. The HKSAR government's report on the incident highlighted the high health risk posed by heavy metal contamination in drinking water, especially for children and pregnant women. As a result, the report emphasised that lead in drinking water should not be tolerated, and measures should be taken to keep its concentration in water as low as possible.

Thus, reducing heavy metals in Hong Kong's water is crucial not only for the ecosystem but also for the long-term health of its residents.

1.2 Global and Local Efforts to Combat Water Pollution

In recent years, the Hong Kong Special Administrative Region (HKSAR) government has implemented several environmental conservation-related policies in response to the global call for action and China's development direction towards long-term sustainability. These policies aim to address the issue of water pollution, which is a significant environmental challenge worldwide.

On the global scale, the United Nations (UN) has made several attempts to combat water pollution. The 2009 Biodiversity Conference held in Copenhagen discussed protecting aquatic ecosystems by improving overall water quality. However, little progress was made, and the UN 2023 Water Conference was hence held in New York in March 2023 to further address this issue. It remains to be seen whether this conference will be effective in improving global water quality.

At the local level, the People's Republic of China (PRC) has also contributed to the battle against water pollution. The PRC's 14th Five-Year Plan includes promoting sustainable development alongside economic growth. The HKSAR government has also implemented the Sewage Charge (SC) since 2008, as well as the Harbour Area Treatment Scheme (HATS), which became fully operational at the end of 2015. The HATS aims to enhance the marine quality of Hong Kong, particularly in the two sides of the Victoria Harbour.

Given the global and government efforts to create a cleaner environment, as students, we would like to contribute to this cause. As such, we propose to design a material that can effectively absorb heavy metal pollutants in the sea. This material could potentially help address the water pollution issue and contribute to the global goal of achieving long-term sustainability.

1.3 Chitosan as a Sustainable Solution for Heavy Metal Pollution in Hong Kong's Seawater

Heavy metal pollution in the ocean is a pressing environmental issue that requires urgent attention to promote sustainable development and protect marine ecosystems. In response to this challenge, we propose the use of chitosan as a potential solution. It is a biopolymer derived from shrimp shell waste and has been found to effectively remove metal ions from water, making it a promising candidate for tackling heavy metal pollution in the ocean.

A study conducted by Kungliga Tekniska högskolan, a world-class Swedish university, has shown that chitosan has a high affinity for metal ions and can effectively remove them from solution. Another dissertation published by the Malaysian Analytical Sciences Society from the Malaysian Journal for Analytical Sciences also demonstrated that chitosan's amino and hydroxyl groups in its molecule structure can serve as attachment sites for metal ions.

Furthermore, chitosan can be extracted from shrimp shell waste using chemical methods and characterised by Fourier-transform infrared spectroscopy (FT-IR). Since the global population generates approximately 6 to 8 million tons of crustacean waste per year, chitosan is a sustainable solution that can tackle heavy metal pollution while simultaneously reusing waste.

The European Union (EU) has recognised the potential of chitosan for tackling water pollution and has provided nearly €15 million in grants for chitosan-related projects between 2000 and 2015. These grants have enabled further research into the effectiveness of chitosan in removing metal ions. Subsequently, grant values have increased, reaching €55 million after 2015, demonstrating the growing interest in chitosan as asustainable solution for water pollution.

Numerous studies have also explored the chemical modification of chitosan for metal ion removal. For example, research from King Abdulaziz University in Saudi Arabia has demonstrated that cross-linked carbohydrate-modified chitosan is preferable for metal uptake over uncross-linked chitosan. The latter can leach carbohydrates into the medium and cause contamination. These studies highlight the enormous potential of chitosan in contributing to the combat against heavy metal pollution.

In conclusion, chitosan's low cost, high affinity for metal ions, and sustainable nature make it a feasible solution for tackling heavy metal pollution in Hong Kong's seawater. Future research should investigate the feasibility and efficiency of chitosan as a product for removing heavy metals from water in experimental settings. This research will be critical in determining the efficacy of chitosan and its potential to address the pressing issue of heavy metal pollution in the ocean, particularly in Hong Kong.

1.4 Binding Action between Chitosan and Metal Ions

Chitosan is a polysaccharide that comes from the outer skeleton of shellfish, including crab, lobster, and shrimp, which are usually treated as food scraps and buried in landfill. After several simple procedures, chitosan can be easily extracted and now widely applied in medicine and in drug manufacturing.

The binding between chitosan and metal ions are well studied. Some binding modes are exemplified as Figure 1 beside. In general, the binding involves the amino groups ($-NH_2$) and hydroxyl groups (-OH).

Chitosan is soluble in water at lower pH due to the protonation of amino groups. (Figure 1) The positive charges can enhance the interaction with water and straighten the polymer chain by electrostatic repulsion. However, the binding of amino group with metal ions is greatly affected by protonation as well. Hence, pH of binding of chitosan and metal ion must be optimised.

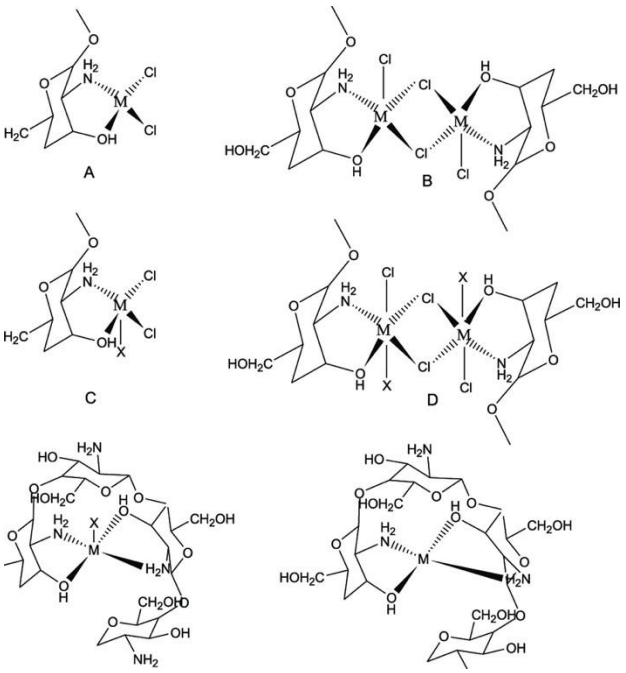


Figure 1 Different bind modes between chitosan and metal ions.

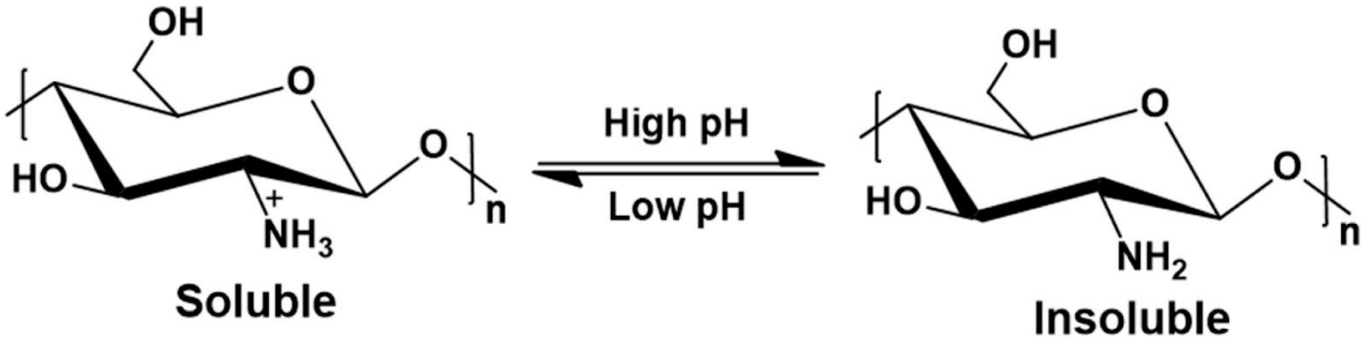


Figure 2 Structure and solubility of chitosan in acidic and alkaline medium.

2. EXPERIEMENTS

2.1 Reagents

Chitosan (Water-soluble, Sigma-Aldrich), $ZnSO_4 \cdot 7H_2O$ (Peaking), $CdCl_2$ (M&B), $BaCl_2$ (Peaking), $CuCl_2$ (RDH), $MnSO_4 \cdot 4H_2O$ (UNI) and $Pb(NO_3)_2$ (Peaking) were used without further purification. Calmagite (UNI) solution is freshly prepared from its crystal (0.1 g in 1000 ml distilled water) and stored in amber bottle.

2.2 Instrument

A PASCO PS-2600 Spectrometer together with PASCO Spectrometry Application is used in obtaining UV-Vis spectrum.

2.3 Procedures

1. *UV-Vis spectrum of calmagite-metal ion complexes:*
   0.01 M stock solution of Zn^{2+}, Cd^{2+}, Ba^{2+}, Cu^{2+}, Mn^{2+} and Pb^{2+} were prepared by dissolving appropriate amount of $ZnSO_4 \cdot 7H_2O$, $CdCl_2$, $BaCl_2$, $CuCl_2$, $MnSO_4 \cdot 4H_2O$ and $Pb(NO_3)_2$ in 250.0 ml distilled water. The solutions were further diluted to target concentrations with distilled water. In order to obtain the UV-Vis of calamagite-metal complex, 2 ml of metal ion solution and 0.5 ml of calmagite solution were added to a 3-ml cell with optical path of 1cm. Then 0.5 ml of pH 10 phosphate buffer was mixed with the mixture.

2. *Preparation of chitosan stock solution:*
   7.50 g of chitosan was suspended in 200 ml distilled water. The mixture was acidified with 2 M nitric acid until all chitosan was dissolved. The resulting mixture was made up to 250.0 ml in a volumetric flask and stored at room temperature until further use.

3. *Action between chitosan and different metal ions:*
   10 ml of chitosan stock solution and 40 ml of metal ion solution were mixed. The pH of resulting mixture was adjusted to above 6 by adding 3 M NaOH hydroxide solution followed by centrifugation at 4,000 rpm for 10 minutes. The metal ion concentration remained in supernatant is determined from the calibration curve based on the UV-Vis spectrum with calmagite solution.

2.4 Results and Discussions

2.4.1 Binding between calmagite and metal ion at different concentrations

Calmagite (Figure 3) is a widely used indicator in complexometric titration with different metal ions which shows different colour upon binding with oxygen atoms and nitrogen atoms as binding sites.

First, we tried to add lead(II) nitrate with calmagite solution. However, its UV-Vis spectrum is almost identical to pure calmagite solution irrespective to Pb^{2+} concentrations. It was suspected that the phenols in calmagite may not be deprotonated which may weaken the binding ability. Hence their UV-Vis spectrum was taken again using pH 10 buffer and shown in Figure 4. In order to minimize the precipitation of Pb^{2+} at higher pH, Pb^{2+} solution was first mixed with calmagite solution followed by slow addition of pH 10 buffer.

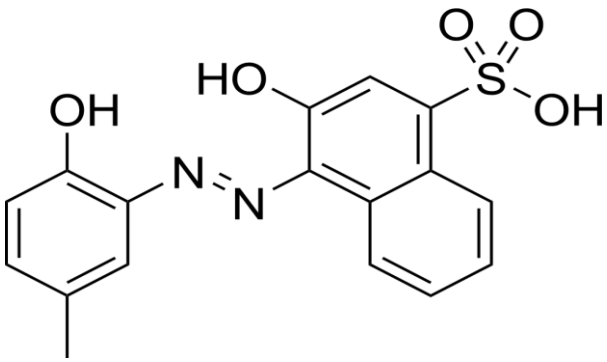


Figure 3 Structure of calmagite

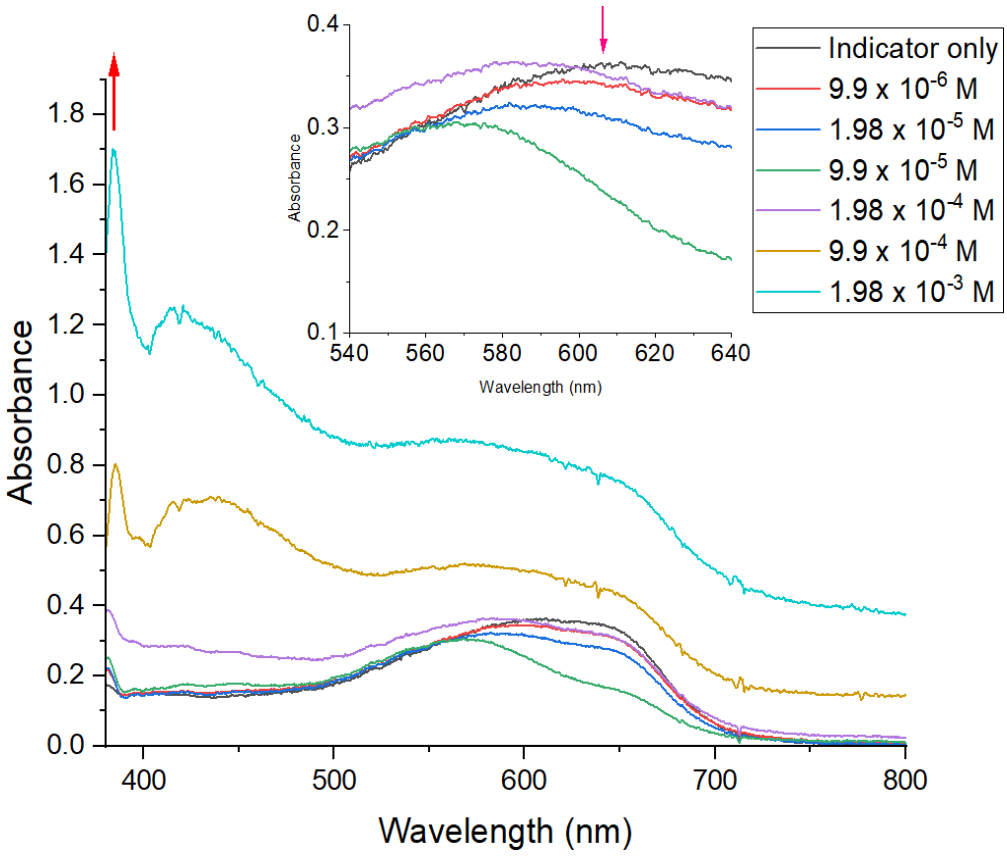
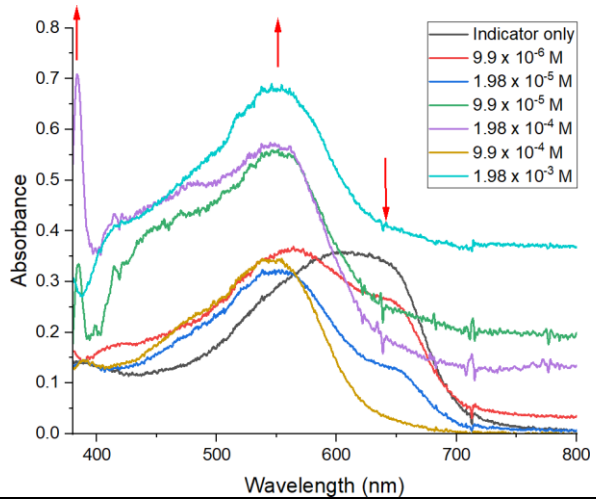


Figure 4 UV-Vis spectrum of calmagite-Pb^{2+} mixture at different concentrations.

From the UV-Vis spectrum, a new peak at 385 nm, which is absent in calmagite solution at the same pH, emerges with increasing Pb^{2+} concentrations. This shows that the calmagite successfully combines with Pb^{2+}. However, at higher Pb^{2+} concentrations, the UV-Vis spectrum shifts significantly from the baseline. This suggests some Pb^{2+} may be in excess and cannot be bound by calmagite, and eventually precipitate out as $Pb(OH)_2$. This coincides with the observation that the solution was turned turbid when using 0.01 M Pb^{2+} solution. Using the same methodology, the UV-Vis spectrum of complexes with Zn^{2+}, Cd^{2+}, Ba^{2+}, $Cu^{2+}$and Mn^{2+} were recorded and summarised as Figure 5.

(a)



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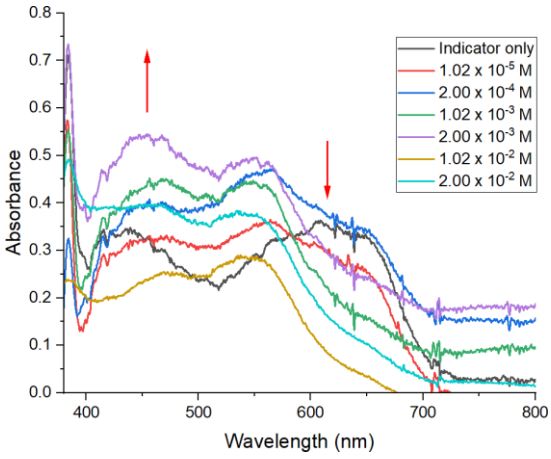

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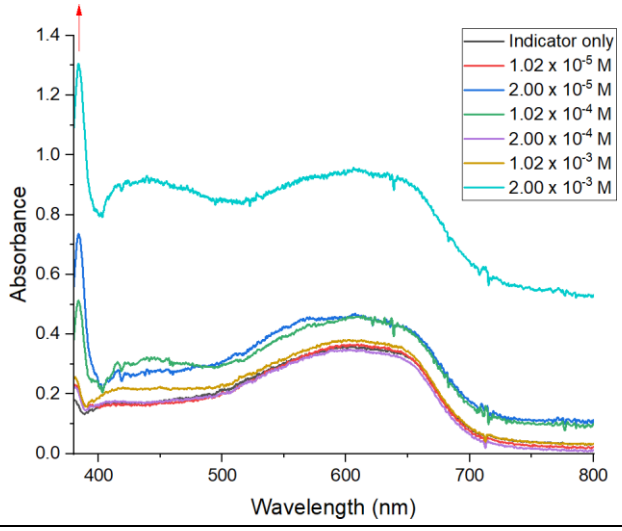

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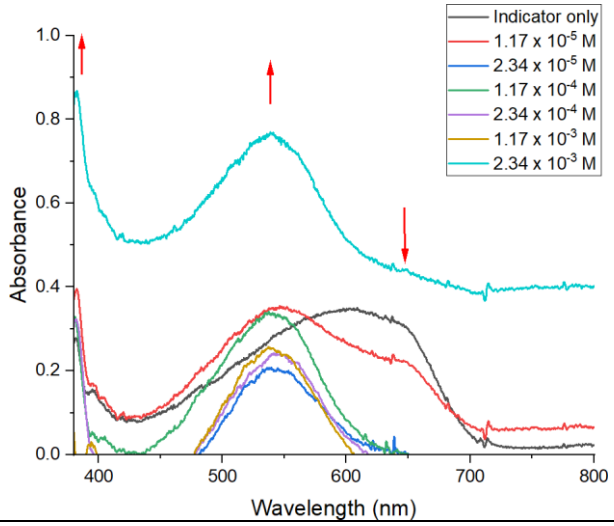


(e)

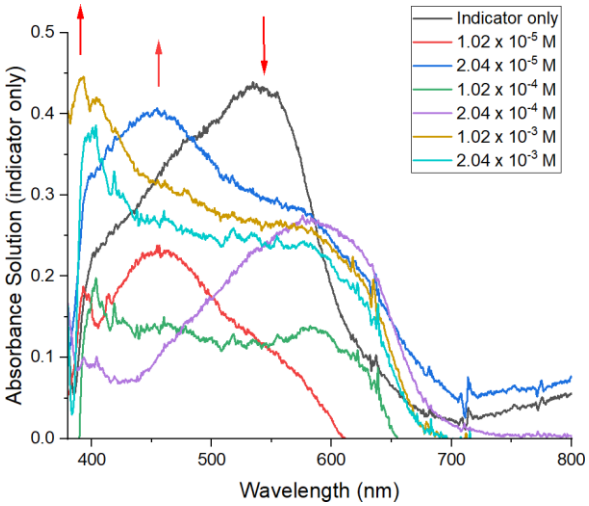


Figure 5 UV-Vis spectrum of calmagite mixture with (a) Zn^{2+}, (b) Cd^{2+}, (c) Ba^{2+}, (d) $Cu^{2+}$and (e) Mn^{2+} at different metal ion concentrations.

Although new peaks emerge as metal ion concentration increases from their UV-Vis spectrum, the wavelength of absorption peak also changes especially at higher metal ion concentration. It is suspected that the binding mode between calmagite and metal ion may be changed at higher metal ion concentrations.

2.4.2 Solubility of chitosan in acidic medium

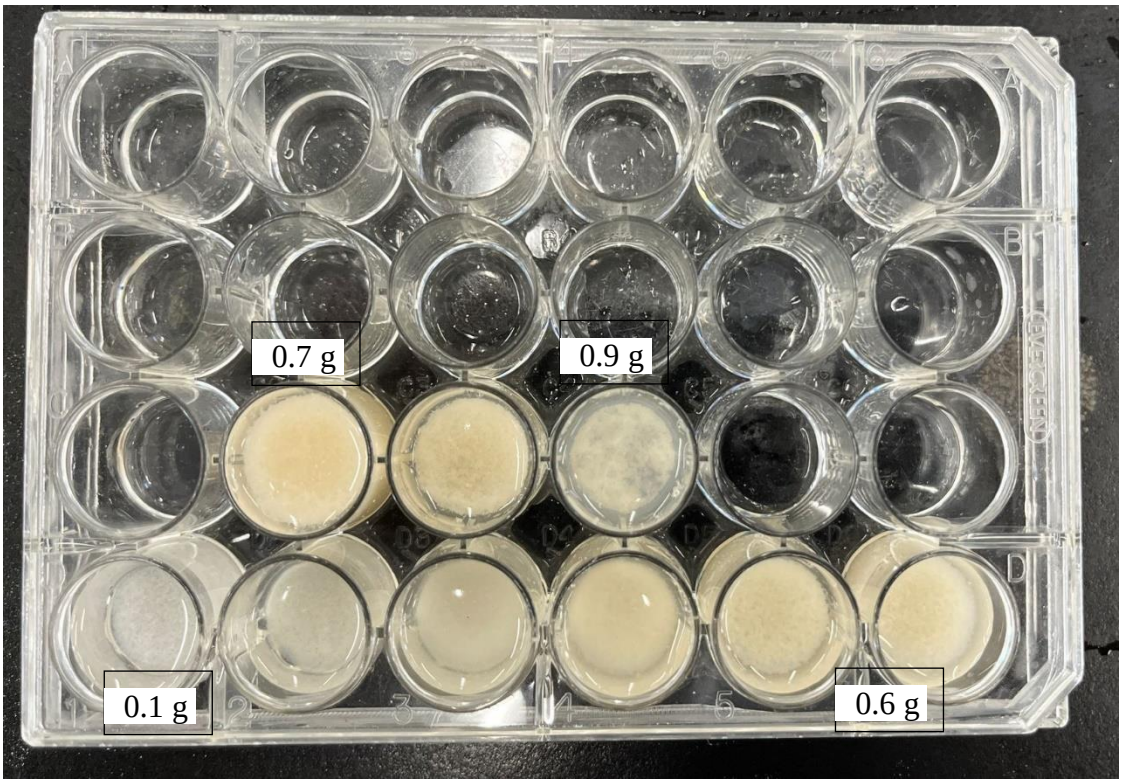


Figure 6 Addition of different amount of chitosan (0.1 to 0.9 g) in 50 ml pH 4 buffer.

The solubilities of chitosan at different pH values (pH 4 to pH 10) were studied in order to find out the optimum condition for binding with metal ions. However, even at pH 4, 50 mol of pH 4 buffer could not completely dissolve 0.1 g chitosan. This is not desirable as undissolved chitosan has limited binding ability with metal ions. In addition, it was found that Pb^{2+} also forms precipitate with pH 4 biphthalate buffer. In order to avoid any complication, the chitosan was dissolved in water by slow addition of 2 M nitric acid instead of pH 4 buffer. The resulting stock solution is shown in Figure 7.

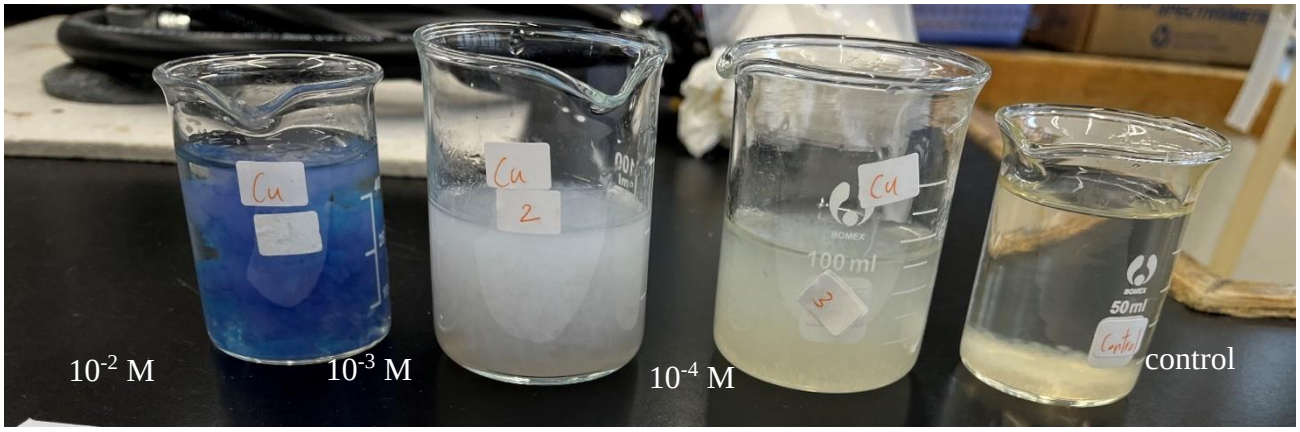
Figure 7 Chitosan stock solution by dissolving 7.5 g of chitosan in distilled water with slow addition of 2 M nitric acid.

2.4.3 Action between chitosan and metal ions

The chelation study of chitosan is achieved by first mixing chitosan stock solution with metal ion solutions. Then the pH is slowly raised by dropwise addition of 4 M NaOH solution with thoughtful stirring. In theory, amino group will be restored after deprotonation and will participate in the chelation. In addition, the slow addition of NaOH solution would minimize the chance for metal ions forming insoluble hydroxides instead of chelating with chitosan.

(i) Cu^{2+}

Figure 8(a) shows the reaction mixture between chitosan and copper(II) ion at different concentrations. The control was prepared by adding distilled water instead of copper(II) chloride solution during preparation. It is clear that a blue gelatinous precipitate, instead of light blue powdery precipitate, was formed. This may suggest that the chitosan has cleated with Cu^{2+} instead of forming $Cu(OH)_2$. After centrifugation, a very pale blue colour is still observed in the supernatant in 10^{-2} M mixture, while the remaining two are apparently colourless as shown in Figure 8(b).



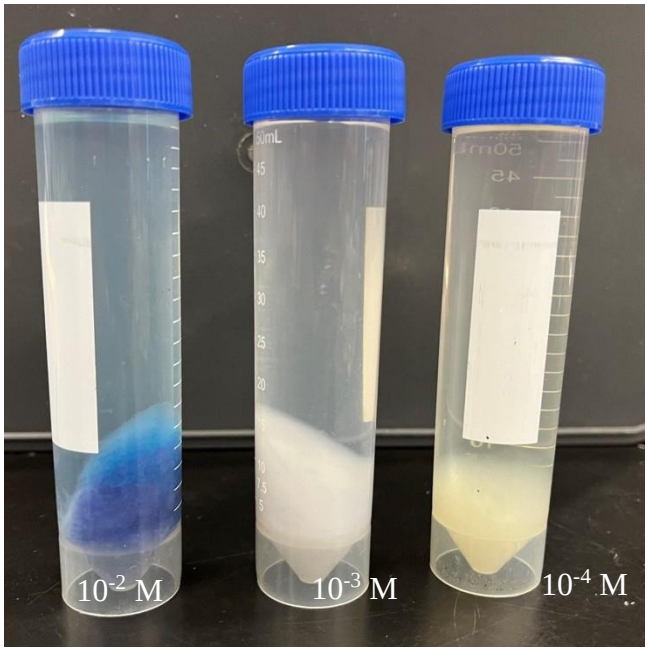


Figure 8 Reaction mixture between chitosan andCu^{2+} of different concentrations (a) before centrifugation and (b) after centrifugation.

(ii) Pb^{2+}, Zn^{2+}, Cd^{2+}, Ba^{2+}

Figure 9 – Figure 12 summarises the appearance of reaction mixture before and after centrifugation. Since all these aqueous ions are colourless, their appearances are very similar to each other as well as against the control. The concentration of residual metal ions will be determined from their UV-Vis spectrum in the calmagite in next section.

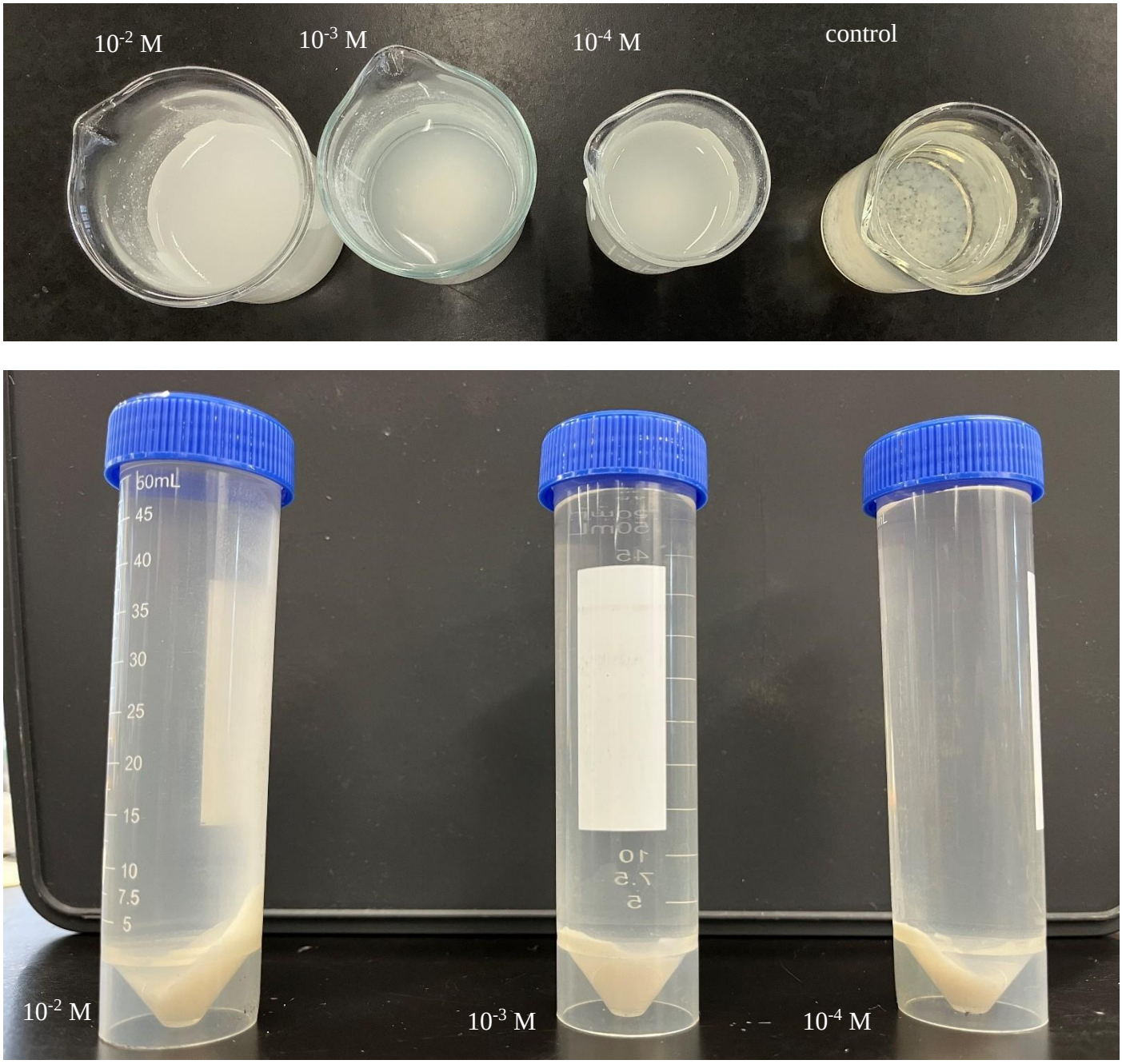
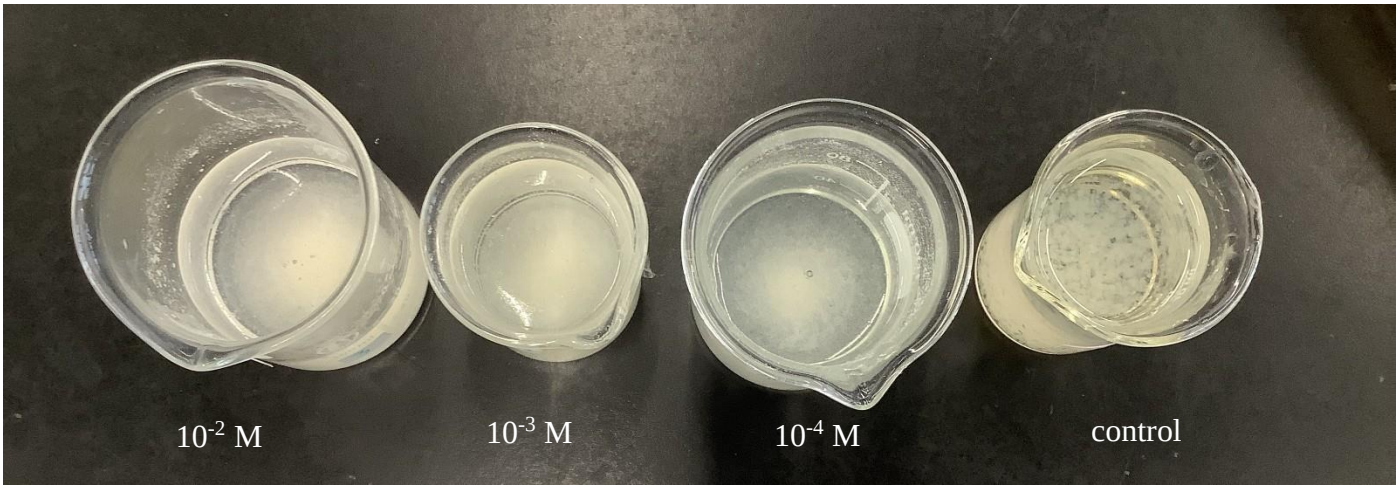


Figure 9 Reaction mixture between chitosan and Pb^{2+} of different concentrations (a) before centrifugation and (b) after centrifugation.



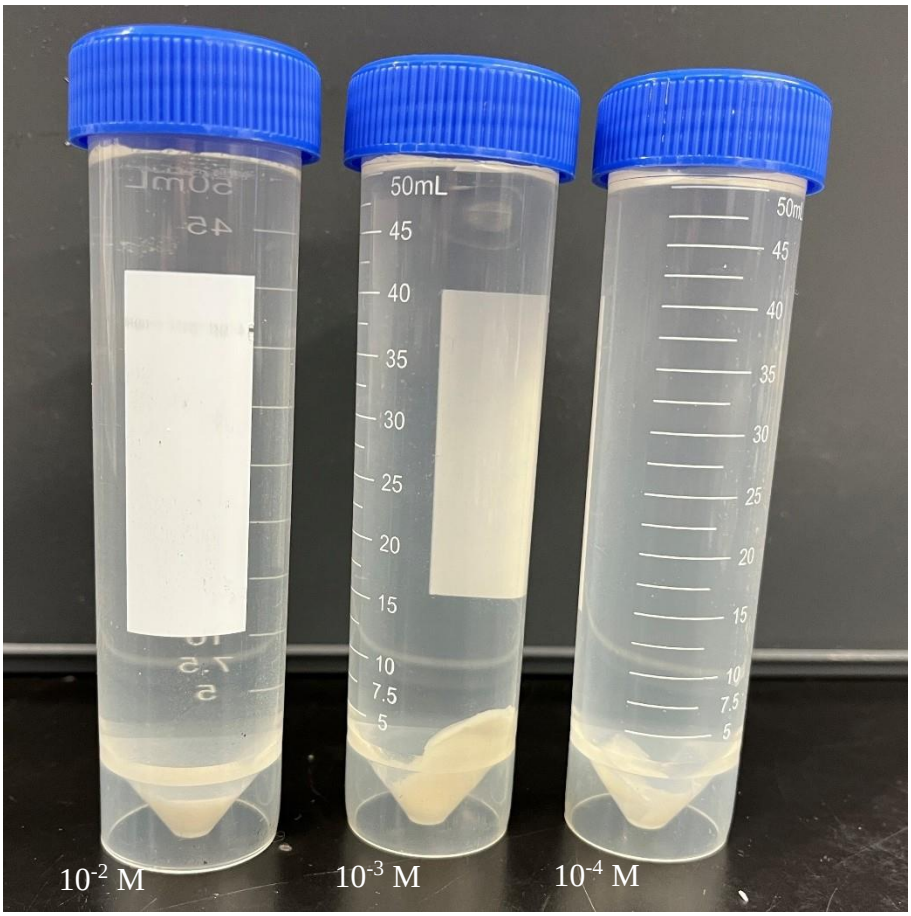
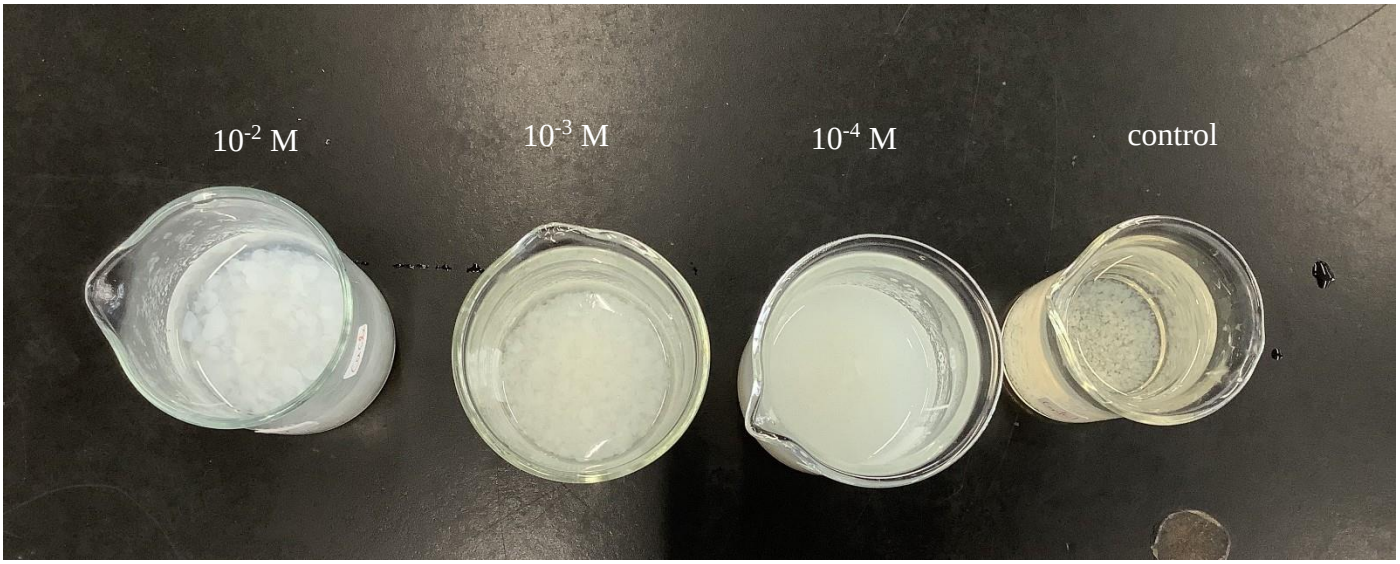


Figure 10 Reaction mixture between chitosan and Zn^{2+} of different concentrations (a) before centrifugation and (b) after centrifugation.



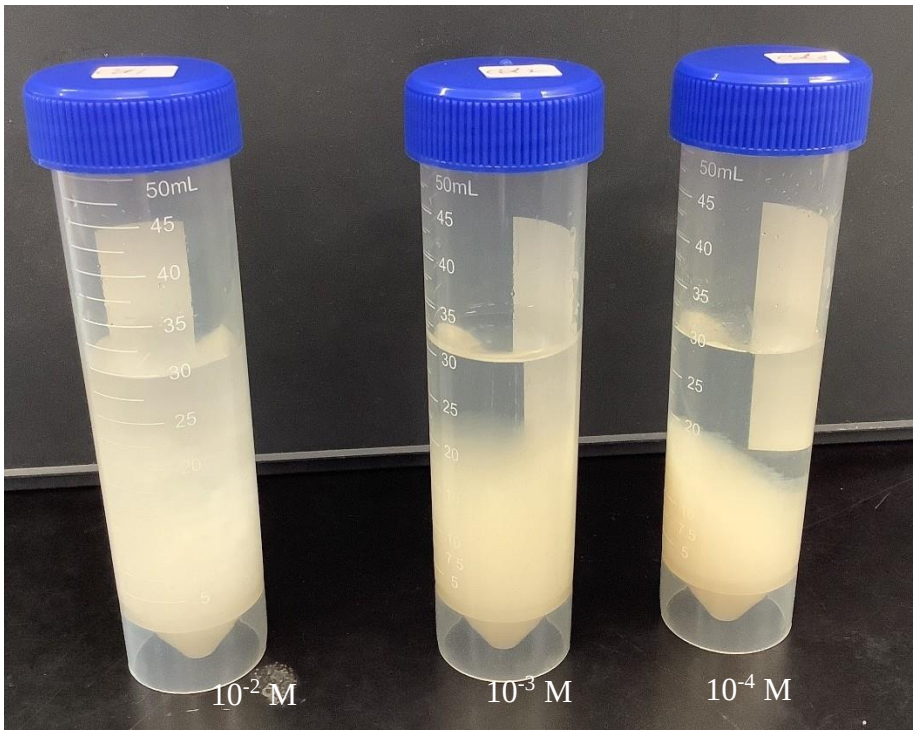


Figure 11 Reaction mixture between chitosan and Cd^{2+} of different concentrations (a) before centrifugation and (b) after centrifugation.

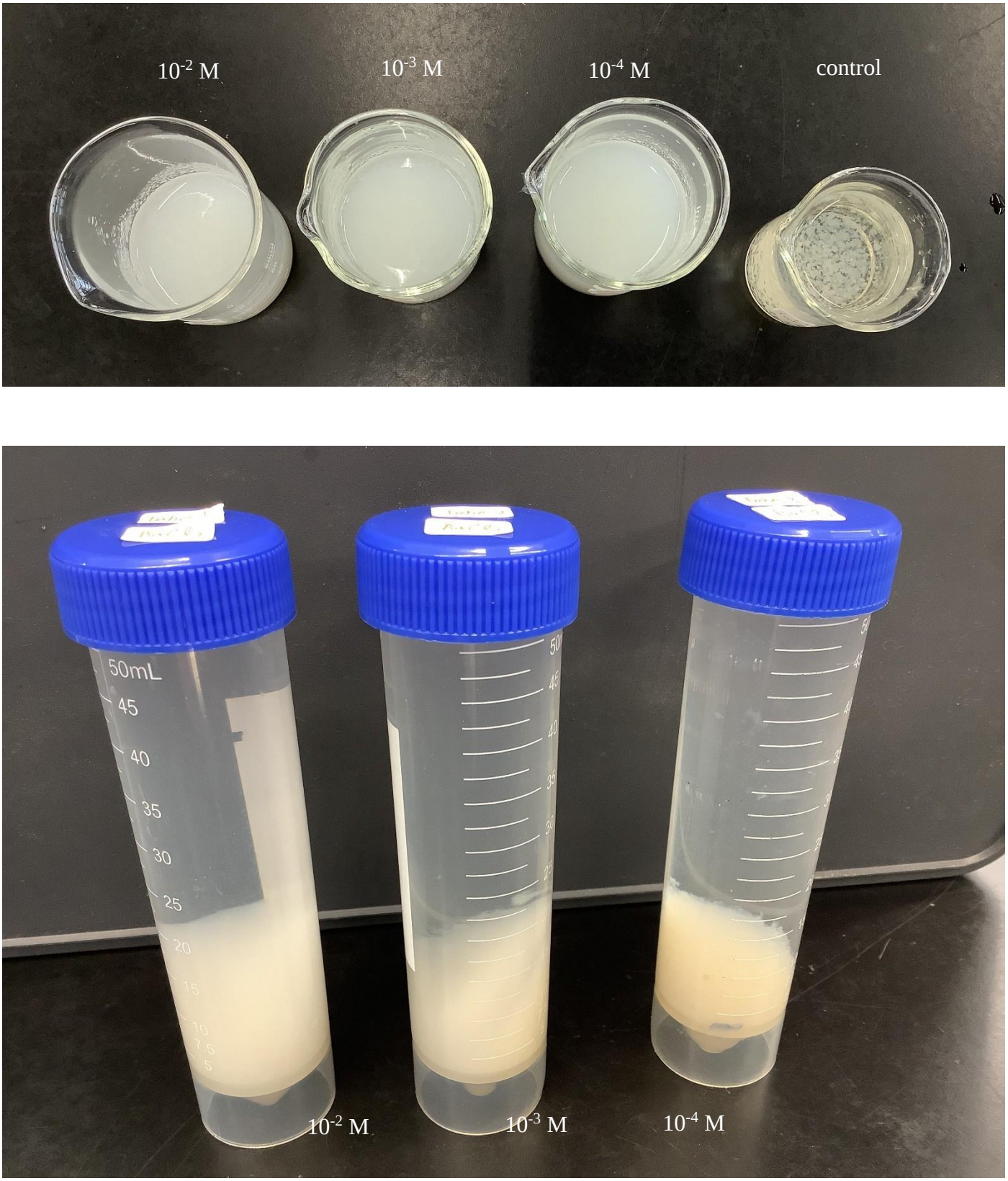
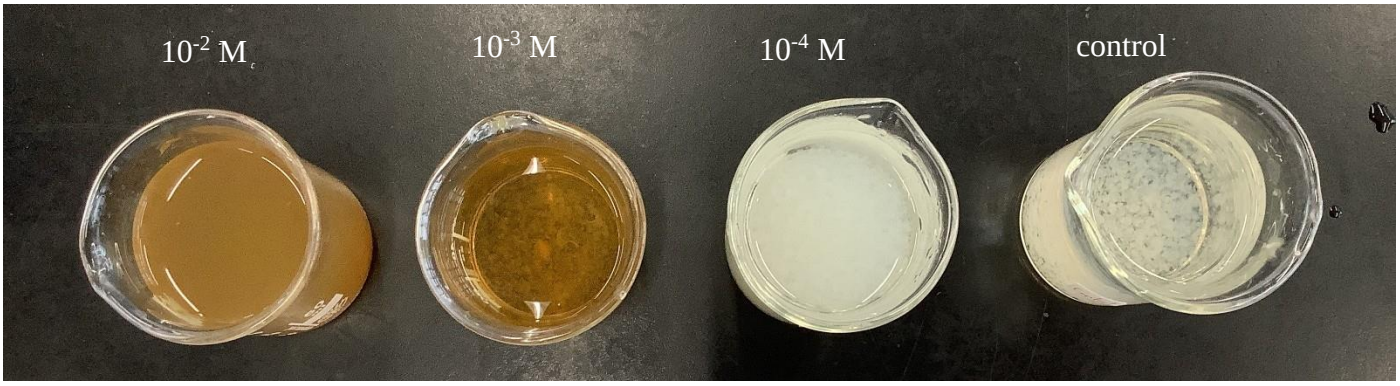


Figure 12 Reaction mixture between chitosan and Mn^{2+} of different concentrations (a) beforecentrifugation and (b) after centrifugation.

(iii) Mn^{2+}

Even though Mn^{2+} is also considered to be colourless at low concentrations, its action with chitosan is very different from aforementioned cases. As seen in Figure 11, the chitosan - Mn^{2+} mixture turns yellow when Mn^{2+} concentration reaches 10^{-3} M. Further studies need to be carried out to investigate whether Mn^{2+} has induced side reaction or the chelation just cause the change in ligand field and hence the absorption by Mn^{2+}



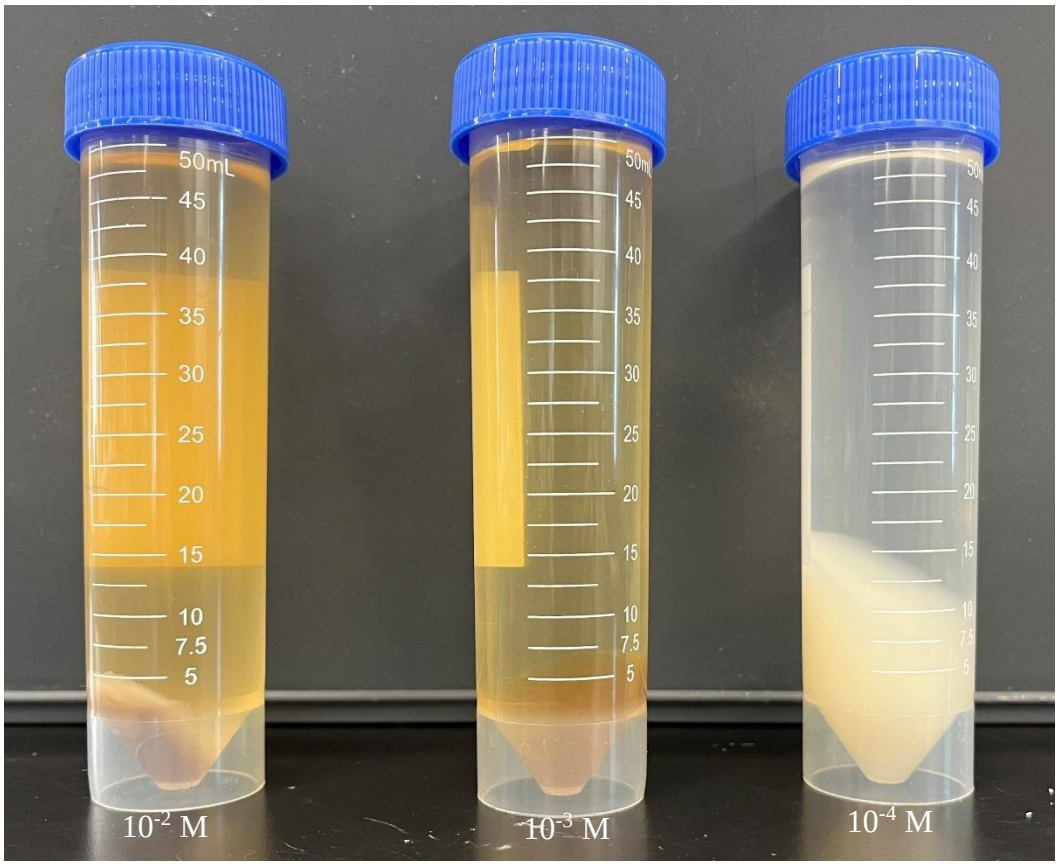


Figure 13 Reaction mixture between chitosan and Mn^{2+} of different concentrations (a) before centrifugation and (b) after centrifugation.

2.4.4 Metal ion removal efficiency

(i) Pb^{2+}

Figure 14 shows the UV-Vis spectrum of calmagite and the supernatant. It is clearly that the spectrum for supernatant using 1×10^{-4} and 1×10^{-3} M is almost identical to that of indicator under the same condition.It suggests that most of the Pb^{2+} ions were removed. In order to determine the percentage of Pb^{2+} ions removed, absorbance of calmagite - Pb^{2+} complex at 384.5 nm was measured and a calibration curve is obtained (Figure 15).

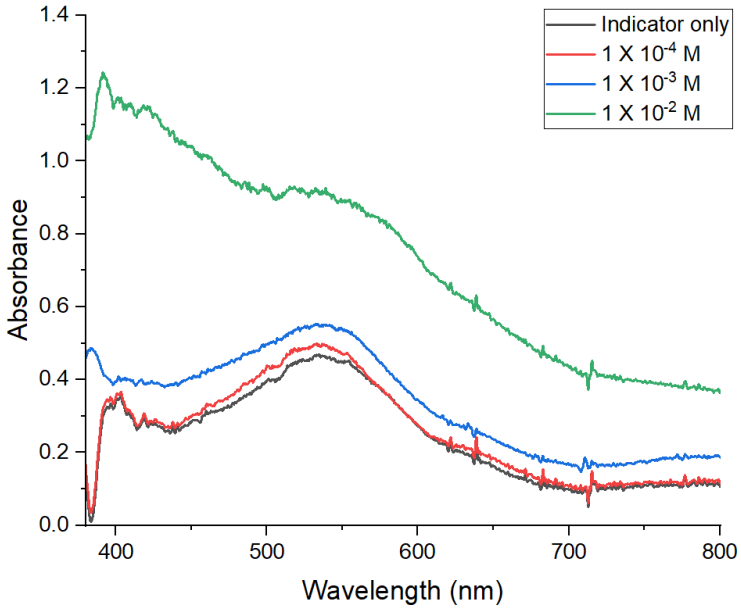


Figure 14 UV-Vis spectrum calmagite mixture with supernatant. The legend shows the initial Pb^{2+} ion concentrations used in the preparation of mixture.

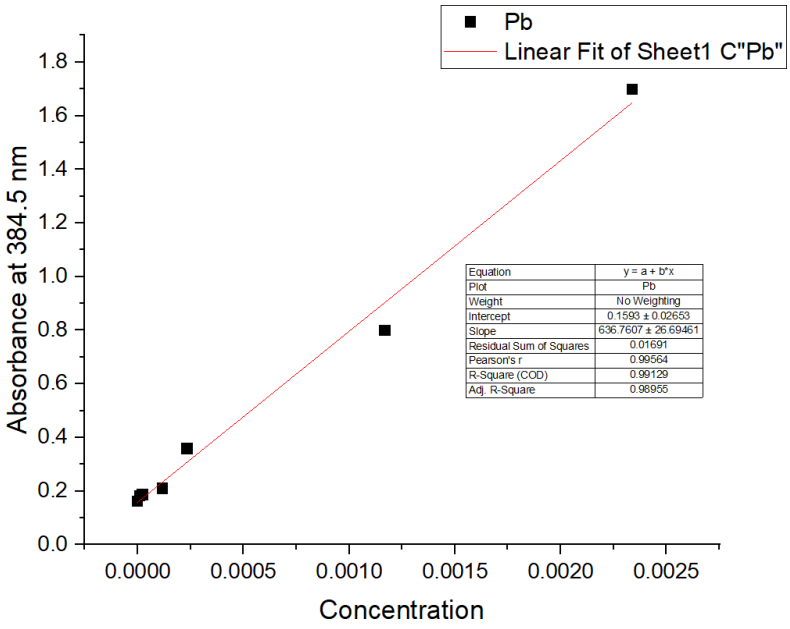


Figure 15 Calibration curve for calmagite-Pb^{2+} complex at 348.5 nm.

By using the calibration curve, the Pb^{2+} concentration in supernatant can be easily determined and summarised as Table 1. When initial Pb^{2+} concentration is about 8×10^{-5} M, its spectrum is almost identicalto that of indicator at the same condition, which strongly suggests that almost all Pb^{2+} ions have been capturedby chitosan. However, when Pb^{2+} concentration was raised to 8×10^{-4} M, the percentage has dropped to 37%.Surprisingly, the percentage is raised to 82% when concentration is increased by 10-fold. The surprisingly lowremoval percentage at 8×10^{-4} M may be due to larger percentage error in measuring the absorbance, or the concentration difference is not extreme enough to drive the equilibrium in favouring the complex formation.

Initial Pb^{2+} concentrations (in mixture)	8×10^{-5} M	8×10^{-4} M	8×10^{-3} M
Final Pb^{2+} concentrations (in mixture)	~ 0 M	5.1×10^{-4} M	1.5×10^{-3} M
Percentage of Pb^{2+} removed	100 %	37 %	82%

Table 1 Pb^{2+} ion removal efficiency.

(ii) Cu^{2+}

When compare with Pb^{2+} , the binding between Cu^{2+} and chitosan apparently to be weaker. As revealedfrom the UV-Vis spectrum (Figure 14), a new peak at 430-450 nm emerges while the absorption peak for free calmagite is still visible. Unfortunately, as shown in Figure 5(d), the change in the absorbance does not totally in line with the change in concentration, which infers the preparation of calibration curve and hence the percentage of removal cannot be determined.

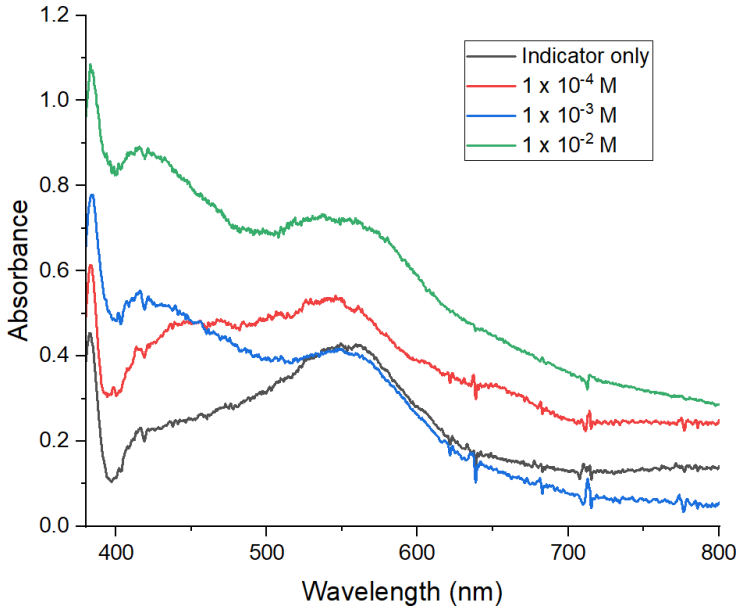


Figure 16 UV-Vis spectrum calmagite mixture with supernatant. The legend shows the initial Cu^{2+} ion concentrations used in the preparation of mixture.

(iii) Zn^{2+}, Cd^{2+} and Ba^{2+}

These ions exhibit similar patten in their UV-Vis spectrum (Figure 17 – Figure 19), which the absorption peak for free calmagite is absent, and a new peak emerges even the metal ion concentration used is as low as 1×10^{-4} M. This suggests that the binding between chitosan and these ions are weaker compare with Pb^{2+} and Cu^{2+}. Similarly, owing to the complexity of their UV-Vis spectrum with calmagite (Figure 5(a), (b) and (c)), the calibration curve cannot be obtained and hence the concentration of metal ions retained cannot be determined.

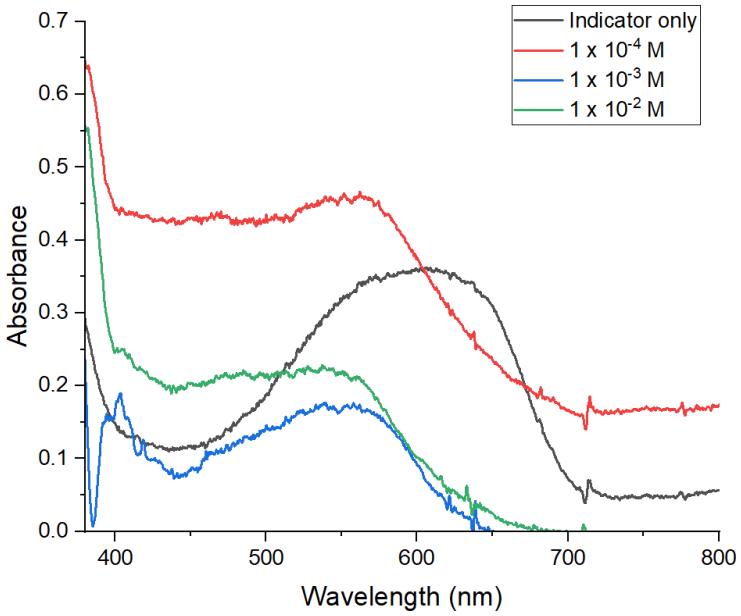


Figure 17 UV-Vis spectrum calmagite mixture with supernatant. The legend shows the initial Zn^{2+} ion concentrations used in the preparation of mixture.

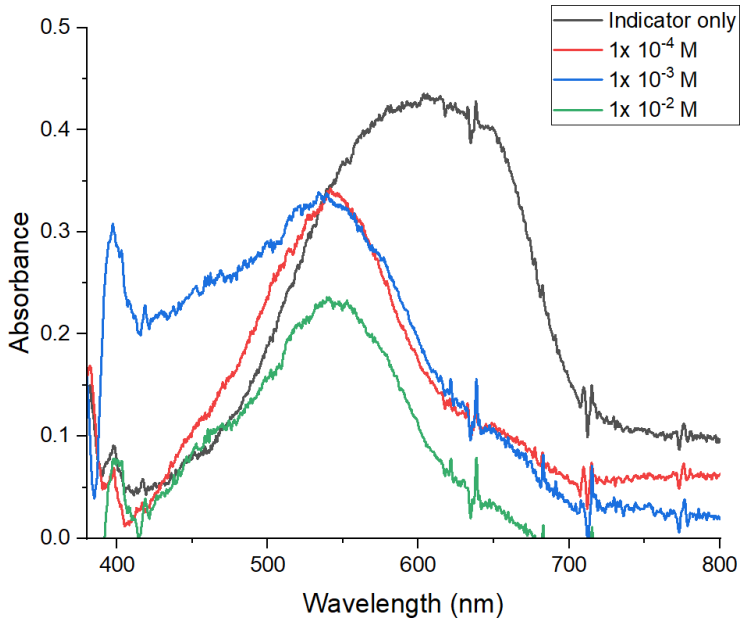


Figure 18 UV-Vis spectrum calmagite mixture with supernatant. The legend shows the initial Cd^{2+} ion concentrations used in the preparation of mixture.

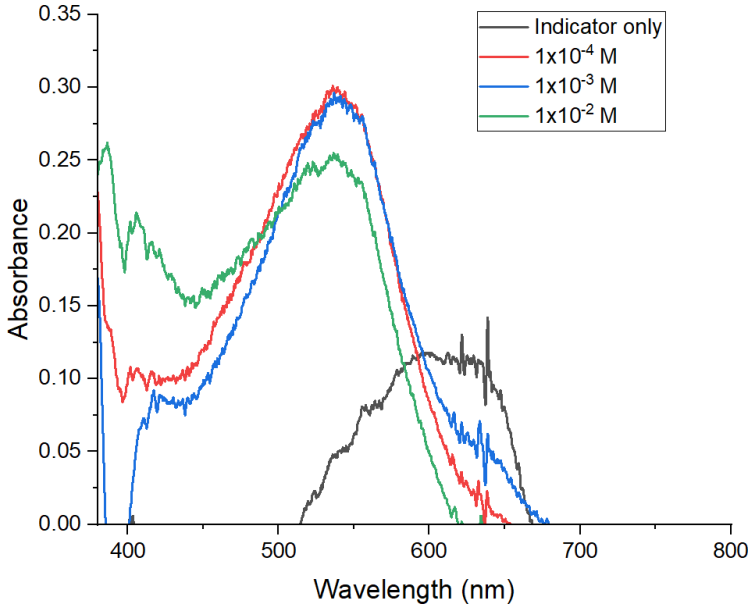


Figure 19 UV-Vis spectrum calmagite mixture with supernatant. The legend shows the initial Ba^{2+} ion concentrations used in the preparation of mixture.

(iv) Mn^{2+}

Figure 20 shows the UV-Vis spectrum of supernatant in the presence of calmagite. The spectrum is very different from other 5 metal ions as it absorbs over a large range of wavelength. Since the absorption peaks are not very distinctive, which may suggest the presence of other side products or multiple equilibria between the metal ion, calmagite and chitosan.

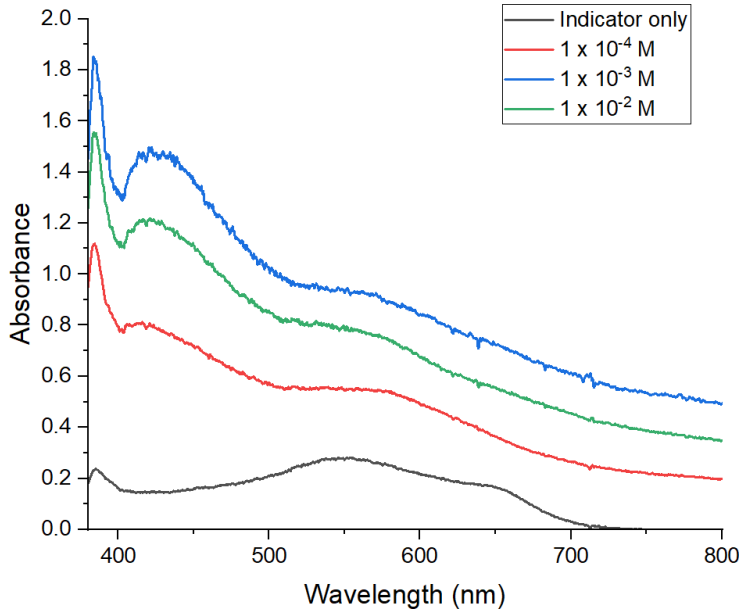


Figure 20 UV-Vis spectrum calmagite mixture with supernatant. The legend shows the initial Mn^{2+} ion concentrations usedin the preparation of mixture.

3. CONCLUSION

In this study, the complexation between calmagite and metal ions has been studied. From their UV-Vis spectrum, the binding mode seems rather complex for some metal ions especially at higher concentrations. The chelation between chitosan and metal ions were achieved by first dissolving chitosan in dilute nitric acid, followed by addition of metal ions, and finally slowly adjusting pH by NaOH solution. In chitosan - Cu^{2+} reaction mixture, both physical appearance and spectrometric analysis suggests chelation was successful and the formation of $Cu(OH)_2$ due to higher pH values was hardly detected.

UV-Vis spectrometry is employed to determine the concentration of residual metal ion concentration. Form the result, it seems that the binding ability varies from one metal ion to another ion, which is found to be Pb^{2+} > Cu^{2+} ~ Zn^{2+}, Cd^{2+} and Ba^{2+} > Mn^{2+}. In this study, it is found that 0.1 g of chitosan can decrease Pb^{2+} concentration by at most 82%.

This investigation provides some preliminary study between chitosan and metal ions. In the future, this work can be extended to using chitosan extracted from shrimps and crab shells instead of pure chitosan. On the other hand, spectrometric methods employed in this study provides a fast and convenient method in determining metal ion concentration compare with traditional titration method. The accuracy and feasibility can be further improved if the complex binding mode between metal ions and indicator can be solved.

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The 16th Hong Kong Budding Scientists Award

2022-2023

SKH Bishop Baker Secondary School

Chau Hei Lam Zoe

Pang Sze Yan

Chan Lok Ya

Man Ka Ki

Wu Yik Hei

Content

Abstract

The research project aims to remove microplastics from water using iron oxides, oil, and a magnet. Our objective is to identify the optimal proportion of iron oxide needed to remove various types of microplastics from a solution mixture that simulates microplastic waste in the ocean. The goal is to address the problem of microplastic pollution in the ocean through this method.

In this project, we successfully removed up to 83.9% of microplastics using ferrofluid with a 1:10 ratio of iron oxide to oil. This method effectively eliminated most microplastics with no residual ferrofluid remaining. The experiment was conducted using simple materials and achieved excellent results.

Significantly, the highest microplastic removal efficiency occurred with Polystyrene (PS) under neutral pH water conditions. The results showed that the experiment met the design requirements of high efficiency, neutral pH, applicability, and eco-friendliness. These results indicate that the method is valid for large-scale application and capable of removing microplastics from seawater effectively.

Ch.1 Introduction

1.1 Problem

With the rapid advancement of technology and the increase in human desires, plastic has become an essential material in our daily lives. However, the excessive production of plastic products not only generates a lot of waste but also leads to the flow of microplastics into the ocean, causing environmental pollution. Plastic is the most common form of marine debris found in oceans, and microplastics are the primary cause of marine pollution. These tiny plastic particles, less than 5 mm in diameter, originate from a variety of sources, including plastic waste and microbeads in personal care products. Marine organisms can ingest microplastics, which then accumulate in the food chain, posing a threat to human health and the ecological environment. Microplastics were estimated at 4 million to 14 million tons in the oceans in the early 21st century. It was found in more than 114 aquatic species.

Studies have revealed that microplastics can have harmful effects on marine life, such as disrupting feeding and reproductive behavior, causing physical damage and inflammation to tissues, and altering gene expression. Approximately 20 percent of the world's population relies on seafood for protein, and microplastics in seawater jeopardize this food source by increasing fish mortality and reducing the efficiency and

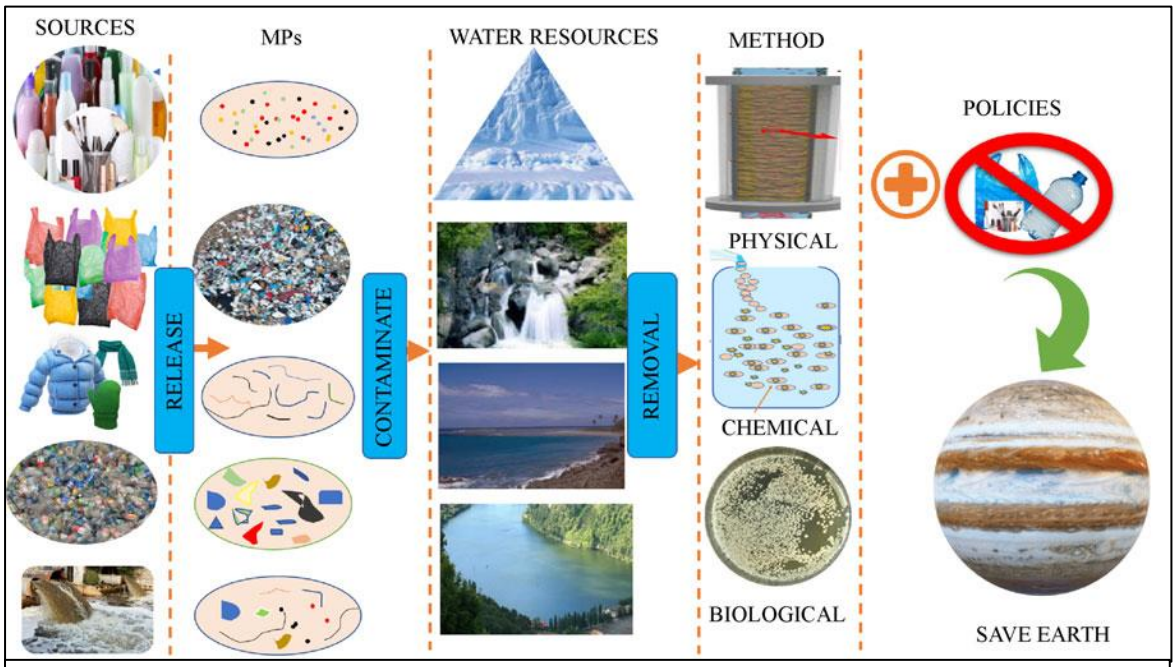
productivity of aquaculture and commercial fisheries.

The widespread presence of microplastics in the ocean has also raised concerns about their potential impact on human health. Ingestion of microplastics through contaminated seafood or drinking water may lead to a variety of health problems, including inflammation, immune system dysfunction, endocrine disorders, and even cancer [1-2].

1.2 Possible answers to the problem

Nowadays, the scientific community is exploring deeper to find treatment and removal options of microplastics. Various physical, chemical and biological methods are researched for microplastics removal, among which few have shown good efficiency in the laboratory. These methods also have a few limitations in environmental conditions. Other than finding a suitable method, the creation of legal restrictions at a governmental level by imposing policies against microplastics is still a daunting task in many countries (Fig. 1.2.1)[4].

According to the available research to date, we observed that physical methods are explored more followed by chemical and biological methods. The percentages of available research on physical, chemical, and biological methods were 45%, 31%, and 24%, respectively [3-4].



Physical methods based on adsorption/filtration are mostly used for microplastics removal. Chemical methods of MPs removal work on coagulation and flocculation mechanism. Membrane bioreactor technology has also shown the removal of MPs from water. Global policy on plastic control is lacking.

Figure 1.2.1 Chemical and biological methods are explored for microplastics removal [4].

Due to the lack of literature on microplastics removal methods, the majorly focuses on ex-situ methods specifically used in waste water treatment plants and in laboratories to cut the supply of microplastics to the water bodies.

Other researchers tried many solutions to solve this problem. One of them: is the reverse osmosis which is a water treatment process that removes contaminants from water by using pressure to force water molecules through a semipermeable membrane.

During this process, the water clarifies from the contaminants. The point of weakness is that it requires a big amount of energy and it is expensive. Another one: is about using oil and mixed it with water then put magnetite and gather all of this with magnate. The point of weakness is that it is not applicable on real life and some contaminates remain in the water [4-6].

Therefore, the idea was to use the chemical concept of "like dissolves like" to reduce costs and make it applicable on a large scale for microplastics removal. In this research project aims to develop a novel method to remove microplastics using iron oxides, oil, and a magnet. We aim to determine the optimal proportion of iron oxide for removing different types of microplastics from water in a solution mixture that emulates microplastic waste in the ocean, thereby solving the problem of microplastic pollution in the ocean. In this study, we evaluated various mixtures of microplastics with water and used different non-polar solvents to remove them to simulate microplastic waste removal in the ocean. To the best of our knowledge, this is the first report studying microplastics removal from water and investigating the highest efficiency of microplastics removal using the best method. We hope to solve the issue of microplastic pollution in the ocean and plan to develop an application for large-scale removal in the future.

1.3 Objectives

1. To investigate the microplastics removal efficiency with various plastics, using iron oxides powder, non-polar solvents and magnet.

2. To find out the optimal ratio of different plastics with iron oxides powder and non-polar solvents to remove microplastics from water.

3. To test the microplastics removal efficiency using various non-polar solvents and iron oxides powder.

4. To study the efficiency of different acidity and alkalinity on microplastics removal.

1.4 Hypothesis

Using iron oxides/ferric oxides, non-polar solvent (such as oil, ethyl acetate, or hexane), and a magnet can effectively remove various microplastics from water. It is expected that in the presence of water, ferrofluids - nontoxic magnetic liquids made up of oil and magnetite, can attract microplastics due to their similar properties. This method can sufficiently remove microplastics from a solution emulates microplastic waste in the ocean and solve the problem of microplastics pollution in the future.

Ch.2 Experimental Methods

2.1 Materials and Apparatus

(a) Microplastic

Various plastics microbeads were purchased from a vendor. Size and recycling codes as indicated (Fig 2.1.1)

(i) Polyethylene (PE): [100 mesh (150 µm)]

(ii) High-Density Polyethylene (HDPE): [50 mesh (270 µm)]

(iii) Polyvinyl chloride (PVC): [150 mesh (106 µm)]

(iv) Polyethylene terephthalate (PET): [150 mesh (106 µm)]

(v) Polypropylene (PP): [30 mesh (550 µm)]

(vi) Polystyrene (PS): [100 mesh (150 µm)]

(b) Water

(i) Distilled Water

(ii) Water with different pH values (pH 3/ 5/ 7/ 9)

(c) Non-polar solvents

(i) Cooking oil

(ii) Ethyl acetate

(iii) Hexane

(d) Iron oxide (Fe_3O_4)

(e) Magnets

(f) Spectrophotometer (at 345nm wavelength)

This absorbance reading for determining the concentration of particles in solution is based on the method used in the literature [4-6].

Figure 2.1.1 Different common types of plastics with numbered according to their recycling codes.

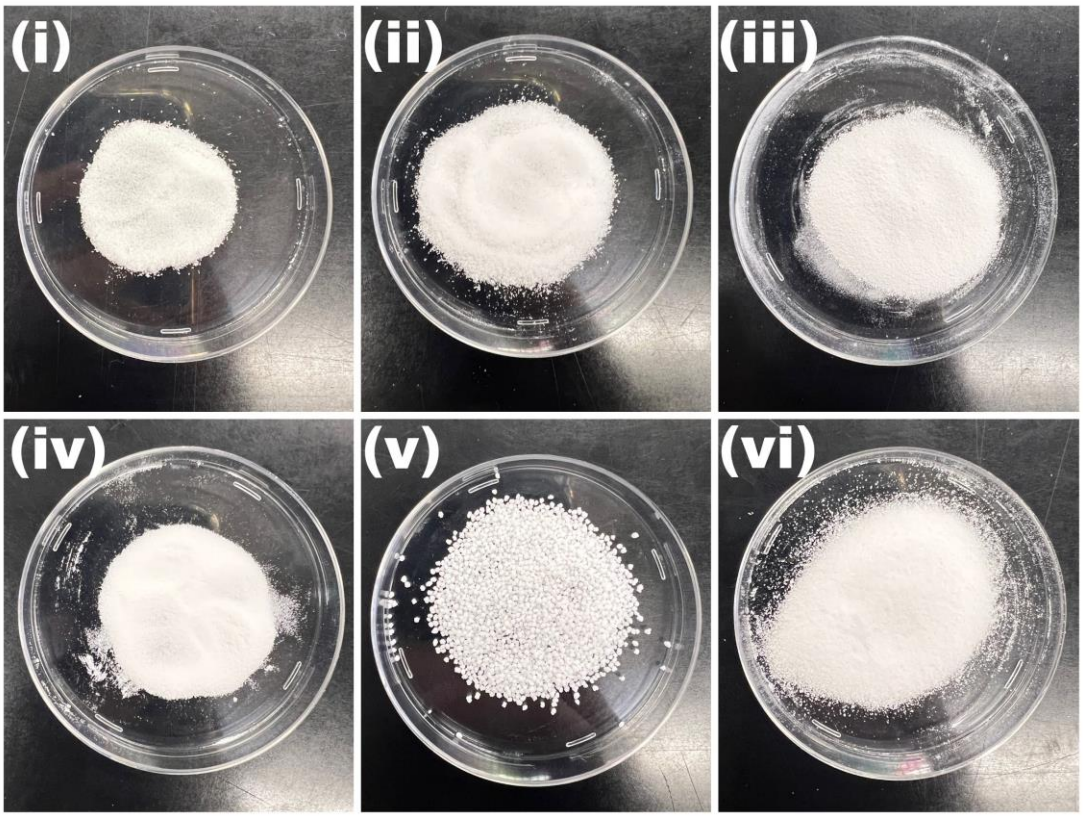


Figure 2.1.2 Various common types of plastics microbeads.

2.2 Experimental Process

[1] Prepare water samples with microplastic

Mix 0.2g of microplastic (PE, HDPE, PVC, PET, PP and PS) with 50mL water to get microplastics solutions.

↓

[2] Add ferrofluid to the samples

Adding 2mL of non-polar solvent (oil/ ethyl acetate/ hexane) and 0.1-0.4g iron oxides to form ferrofluid.

↓

Stir the mixture to ensure complete interaction between microplastic and ferrofluid.

↓

[3] Remove microplastics in water

Use a magnet to retrieve microplastic and ferrofluid from the water.

↓

[4] Analysis the removal of microplastics

Use a spectrometer to analyze the concentration of remaining microplastics and other substances.

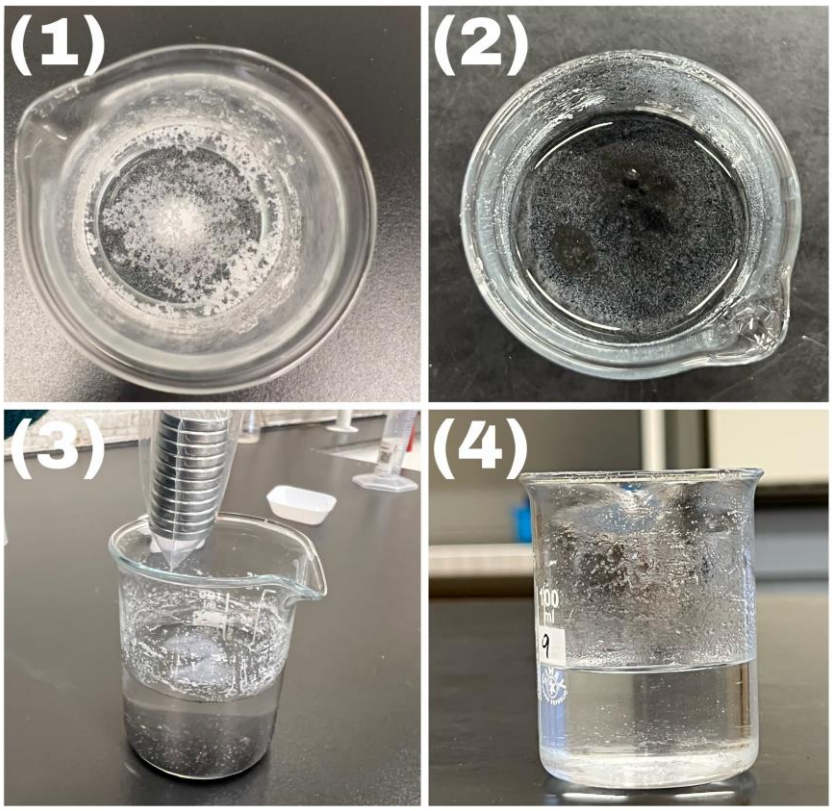


Figure 2.2.1 Various common types of plastics microbeads.

Statistical Analysis

All experiments were performed at least four or five times. The analysis of every time point from each experiment was carried out in duplicate or triplicate. Means, standard errors, and standard deviations were calculated from replicates within the experiments and analyses using Microsoft Excel.

2.3 Investigate the removal efficiency of different types of microplastics

In the experiment, several types of microplastics are used to investigate the removal efficiency. Including polyethylene (PE), Polyethylene terephthalate (PET), Polypropylene (PP), Polystyrene (PS), Polyvinyl chloride (PVC), and High-Density Polyethylene (HDPE), various types of microbeads are added into water to order to simulate microplastics in sea water and ferrofluid separately. Then, the removal efficiency of different types of microplastic was analyzed. The analysis was based on the experimental processes as shown in Section 2.2.

The removal efficiency of different types of microplastics was calculated using the following formula:

$$Microplastics\ removal\ (\%) = \left[\frac{C0 - C}{C0}\right] \times 100\%$$

C0 = concentration of microplastics in microplastics solutions before adding ferrofluid

C = concentration of remaining microplastics and other substances in microplastics solutions after removal

2.4 Investigate the removal efficiency using different types of non-polar solvents

During the experiment, three types of non-polar solvents (oil, ethyl acetate, and hexane) were used to study microplastic removal efficiency. 2mL of each non-polar solvent was added to the microplastics solution. Since all three solvents are hydrophobic, their removal efficiency in relation to three types of microplastics (Polyethylene terephthalate (PET), Polystyrene (PS), Polyvinyl chloride (PVC)) was investigated. The analysis was based on the experimental processes described in section 2.2. The removal efficiency of different types of non-polar solvents was calculated using the following formula as in section 2.2

2.5 Investigate the removal efficiency using different proportions of iron oxide

After preparing water samples with microplastics to simulate microplastics in

seawater, different proportions of iron oxide (Fe_3O_4) are added to form ferrofluids at ratios of 1:20, 1:10, and 1:5 (amount of iron oxide to non-polar solvent-oil). This means that 0.1g, 0.2g, and 0.4g of iron oxide are added to the microplastic solutions, respectively. The objective is to investigate the difference in microplastic removal efficiency among these three ratios, using the experimental processes shown in section 2.2.

The experimental procedures were listed as follow:

1. Prepare water samples with microplastic

Mix 0.2g of microplastics (PS/PVC/PET) with 50mL water to get microplastics solutions.

↓

2. Add ferrofluid to the samples

Add 2mL of oil and 0.1g/ 0.2g/ 0.4g iron oxide to form ferrofluid. Stir the mixture to ensure complete interaction between microplastics and ferrofluid.

↓

3.Remove microplastic in water

Use a magnet to retrieve microplastics and ferrofluid from the water.

↓

4. Analysis the removal of microplastic

Use a spectrometer to analyze the concentration of remaining microplastics and other substances.

2.6 Investigate the removal efficiency from different pH values of water

In this experiment, four different pH values of water were used to investigate the

effect of pH on microplastic removal efficiency. After preparing water samples with microplastics to simulate microplastics in seawater, iron oxide (Fe_3O_4) was added to the microplastics solution with oil to form ferrofluids. The microplastics removal efficiency at different pH values of water was calculated using the formula described in section 2.2.

2.7 Investigate the removal efficiency of different daily used plastics

To investigate microplastic removal efficiency using pre-made microbeads from daily used plastics instead of purchased microbeads, microbeads were prepared from daily used plastic products using an electric blender to obtain tiny plastic particles. We prepared five different daily used plastic products for the experiment, which are:

1. plastic box (PP, recycling code [5])
2. Plastic spoon (PP, recycling code [5])
3. Plastic bottle label (PET, recycling code [1])
4. Plastic sealed bag (LDPE, recycling code [4])
5. Plastic straw (PP, recycling code [5])

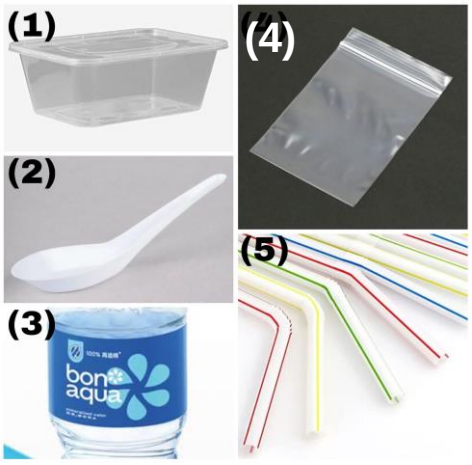


Figure 2.7.1 Various daily used plastics for preparing microbeads.

The microplastics removal efficiency of different microplastics prepared from daily used plastics was calculated using the formula described in section 2.2.

The experimental procedures were listed as follow:

1. Grind the daily used plastics with an electric blender

Prepare 0.2g of each plastic product and grind it into small particles (around 2mm) respectively.

↓

2. Add microplastics to the water

Mix the plastic particles with 50mL water to get microplastic solutions respectively.

↓

3. Add ferrofluid to the microplastics solutions

Adding 2mL of oil and 0.2g iron oxide to form ferrofluid. Stir the mixture to ensure complete interaction between microplastics and ferrofluid.

↓

4. Remove microplastics in water

Use a magnet to retrieve microplastic and ferrofluid from the water.

↓

5. Analysis the removal of microplastic

Use a spectrometer to analyze the concentration of remaining microplastic and other substances.

Ch.3 Results

3.1 The removal of microplastics from water

According to the experiment of section 2.3, using non-polar solvent – oil, iron oxide to form ferrofluid, mixed with microplastics solution and a magnet, we have successfully removed microplastics from water. Different microplastics removal efficiency was

observed when using several types of microplastics in this experiment. In general, six types of microplastic used were polyethylene (PE), Polyethylene terephthalate (PET), Polypropylene (PP), Polystyrene (PS), Polyvinyl chloride (PVC), and High-Density Polyethylene (HDPE). Results showed that the microplastics removal efficiency are 23.8%, 65.6%, 42.9%, 83.9%, 72.2% and 26.9% respectively (Fig 3.1.1). This suggests that our method using iron oxides/ferric oxides, non-polar solvent (such as oil), and a magnet can effectively remove various microplastics from water. This significant result highlights the success and proof of concept of this investigation.

Microplastics	Absorbance before removal (Abs)	Absorbance after removal (Abs)	Removal efficiency
PE	0.42	0.38	9.52%
PET	0.64	0.22	65.6%
PP	0.42	0.24	42.9%
PS	1.12	0.18	83.9%
PVC	1.33	0.37	72.2%
HDPE	0.52	0.38	26.9%

Table 3.1.1 Results of the different microplastics removal from water.

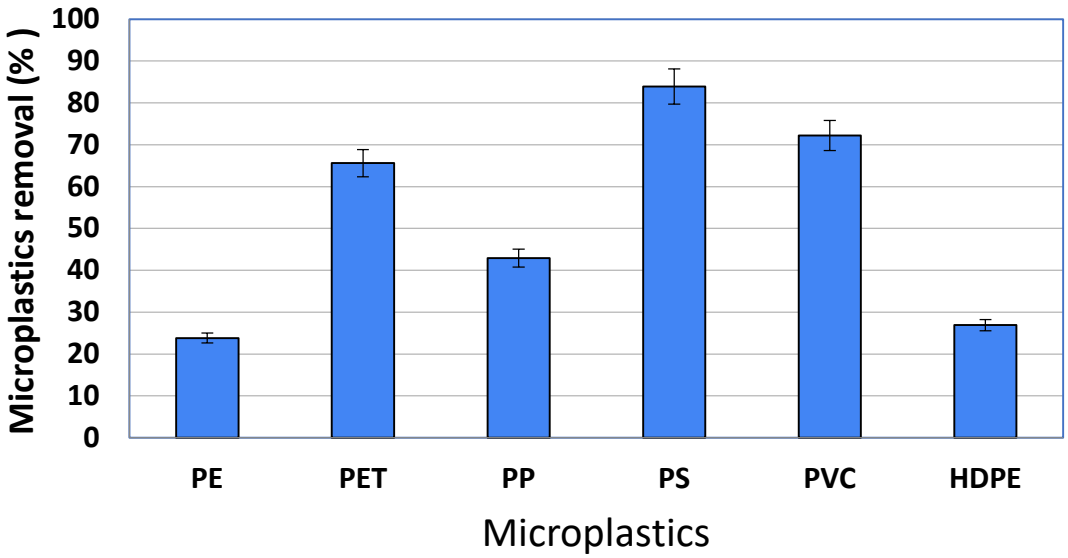


Figure 3.1.1 Results of the different microplastic removal from water. Polyethylene (PE), Polyethylene terephthalate (PET), Polypropylene (PP), Polystyrene (PS), Polyvinyl chloride (PVC), and High-Density Polyethylene (HDPE).

3.2 Removal efficiency of different types of microplastics

Using different types of microplastics for microplastic removal experiments can observe different removal efficiency. The highest average removal efficiency of 74% was achieved with a ratio of 0.2g microplastics among six tested microplastics.

The results of different microplastics removal were shown in Table 3.3.1 and Figure 3.1.1. These results show that the three microplastics with the highest removal efficiency of PET, PS and PVC plastics have microplastics removal of 65.6%, 83.9% and 72.2%, respectively. Based on these experimental results, PET, PS, and PVC were found to have the highest microplastic removal efficiency at a ratio of 0.2g microplastics among six tested microplastics.

3.3 Microplastics removal efficiency using different non-polar solvents

In tests using three different non-polar solvents, oil showed the highest removal efficiency in three of them, removing 65.6%-83.9% of microplastics. Ethyl acetate had the second-highest removal efficiency (42.6%-64.9%). While hexane effectively removed 66% of PET, it was less effective at removing PVC and PS, with removal rates of 22.5% and 58.3%, respectively (Table 3.3.1 and Fig.3.3.1). Moreover, residual hexane in water can have negative environmental impacts. Therefore, oil is the best solvent for forming ferrofluid.

Microplastics removal efficiency using different non-polar solvents (%)				
No.	Microplastic	Oil	Ethyl acetate	Hexane
1	PET	65.6	52.0	66.0
2	PS	83.9	64.9	58.3
3	PVC	72.2	42.6	22.5

Table 3.3.1 Microplastic removal using different non-polar solvents.

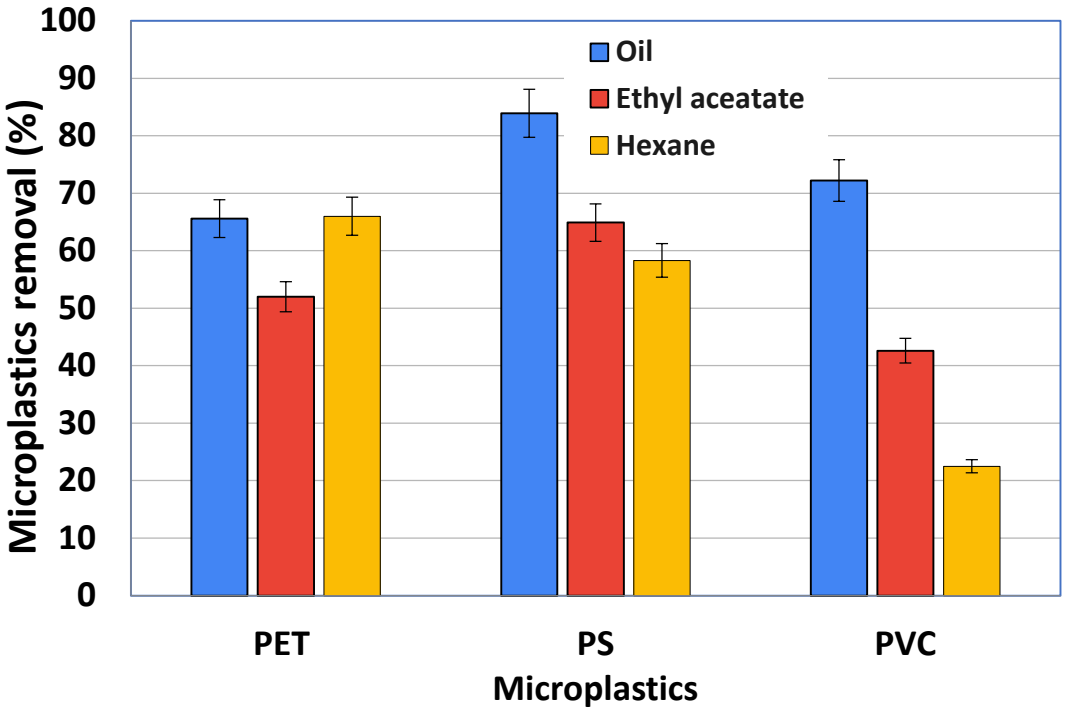


Figure 3.3.1 Microplastics removal efficiency using different non-polar solvents

3.4 Microplastics removal efficiency using different proportions of iron oxide

On average, different amounts of iron oxide lead to different removal efficiencies of microplastics, as observed in the experiment described in section 2.5. Overall, the removal efficiency of six types of microplastics was 12.6%, 74%, and 44.6% for ratios of 1:20, 1:10, and 1:5, respectively, measured by weight.

Table 3.4.1, Table 3.4.2 and Figure 3.4.1 show the results of different proportions of iron oxide for microplastic removal. These indicate that using a ratio of 1:10 for iron oxide to oil can improve the removal efficiency of microplastics, but this benefit reaches saturation to a certain extent. Meanwhile, a ratio of 1:5 is insufficient for complete removal of microplastics and may leave residual oil. The ratio of 1:20 was

found to be less effective. Therefore, based on these experimental results, a ratio of 1:10 for iron oxide to oil produced the highest microplastic removal efficiency, reaching 74%.

Using ratio of iron oxide to oil 1:20

Microplastics	Absorbance before removal (Abs)	Absorbance after removal (Abs)	Removal efficiency
PET	0.40	1.02	*0%
PS	0.80	1.32	*0%
PVC	2.62	1.64	37.4%

Using ratio of iron oxide to oil 1:10

Microplastics	Absorbance before removal (Abs)	Absorbance after removal (Abs)	Removal efficiency
PET	0.64	0.22	65.6%
PS	1.12	0.18	83.9%
PVC	1.33	0.37	72.2%

Using ratio of iron oxide to oil 1:5

Microplastics	Absorbance before removal (Abs)	Absorbance after removal (Abs)	Removal efficiency
PET	0.40	0.65	*0%
PS	0.65	0.20	69.2%
PVC	2.62	0.87	66.8%

Table 3.4.1

Microplastics removal efficiency using different proportions of iron oxide (%)				
No.	Microplastic	0.1g (1:20)	0.2g (1:10)	0.4g (1:5)
1	PET	*0	65.6	*0
2	PS	*0	83.9	69.8
3	PVC	37.7	72.2	66.9

***** : Since a small number of microplastics cannot be effectively removed due to the residue of iron oxide, the following data will be expressed as an 0% microplastics removal efficiency.

Table 3.4.2 Microplastic removal efficiency of different proportions of iron oxide.

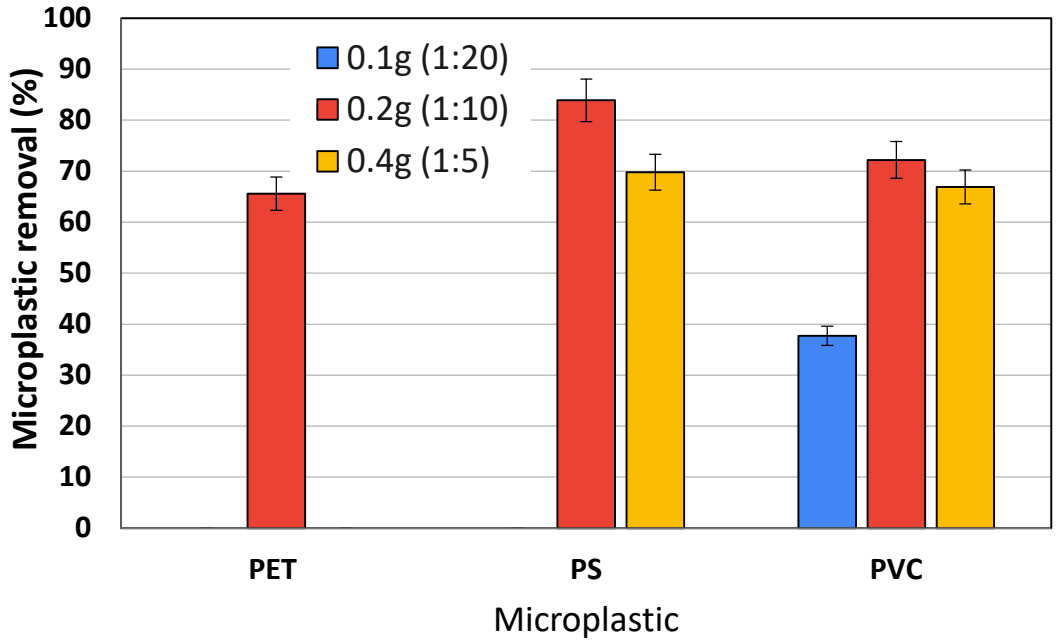


Figure 3.4.1 Microplastic removal efficiency using different proportions of iron oxide

3.5 Microplastics removal efficiency from different pH values of water

According to the experiment described in section 2.6, the removal efficiency of microplastics can be affected by different pH values of water. On average, at pH3, pH5, pH7, and pH9 of water, the microplastics removal efficiencies were 40%, 40.7%, 51.1%, and 8.5%, respectively, measured by weight. Table 3.5.1 and Figure 3.5.1 show these results, indicating that the highest removal efficiency was at pH7 of water. Furthermore, these results suggest that microplastics cannot be effectively removed under strongly basic conditions.

Microplastics	pH3	pH5	pH7	pH9
PET	41.8	16.7	37.5	25.6
PS	11.5	51.7	57.4	0*
PVC	66.7	53.8	58.5	0*

* : Since the plastic cannot be removed in strong base conditions, the following data will be expressed as an 0% removal efficiency.

Table 3.5.1 Microplastic removal efficiency from different pH values of water.

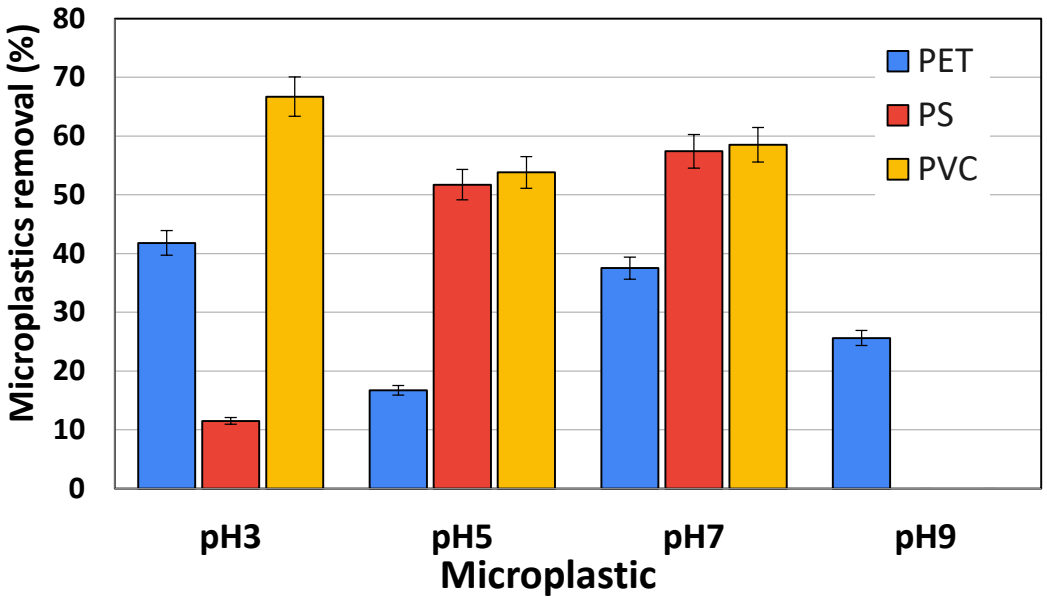


Figure 3.5.1 Microplastic removal efficiency from different pH value of water

3.6 Removal efficiency of different daily used plastics

According to the experiment described in section 2.7, the removal efficiency of several types of microplastics commonly found in daily used plastic products can be affected. The microplastic removal efficiency ranged from 26% to 88%. In experiments using real-life plastic products, all of their removal rates were over 25%. The best result was achieved in removing plastic spoon particles, with a removal rate of 88%. The second-best result was achieved in removing sealed bag particles, with a removal rate of 78%. The results of removal rate of different microplastics are shown in Table 3.6.1 and Figure 3.6.1.

Microplastics	Absorbance before removal (Abs)	Absorbance after removal (Abs)	Removal efficiency
box (PP)	0.75	0.55	26%
spoon (PP)	1.75	0.21	88%
Bottle label (PET)	1.28	0.78	39%
Sealed bag (PE)	2.44	0.52	78%
Straw(PP)	2.59	1.36	47%

Table 3.6.1 Removal efficiency of different daily used plastics

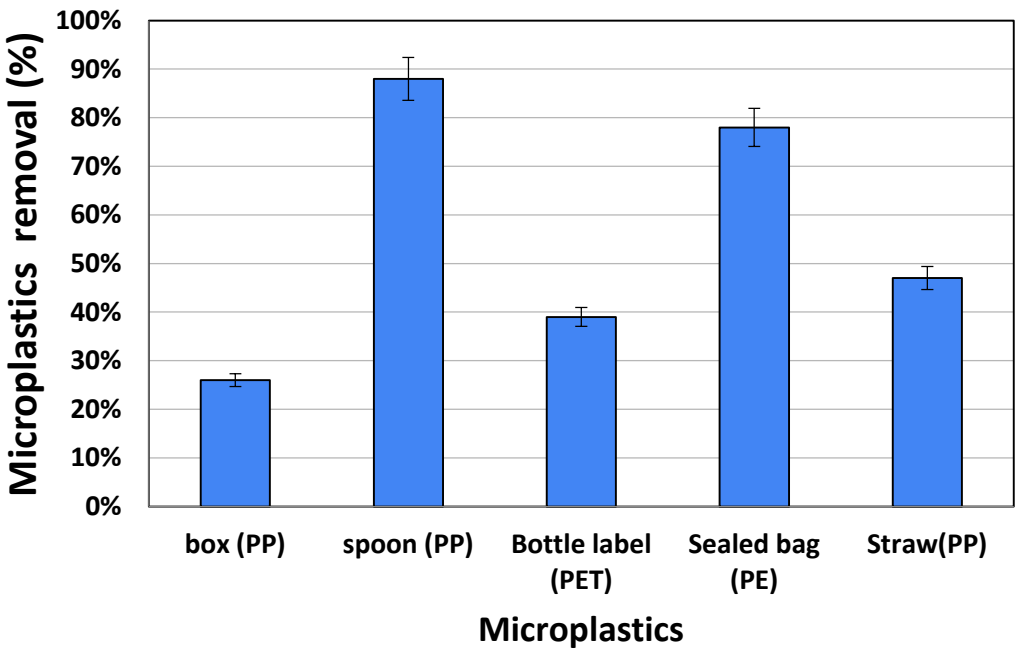


Figure 3.6.1. Removal efficiency of daily used plastic products

Ch.4 Discussion

According to our experimental results, using ferrofluid to remove microplastics was most effective for PS, PVC, and PET, with removal efficiencies ranging from 83.9% to 65.6%. However, removal of PE, HDPE, and PP was less effective, with removal efficiencies ranging from 23.8% to 42.9%. These results suggest that the method is more effective for removing microplastics with higher density (Fig 3.1.1).

In tests using three different non-polar solvents, oil showed the highest removal efficiency in three of them, removing 65.6%-83.9% of microplastics. Ethyl acetate had the second-highest removal efficiency (42.6%-64.9%). Although hexane was effective at removing PET with a removal efficiency of 66%, it had lower removal rates for PVC and PS, at 22.5% and 58.3%, respectively. Additionally, residual hexane in water can have negative environmental impacts. Therefore, oil is the best solvent for forming ferrofluid (Fig 3.3.1).

Ethyl acetate is a versatile fine chemical product with excellent solubility, which is why it dissolves microplastics and causes marine pollution. Hexane, on the other hand, is a chemical substance extracted from crude oil, and its vapor is still explosive. Therefore, the use of the above two solvents is not recommended. On the contrary, oil is more viscous, it can better blend with iron powder, and removes plastic best, so it is recommended to use oil.

When investigating the relationship between oil and iron oxide, the results showed that a ratio of 1:10 was optimal for complete ferrofluid formation with no residual oil. In a ratio of 1:20, a small amount of oil cannot interact with iron oxide and remains in the water, may cause further pollution. For a ratio of 1:5, there is not enough oil to wrap microplastics, resulting in more microplastics remaining in the water. Therefore, a ratio of 1:10 is most suitable for removing microplastics. Additionally, this method is more effective in water with lower pH values. In the final part of the experiment, an up to 80% microplastics removal efficiency was achieved for microplastics commonly found in daily used plastic products

Ch.5 Conclusions and important findings

In this study, we successfully removed up to 83.9% of microplastics using ferrofluid with a 1:10 ratio of iron oxide to oil. This method effectively removed most microplastics with no residual ferrofluid remaining. The experiment was made with simple materials and achieved great results. It is low cost, highly effective, and environmentally and biologically friendly, indicating its potential to become a major approach for removing marine microplastics in the future.

Ch.6 Prospect

We look forward to testing this method with microplastics contaminated seawater samples so that this removal method can be applied and used in reality. At the same time, we will continue to study the use of different materials to improve the microplastic removal efficiency.

In the future, we will collaborate with Prof. Apple PY Chui, Research Assistant Professor from Marine Science Laboratory, School of Life Sciences, CUHK., for getting seawater samples from several spot along the Tolo Channel all the way out to Tung Ping Chau Marine Park. We will further test our method in microplastics removal from these seawater samples.

Ch.7 References

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An Interview with Dr. Jim Luk

Chan Tsz Nam Aelita
Cheuk Nim Yan
Chung Hei Man Isabel
Tsang Evelyn Wai Ning
Li Ruyi

Background

Dr. Jim Luk is an assistant professor in Sports and Recreation Management at The Technological and Higher Education Institute (THEi). He received his Bachelor of Science in Engineering Physics from Hong Kong Polytechnic University in 1996. In 1998 and 2003, he received his M.Phil. in Sports Science and his Ph.D. in Education, both from the Chinese University of Hong Kong (CUHK). In 2011, he became a Certified Taekwondo Instructor in the World Taekwondo Academy in Kukkiwon, Korea.

Dr. Luk's primary research and publications focus on sports biomechanics, ergonomics and strength and conditioning, including:

- Effects of Different Intraset Rest Durations on Lifting Performance and Self-perceived Exertion During Bench Press Exercise;
- Biomechanical Comparison of Tire Flipping Techniques;
- Relationship between Biomechanical Characteristics of Sprint-specific Plyometric Exercises and Sprinting Performance in Youth College Sprinter
- Effect of Repetition and Rest Interval in Plyometric Training Exercise

Occupation

Sports Science

The majority of Dr. Luk's work lies in teaching, education, and administration. He enjoys working for and working with young, bright minds who hold future potential in the industry. He collaborates with sports coaches and those in the industry to help coaches of various teams with sport coaching, sport therapy, and coming up with training strategies. Dr. Luk mentioned that they provide exercise therapy courses for students, who can help athletes recover and take on the job of sport therapy. He also forms partnerships with designers in institutes and those in the industry and is in charge of testing out sports-related products. He shares with us his previous industry-based project of creating 3D face masks that are easier to breathe in, and athletic tape that can generate heat. Other than practical research, he works hard in training athletes. He believes in every one of his fellow athletes and helps them get the support they deserve from the government by proving themselves through their achievements in worldwide competitions.

The current sports industry

Before the interview, we had little to no idea what area of sports science we are going to be researching in. Dr. Luk starts by introducing different aspects of the sports science industry. Major aspects of sports science can be divided into three parts: Sports coaching, sports therapy, and sports management. Sports coaching includes sports skill analysis, strategy analysis, and performance testing and measurement; Sports therapy focuses on ways to prevent injuries for athletes particularly before competitions, finding methods to accelerate healing rates for athletes to regain and maintain constantly improving performance

levels, as well as to increase the stamina of athletes. Sports management focuses more on sports-related facilities which come into use during sports events. Dr. Luk mentioned some other fields of research in sport science, such as measuring and recording the opponents' behaviors and actions during competitions and undergoing analysis. In this way, athletes know the best way to deal with their opponents, which maximizes their chances of winning.

Dr. Luk shared with us some previous products in the sports science industry, one being a waterproof GPS system attached to a sailboat's boat to measure water resistance, watches that measure and record health data like blood pressure. Examples of databases, he mentioned, used by famous sports brands Nike and Under Armour, record data from online questionnaires and develop products according to these data.

Challenges faced by the sports science industry

Ethical dilemmas on sports science research

When asked about obstacles faced within his journey of scientific research, Dr. Luk mentioned the impact of Covid-19 restrictions leading to a halt on physical experimentations and trials in the past three years, touching on how the involvement of people in trials makes the research much more complicated than it would be compared to biological research. Ethical issues are not uncommon among different scientific fields, such as ethical dilemmas about chemical trials on rats, and do take a toll on the sports science industry as well. The problem proves itself to be challenging when it comes to the truth that athletes who undergo clinical trials are often the ones who also need to tackle rounds of nerve-racking competitions on a daily basis. While sports scientists cannot be fully sure of the safety of their creation, minimal damage or effects caused by experiments would easily be the reason these athletes lose to others while competing. Other problems encountered include voluntary participation, informed consent, anonymity and confidentiality.

Overshadowing and inferiority of the sports science industry

Dr. Luk was surprised that we have chosen a research topic based on sports science. “It’s a special scientific field – it’s not common for young aspiring scientists to choose a research path related to sports and biomechanics compared to biological or chemical research,” he says, “usually it’s those who either love and have high interests in sports, or are athletes themselves.” In fact, we have chosen sports science as our research topic because there are gymnasts and athletes among us. In comparison to athletes across the globe, it’s hard to deny that Hong Kong athletes are relatively less successful in international sports competitions such as the Olympics, or World Cups. The market for sports brands in Hong Kong isn’t thriving as well as it is in other countries, evident by how the popularity of foreign brands continuously overshadow local-made sports products. Hence, it’s not surprising that sports science has often been looked down upon and seldom seen by current young researchers as a potential area for research. On the bright side, Dr. Luk brings up how the current situation in Hong Kong is turning things around – with enlarging lists of athletes like Cheung Ka Long and Lee Wai Sze seizing accomplishments internationally, there would be more resources provided to this field, such as more government subsidies, sport facilities and people willing to join.

Lack of support from physiotherapy for professional athletes

Dr. Luk shared with us the downsides to physiotherapy and the impact and importance of sports therapy in overcoming these disadvantages. Previously, athletes rely on physiotherapy when faced with physical problems, but physiotherapy alone for professional athletes slowly unfolds its own flaws – firstly being that athletes are unable to attain enough support from physiotherapists due to the sky-high prices of hundreds of dollars for each physiotherapy session, ending up needing over thousands of dollars for athletes to recover. Another flaw that reveals itself is the incapability of physiotherapy to assist in the long-term well-being of athletes. “For example, if you have a broken arm or leg,” he mentions, “after

visiting physiotherapists for say, a few months, you regain the ability to walk normally. But that is not the case for athletes. Physiotherapy stops when you regain normality, not when you fully recover. What athletes need is long-term support. How do they fully recover quickly and regain their previous level of performance? How do they strengthen their bones so they do not encounter the same problems again? This is where sports therapy comes in."

Insights for research and qualities of an outstanding scientist

Dreams v.s. Reality in scientific research: how to get the most out of it?

When we conducted our interview, we thought about doing large-scale research and experiments in school, but reality hit us when we had little to no idea about the details of managing research such as clinical trials involving a wide range of audience with various limitations on time, technology, and number of participants. Dr. Luk mentioned the importance of identifying the problem and designing a specific solution before generating the idea and methods to create an actual product that is useful. Obtaining data takes a considerable amount of time, and especially for us, inexperienced and beginner researchers would even require time for training. He advises us to keep it realistic by identifying resources we have at hand, including technology, devices and support that we could use, to get a clear picture of potential areas of doable experiments. He suggests finding an impactful problem by reviewing current challenges in the sports science industry online or collecting data through questionnaires. It is also important to consider the limitations we have, the hardest being the timeframe of our project – products such as applied medicine requiring long periods of time to take effect would end up in long testing periods that we would not be able to fit in our deadline. Dr. Luk also reminded us of the procedures of testing out the created product: we should always first identify a target group and give ourselves enough time to carry out all the measurements and recordings.

Transformation of subjective results into objective data

We then asked about how we could solve challenges we would face due to the subjectivity of results, for instance, whether athletes feel more comfortable after using certain knee pads. Dr. Luk suggests conducting tests for improvement in abilities of athletes after using the product, or using professional tools or devices, for instance, to test for pressure on muscles and bones, or to measure changes in time spent by the athlete doing a certain action.

A dream isn’t a dream without love and passion

Scientists are dreamers – dreamers of discovery, of inventions, of seemingly unattainable things. Any dream isn’t a dream without love and passion. After all, dreams give us a sense of irrationality to believe in ourselves that we would be able to overcome the challenges we face. Dr. Luk reinforced that passion for research is particularly important for sports science, an industry that is often looked down upon, as mentioned above. He believes that his love for the industry is the force that pushes him to spread ideas of sports science to young minds and individuals. His passion for sports science comes from his love of taekwondo, which became his drive and motivation to assist young athletes and researchers to aim high and pursue their dreams.

Reflection

I am very inspired by Dr Jim as he made us feel at ease from the start—not only did he provide us with detailed information, but he also possessed a great character. He prepared a set of PowerPoint slides beforehand to illustrate the working systems of THEi and various student training programs initiated by the institute. It was unexpected but eye opening.

What struck me the most was Dr Jim's passion towards sports science and his commitment towards supporting athletes and stressing the importance of this subject. His dedication to experiment and research, especially collaborating with specialists to enhance training quality and injury rehabilitation, is exceptional. His thirst for knowledge and enthusiasm in educating young people is something that I think everyone, no matter their interest and occupation, should learn from.

The professor reminded us that the purpose behind all efforts and hard work is to contribute to society and aid those in need. His experience in the field allows him to recount all the brilliant aspects of a sports science professor's career, deepening my knowledge of this path and what it entails. I believe that his determination and resilience is the key to his success and is something I have to acquire to equip myself for the road ahead.

科學家報告書獎

The 16th Hong Kong Budding Scientists Award 2022-2023

SHATIN PUI YING COLLEGE

Interview with a Scientist – Professor Kenneth LEUNG Mei Yee

Students:

Mr. HON Chi Kin (S.2)
Mr. CHAN Chi Wing (S.3)
Mr. SHE Chun Hin (S.3)
Mr. CHOW Yui Hin (S.4)
Mr. YEUNG Pui Yin (S.4)

Teacher:

Mr. WONG Kwan Ho

1. Introduction

We are very grateful that Professor Kenneth LEUNG Mei Yee agreed to do this interview with us to share his experiences and gave us very useful advice on 11th April at the State Key Laboratory of Marine Pollution in the City University of Hong Kong. Prof. Leung shared many fun stories with us, ranging from his personal life, education, recent work and researches. It was our pleasure to have this opportunity to meet Prof. Leung personally. In this interview report, we will first introduce Prof. Leung and discuss his recent projects. Then, we will talk about our reflections from the interview, together with the advice he generously gave us.

2. Professor Leung's Stories

2.1. Motivations Since Childhood

Prof. Leung had always been a curious person since primary school. He investigated on the behaviours of ants by conducting experiments to put them in a fridge or with chemicals. Visiting the sea often with his father who was a mechanical engineer in the Marine Department, he would follow his father to swim and explore the open water. He would observe different marine creatures every time. Having found the ocean gigantic and mysterious, Prof. Leung became genuinely interested in the undersea environment.

2.2. No Pain, No Gain

Prof. Leung's learning process was full of ups and downs. Having paid little effort to learn in school for spending much time to play basketball, Prof. Leung received unsatisfactory HKCEE results and even failed the Chemistry subject. He then worked in the Youth League of the Civil Aid Service for a period of time. Understanding that the income and career development were not attractive enough, he wanted a change. He managed to persuade his parents to let him retake the HKCEE over having to work to make a living with his big family. After he passed the exams in the second time, he enrolled in a course in the Hong Kong Institute of Vocational Education (IVE) to be a drug dispenser, despite the fact that he preferred more the environmental science programme. Luckily, because of a sudden vacancy, he got admitted to his prioritised choice at last, where he conducted a project about sewage treatment to examine how germs consumed organic matters. Every time before a class, Prof. Leung worked hard to do his pre-studies and found himself enjoying the process of learning science. With great and consistent effort, he ranked the first among others in the programme.

To continue his pursuit in science, Prof. Leung took a Higher Diploma programme in Environmental Science and Technology in City University of Hong Kong (CityU). For his

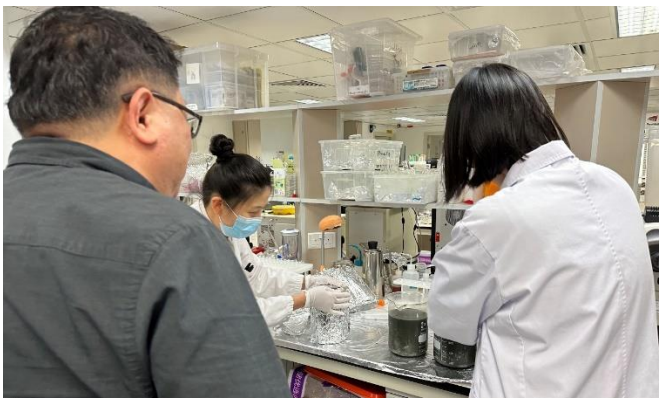
excellent academic performance, his professor at the time encouraged him to study in the University of Portsmouth, United Kingdom for a year. Having spent much of his father's pensions, Prof. Leung dedicated much in his research on air pollution in the UK. He successfully identified the most polluted area would be around the traffic lights, using active carbon methods. Prof. Leung eventually graduated with his Bachelor's degree with first-class honours.

2.3. Becoming A Scientist

After returning from the UK, Prof. Leung taught in IVE for a year. Although it was a fairly stable job, he was desiring more for his passion. He was eager to conduct more marine researches which he enjoyed and was capable of doing. Thus, Prof. Leung decided to continue researching into Environmental Science. For example, he investigated on marine pollution through studying the grouper fish. With outstanding findings, he earned a Swire Group Scholarship and Croucher Scholarship, which supported his PhD studies. In 2000, he graduated with a PhD in Marine Environmental Toxicology and began his professional career as a marine scientist.

2.4. Current Missions

Prof. Leung is Director of the State Key Laboratory of Marine Pollution (SKLMP), CityU. His team and himself are wholeheartedly dedicated in protecting marine environments. In his job, he has to attend international conferences and run collaboration programmes with governments and other universities. For instance, he was one of the representatives at the United Nation conferences in the Global Estuaries Monitoring Programme. In March 2023, he also went to Jakarta, Indonesia to attend the Intergovernmental Oceanographic Commission (IOC) Westpac meeting. The IOC granted Prof. Leung's SKLMP to set up the first UNESCO RTRC-Coastal COMMIT in Hong Kong in order to provide trainings for 6 other countries in marine protection. Prof. Leung with his team are committed to become one of the leading institutes in Marine Science in West Pacific Ocean, in order to preserve our oceans.



3. Our Reflections

3.1. Always Prepare For The Worst

During Prof. Leung's MPhil studies in CityU, he was conducting a research on marine pollution due to fish feeding. He and his fellows farmed thousands of fish (*Epinephelus areolatus*) in Kat O. However, due to a cold snap, all fish unfortunately died in one night. He could not get the data from the fish and the project at the time could only end in failure. As a result, he and his fellows had to restart the project all over again. It was an important lesson for Prof. Leung at the time. The worst is yet to come. There would be consequences for those who did not prepare enough.

Having learnt it the hard way, whenever Prof. Leung was doing experiments involving fish farms, he would always prepare two batches of fish, one in the fish farm and another in the laboratory. If, unfortunately, anything went wrong with the fish in the farm, he could at least adopt the data from the laboratory replica batch in order to keep the project running.

We found Prof. Leung's advice very true and practical in our school life. School days are full of surprises and incidents. For example, if we are on a school project, we should always aim to finish a few days before the given deadline. There can only be so many undesired problems to pop up to hinder the whole progress, such as a file loss. Chances are that these situations would cost a lot of time to fix, or even to restart the whole project. In contrast, if we are finishing projects just by the deadline, we can never have the time no the mental capacity to fix any issues that come up calmly. Therefore, we should learn from Prof. Leung to always prepare for the worst. At the very least, we wouldn't be losing everything when the storm comes.

3.2. Be Inspired By Our Everyday Life

Prof. Leung shared another story with us. In a meeting, a woman recommended him to put a rusty knife when washing clams. This could make clams spit sand from within the shells more quickly. He was intrigued and would like to see if this was true. He then went back to the laboratory and started to perform some experiments on it. After his investigations, he found that the only factors affecting the speed of clam spitting out sand are temperature and water salinity. He could learn all these about clams by following the inspirations he had from a normal meeting.

He then encouraged us to take inspirations from our everyday life. We just need to pay more attention in observations of nature, including anything that seems useless or meaningless at first sight. By that, we may even learn one thing or two that cannot be taught at school. It is helpful to learn from Prof. Leung's experience. Very often we are frustrated at school of thinking of a research topic for science projects or competitions. This is because we tend to overthink and we want to have something special since the beginning. However, the golden rule is about doing

something we truly feel interested in. We should look for inspirations from our daily life to see where our passions lead us to. Moreover, whenever we have questions over something, it is always beneficial to start acting, to gain hands-on experience.

Other than doing research in science, we can also apply this in writing essays. When we run out of ideas to write, we can always have a look at the surroundings. Then, we may discover something interesting and worth writing about. Inspirations that come from our daily life can enhance the resonance with the readers' experiences.

3.3. Pay Constant Effort

Prof. Leung also told us a story about his research project on seaweed population relocation on Lantau Island during his time in the University of Hong Kong. He first tried to collect the seaweed's seeds and to sow them by himself. This was very time consuming and unfortunately, it did not work. Then, he tried to move the whole seaweed population to another location. This worked. The seaweed managed to survive even under the construction of the new airport.

He also made a breakthrough in upcycling waste to make grooved eco-tiles, providing suitable habitats for marine organisms in the coastal regions. In the SKLMP, Prof. Leung led a research team to test the effectiveness of eco-tiles in Hong Kong. After a dozen of months of trials and errors with different eco-tile models, his team showed a successful result to raise the number of inhabiting marine organisms 4 times more than before. These ongoing trials of installing other different components like artificial tidal pools and oyster baskets along the coast line of Hong Kong had brought his team a few patented designs. His success in science research and marine protection only came because of his constant effort.

Prof. Leung advised us to dedicate ourselves in learning. As the famous quote by Thomas Edison goes, "success is 10% inspiration and 90% perspiration", paying effort persistently is the key to great achievements. If we are not serious in what we do and treat things casually, no matter how talented we are, the road would never be easy. Subsequently, we must make constant effort in self-improvement so that we are better than who we were yesterday.

In addition, when scientists conduct researches, even if their experiments fail, they do not stop. Rather, they continue to think about why and keep on trying from where they failed. Therefore, researching is a long-term commitment and requires time as well as effort. We should respect and appreciate all scientists for their hard work, or our lives wouldn't have been improved as such nowadays.

4. Conclusion

One of our most profound learnings from the interview with Prof. Leung was that "we are standing on giants' shoulders" he quoted. As students of modern time, we should make good use of all paper-based and digital learning resources to obtain knowledge. Learning now is much easier than in the past because we do not need to start things from scratch. We can always read more to learn from the experiences of the great people before us. Only by constantly referencing what we have understood from the past, can we then try to think of new ways to improve and to make things better today and in the future. We ought to keep learning as a continuous progress, or we would only fall behind of others. We would like to thank Prof. Leung again wholeheartedly for this interview and such an experience to tour in his laboratory.

End

科學家報告書獎

The 16th Hong Kong Budding Scientist Award

2022 – 2023

Interview with Scientist –

Professor Ng Kee Pui, Dennis

CChem FRSC CSci

Professor, Department of Chemistry, Chinese University of Hong Kong

Students:

1. Leung Hoi Ching 4A12
2. Suen Simeon Wan To 4D21
3. Chan Shing 3E01
4. Tang Shing Chun 3E23
5. Wong Cheuk Yan 3E24

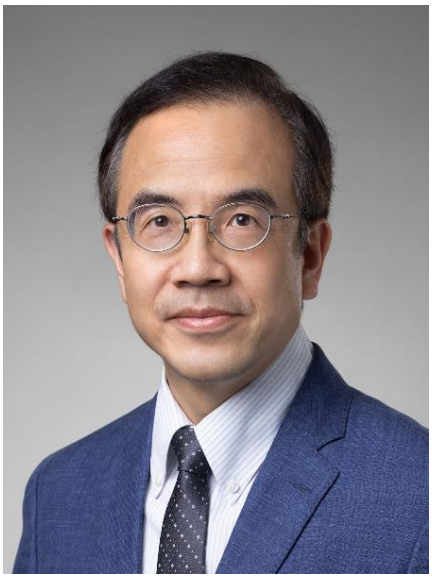
Bishop Hall Jubilee School

何明華會督銀禧中學

INTRODUCTION

On May 5th, 2023, we had the great privilege of conducting a face-to-face interview with the esteemed Professor Ng Kee Pui Dennis at the Chinese University of Hong Kong. Throughout the interview, he imparted a wealth of knowledge regarding his life experiences and his journey to becoming a distinguished and accomplished scientist. We were deeply impressed by his remarkable achievements and inspired by his compelling story. The insights gained from our conversation are invaluable, we have been enriched by the knowledge he has shared with us. We are immensely grateful for the opportunity to have engaged with such a distinguished and accomplished scientist and will carry the lessons we have learnt in the future.

BIOGRAPHY



Professor Ng Kee Pui Dennis is a highly accomplished and distinguished chemist who currently holds the position of professor in the Department of Chemistry at the Chinese University of Hong Kong (CUHK). Professor Ng has committed to advancing scientific research while also providing exceptional teaching to his students. He served as the former Vice-President of the CUHK and has held several other positions within the institution.

Professor Ng's educational background includes a First-Class Honours degree in chemistry from the CUHK, as well as a Master of Philosophy (M.Phil.) and Doctor of Philosophy (D.Phil.) from CUHK and the University of Oxford, respectively. He returned to his alma mater, the CUHK in 1994 as a lecturer in Chemistry, where he has since made significant contributions to the field of chemistry through his research and teaching.

Professor Ng's dedication to the scientific community has been widely recognised both locally and globally. He is a recipient of the CUHK Faculty Exemplary Teaching Award four times, as well as the Vice-Chancellor’s Exemplary Teaching Award in 2000. In addition, he was named a Fellow of the Royal Society of Chemistry (FRSC) in 2000 and a Chartered Scientist of the Science Council in the United Kingdom.

Throughout his teaching career, Professor Ng has nurtured many new Hong Kong scientists and has made enormous commitment to the field of chemistry. His research interests currently include the chemistry of various functional dyes, such as phthalocyanines and boron dipyrromethene derivatives, with a focus on their synthesis, supramolecular chemistry, bioconjugation, bioorthogonal chemistry, and applications in photodynamic therapy, photothermal therapy, bioimaging, fluorescence sensing, logic devices, and renewable energy production.

Overall, Professor Ng is a highly respected figure in the field of chemistry, with a career spanning several decades. He has made exceptional involvement in scientific research and education, and his devotion to educating new talent in the field is a testament to his commitment to advancing the field of chemistry.

RESEARCH INTEREST

A Further Development in the Cancer Industry

A new series of compounds that have therapeutic effects have been developed by the research group of Professor Ng. Everyday at the hospital, curing all diseases, such as cancer, poses a significant challenge for medical staff. Throughout history, the issue of cancer has been a tough one for patients and doctors alike. However, with the breakthrough research of many biomedical scientists, there is hope that many lives could be saved.

Professor Ng is currently researching functional dyes which can target tumour cells specifically. Dyes, which are commonly used as pigments in everyday life. Some dyes can also change their reactivity when being exposed to light, becoming highly reactive and interacting with nearby oxygen to produce reactive oxygen species (ROS), which can eradicate tumours. This novel treatment modality is called photodynamic therapy. Professor Ng's team is working on the design of dyes that can function as photosensitizers for cancer treatment. It involves the identification of molecules that can produce ROS when being exposed to light, modification of the molecules to improve their tumor specificity, and examine their treatment efficacy through in vitro and in vivo experiments. By localising the dyes at the tumour site and using light to activate them, this approach can potentially provide a non-invasive and targeted approach for cancer therapy. With continued research and development, this approach may lead to the development of new and more effective anticancer drugs.

CONTRIBUTION TO THE SOCIETY

1. Scientific contribution

Professor Ng has made great tribute to the development of science in Hong Kong, particularly in the field of chemistry. Over the course of his career, he has published more than 250 papers, which have been cited over 10000 times. His h-index, a measure that reflects both the productivity and citation impact of an author's publications, is an exceptional 61, placing him among the top scientists globally.

Currently, Professor Ng's research is focused on the development of advanced functional dyes for photodynamic therapy. This research has the potential to be a significant breakthrough in the fight against cancer, with far-reaching benefits for society.

Professor Ng's academic achievements have been widely recognised. He was awarded the prestigious Croucher Foundation Scholarship during his Ph.D. studies and is a full member of the renowned Sigma Xi – The Scientific Research Honour Society. These reflect his commitment to advancing scientific knowledge and his dedication to making a positive impact on society.

2. Nurturing the next generation

Professor Ng has had a long and illustrious career as an educator. He began his teaching journey in 1994 after working at the California Institute of Technology as a Research Fellow for a year to take up a position as a lecturer in the Department of Chemistry of The Chinese University of Hong Kong (CUHK). In addition to his teaching duties at CUHK, he also served as a part-time Lecturer in the School of Pharmacy from 1997-2000 and as a part-time professor at Fuzhou University in China.

Professor Ng's contributions to CUHK have been significant, and he is widely respected as an impactful and successful professor. He has supervised 40 Ph.D. students and 14 M.Phil. students, nurturing many young scientists who have gone on to make their own contributions to the field. His dedication to education has been recognised through various awards, including the Young Researcher Award and the Vice-Chancellor's Exemplary Teaching Award at CUHK.

Professor Ng's commitment to teaching extends beyond the university setting. He has also served the Hong Kong community by offering advice for curriculum development and contributing to the Hong Kong Diploma of Secondary Education (HKDSE) chemistry paper as a committee member of the Hong Kong Examinations and Assessment Authority (HKEAA).

Professor Ng's lifetime of enormous effort and devotion to education is truly deserving of the accolades he has received. He has played a significant role in shaping the scientific community in Hong Kong by helping to produce a new generation of students who will continue to make important contributions in their own right.

PATH TO BECOME A SCIENTIST

1. Embarking his journey of chemistry

Every successful scientist has a starting point, a moment when they realise their passion for discovery. For some, that spark is ignited in childhood, driven by a curious mind and a thirst for knowledge. For others, it's a turning point in their lives that propels them towards a career in science. But as we discovered in our interview with Professor Ng, you don't have to be a genius like Albert Einstein or Thomas Edison to make an impact in the world of science. Even an average student can become a great scientist with hard work and dedication.

As a secondary student, Professor Ng's academic prowess in science and mathematics was evident through his outstanding exam results. It was this success that led him to choose chemistry as one of his elective subjects in senior form, and later his undergraduate degree in the Chinese University of Hong Kong (CUHK). After graduating, he continued his academic pursuits and obtained a master's degree. Thanks to his remarkable grades that earned him a scholarship, his academic journey led him to pursue a PhD at the prestigious University of Oxford.

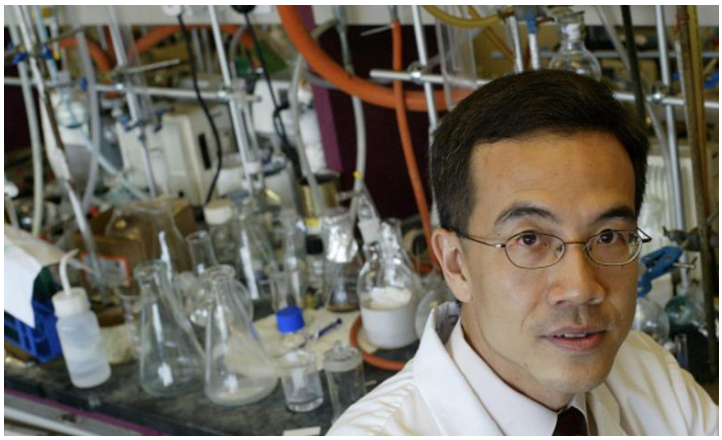
After that, Professor Ng remained humble and grounded. He returned to the CUHK, as a professor. When asked about the reason for his decision to become a professor, apart from the lack of choices at that time, Professor Ng also expressed his passion for science and his desire to nurture future scientific talents. It was clear that his dedication to science extended beyond his own research and academic pursuits.

Professor Ng's early journey in science highlights that anyone can become a successful scientist if they are passionate, hardworking, and committed to their goals. It's not about being a genius, but rather about finding your interest and pursuing it with determination and perseverance.

2. Step by step, striving for excellence

As a professor at the CUHK, Professor Ng had access to a wealth of advanced scientific knowledge. He began his research by investigating relatively basic and fundamental concepts in chemistry, such as small molecules and their molecular structures. However, through teaching and constantly challenging himself to learn more, he gradually delved into more complex topics, such as the biomedical application of dyes in treating cancer.

Professor Ng's studious spirit and willingness to push the boundaries of his understanding are key traits of a promising scientist. He told us that the path to scientific discovery is not always filled with obvious breakthroughs, turning points, or fancy stories. However, with passion, he believes that anyone can become an impactful scientist, step by step.



Indeed, this shows that becoming a successful scientist is a continuous process of learning and growing. It's not just about making groundbreaking discoveries, but also about constantly expanding our knowledge and challenging ourselves to explore new frontiers in science. With passion, everyone can make a difference in the world of science, eventually.

3. Obstacles on the way

Professor Ng's career has not always been smooth sailing. He has faced numerous obstacles and challenges, which have occasionally caused him frustration. One such challenge he shared with us was the review process for his research papers before they can be published in academic journals. Sometimes, the peer reviewers can be biased, which will be disheartening. He recalled how it took him almost a year to revise his paper before it was finally accepted.

Despite facing such setbacks, Professor Ng remained undeterred. He recognised that this was just part of the process and refused to let his passion for science be dampened by rejection. His perseverance paid off when his paper was finally accepted and published a few months ago.

Professor Ng's experience tells us that setbacks and rejection are part and parcel of any successful scientist's journey. It's not always about achieving immediate success, but rather about learning from failures and continuing to pursue our passions and goals with determination and resilience. While it may be frustrating to face rejection, it's important to remain focused and determined, knowing that every obstacle we overcome brings us one step closer to achieving our goals.

4. Future ambitions

After being in the present position for three decades, Professor Ng has no plans to slow down his research efforts in the foreseeable future. He is determined to continue his work on functional dyes and hopes to achieve even more with this topic, not just in the laboratory, but also in actual clinical application in curing cancer. His goal is to look for collaboration with clinicians and implement his idea clinically on human patients. As at this stage, his work is only at the cellular level and has only been tested in mice.

Professor Ng's research shows great promise in the fight against cancer, and we eagerly anticipate his continued contributions to this field. His dedication to advancing chemical science and improving human life is truly inspiring. Through his work and the contribution of countless biomedical scientists, they are making a meaningful impact on the lives of countless people affected by this devastating disease.

In conclusion, Professor Ng's passion for science and his commitment to advancing biomedical research are truly remarkable. His work on functional dyes and their potential use in cancer treatment holds great promise for the future. We look forward to seeing his continued contributions to this field and wish him all the best in his endeavours.

WORDS TO FUTURE SCIENTISTS

At the end of the interview, as science students, we asked Professor Ng about his advice to us and the new generation who want to dedicate their lives to science as well. And he has replied us with three main points:

1. Determination

Professor Ng mentioned that the students in this generation have much more resources than before, allowing them to explore in a multi-perspective. Thus, he encouraged us to find our true interest. It may not necessarily be science, but he still believes we should focus on our interest. For instance, if science is your passion, then he suggests you go for it, dig deeper on the topic. Even though the world is competitive, and success may not be the immediate result, we should never give up on our interest, our passion, our dream. In that way, we will be able to enjoy our career and do something meaningful for the future world.

In Professor Ng's opinion, today's students have access to an abundance of resources that were not available in the past, providing us with the opportunity to explore a wide range of perspectives and disciplines. He believes that it is crucial for us to discover our true interests and passions, even if they do not necessarily lie in the field of science.

But then, if science is your passion, Professor Ng encourages us to dive deeply into the subject matter. He acknowledges that the world is highly competitive, and that success may not come immediately, but he encourages us to remain steadfast in our interests and pursuits. Pursuing our passions and dreams will allow us to enjoy a fulfilling and meaningful career, making a positive impact on the world around us.

2. Dare to try

Professor Ng firmly believes that learning is a lifelong process, and he has embodied this philosophy throughout his career as a professor. He recognises that teaching is not just about imparting knowledge to others; it is also about learning and growing as an individual. To become a promising scientist, Professor Ng advises us to embrace new experiences, be open to learning, and never

settle for mediocrity. We should not shy away from challenges, but rather, embrace them as opportunities for growth and discovery.

That's the reason why Professor Ng loves his job, which is from the fact that it is never dull or routine. Even though it may seem like that on the surface, there are always unexpected challenges and opportunities for breakthroughs along the way. His willingness to embrace challenges and continue to learn is a testament to his dedication to scientific discovery and his commitment to making a positive impact on the world.

3. Perseverance

In addition to his other valuable insights, Professor Ng emphasises the importance of perseverance in achieving success. He has observed that many students today lack patience and tend to give up easily when faced with challenges. To become a successful scientist, Professor Ng advises us to ask ourselves whether we are willing to make sacrifices to achieve our goals. He reminds us that there are no shortcuts to success and that we must be willing to persist in the face of adversity, with perseverance, determination, and confidence.

Professor Ng's advice is particularly relevant in today's fast-paced and ever-changing world. As we pursue our goals and passions, we must be prepared to face challenges and setbacks, and we must remain steadfast in our determination to achieve success. By cultivating the mindset of perseverance, we can overcome obstacles and ultimately achieve our dreams.

In conclusion, Professor Ng's advice serves as a valuable reminder that success is not achieved overnight, but rather through hard work, dedication, and perseverance. By embracing learning, accepting challenges, and never giving up on our passions and goals, we can all strive towards a brighter and more fulfilling future.

EPILOGUE

Throughout the interview, we have had the opportunity to broaden our academic horizons. Professor Ng has not only provided us with a new perspective on the field of chemistry but has also imparted priceless life lessons. Looking back at his career and life, he realised that science has had a profound impact on him, equipping him with problem-solving skills that are essential for both research and interpersonal relationships. This experience has been truly meaningful and impactful for all of us, and we eagerly anticipate Professor Ng's future achievements and contributions to the modern world.

REFLECTION

In this competition, we had the amazing opportunity to interview Professor Ng, and it was a unique and inspiring experience for us. During our conversation, he shared valuable insights into what it takes to be a successful scientist, and we found his advice to be motivating and encouraging.

One thing that really stood out to us was Professor Ng's emphasis on the importance of confidence, interest, passion, and diligence in becoming an impactful scientist. He explained that while talent is important, it's not the only thing that matters. With dedication and perseverance, anyone can cultivate their skills and make a meaningful contribution to the field.

Another thing that we found inspiring was Professor Ng's personal journey. He wasn't always a science prodigy, but he discovered his interest in the subject and worked hard to develop his skills over time. His story reminded us that success is not always about innate talent but putting in the effort and never giving up.

All in all, our conversation with Professor Ng was insightful and motivating. His advice gave us a new perspective both academically and about life, and we feel more confident and inspired to pursue our interests in science.

ACKNOWLEDGEMENT

We would like to express our sincere gratitude on Professor Ng Kee Pui Dennis for accepting our invitation and sharing with us his life experiences.

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