2023/24
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」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. **與環境科學有關的科學探究**

   識別一個與「環境科學」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 environmental science**

   Identify a problem related to environmental 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

第十七屆香港科學青苗獎

「微塑瓜移」

利用絲瓜絡過濾水中微塑膠的研究

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指導老師: 陳穗雯老師、黃旭霖老師

引言

定義及現況

根據歐洲食物安全局的定義，微塑膠泛指微細的膠粒，其直徑少於 5 毫米(mm)[1]。近年社會開始關注微塑膠的問題，因為研究人員在不同的食物及飲品(如海鮮、食用鹽、自來水、啤酒和蜂蜜)，甚至在不同地方(如深海、聖母峰、北極海洋及農田)都發現微塑膠[2]。有研究估計，在海床上有多於 1400 萬噸的微塑膠存在[2,3]。

微塑膠的分類

微塑膠可分為初級微塑膠和次級微塑膠[4,5]。初級微塑膠泛指以人工方式生產的微細塑膠粒，包括個人護理產品中的微珠及合成紡織品（例如尼龍）中使用的塑膠纖維；而次級微塑膠是由較大的塑膠經磨損、沖刷、風化作用或長期曝曬後分解而成。

在眾多微塑膠的生成方法當中，布料和衣物所產生的微塑膠所佔比率最大，高達 35%，估計每年有高達 2.2 百萬噸的微塑膠進入海洋[6]。利用洗衣機清洗人造纖維衣物的過程中，機器與布料磨擦產生纖維碎片脫落，經排污系統進入海洋，因此我們在不知不覺間已經產生大量微塑膠。

微塑膠帶來的影響

已有研究證實生產塑膠材料時所使用的某些化學物質具有致癌性，可能會影響人體的內分泌系統，繼而引起發育、生殖、神經和免疫系統方面的疾病，有科學家更在人類胎盤中也發現微塑膠 [4,7]。

當微塑膠被排放到大海後，有毒污染物也會逐漸依附在微塑膠表面。當海洋生物吞下塑膠碎片時，這些污染物便會進入其消化系統，整個食物鏈在逐層積累下會提升污染程度，最後人類也會受影響。然而，目前還沒有研究反映進食含微塑膠的海鮮會對人體帶來怎樣的危害，所以暫時還未有國家對食物所含的微塑膠訂出任何標準[7]。

現有的解決方法

污水處理廠會透過化學強化方法處理污水中的微塑膠[8]。而逆滲透過濾技術(Reverse Osmosis，下稱 RO)則能處理食水中的微塑膠。然而，這兩種方法也需運用一定的化學物質、電力及能源，所以也需要一定的成本及製造一定的碳排放。對於經濟較落後的地區，這些方法未必達到普及化的效果。

探究目標

我們希望製作一個天然、便宜而且過濾效能高的過濾器，將洗衣過程中產生的微塑膠進行過濾，以減少排出海洋的微塑膠量。同時也希望這個過濾器能變得普及化。

濾芯的選用

我們的探究以測試環保天然濾芯為主題，希望不用生產額外非天然物料，避免製造更多垃圾，亦希望這個濾芯的過濾效能高、容易製作及成本低廉，從而可以推廣至低收入人士和發展中國家。

在思考選取哪種物料作為這次研究的濾芯時，我們參考了 RO 過濾膜的特性，以提升濾芯過濾污染物的效能。根據圖 1a，其中一個重要特性是過濾膜表面有一定的粗糙程度，讓污染物較易依附在過濾膜。根據圖 1b，另一個重要特性是要有孔徑讓過濾後的水能順暢地通過過濾膜。根據圖 1c，過濾膜要有一定的層數。

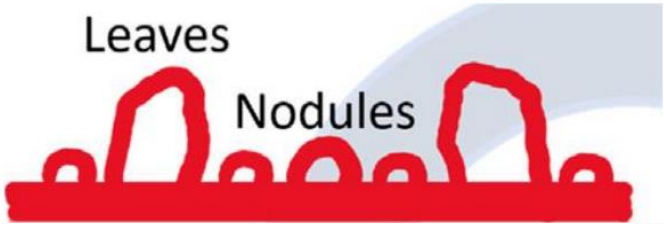


圖 1a. RO 過濾膜的表面粗糙度特徵[9]

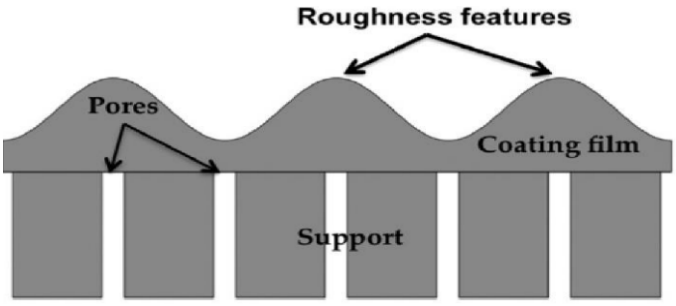


圖 1b. RO 過濾膜的表面粗糙度示意圖[10]

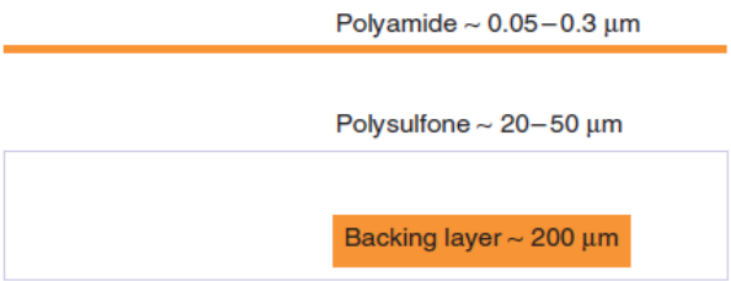


圖 1c. 薄膜複合材料 RO 過濾膜示意圖[11]

綜合了以上條件，我們聯想到校園中所種植的絲瓜，除了可吃用外，也可製成絲瓜絡。我們觀察到絲瓜絡具有網狀結構，而且纖維表面粗糙，於是萌生出利用絲瓜絡作為濾芯的念頭。而絲瓜是天然作物，容易種植，而且成本低，正正符合我們上述的目標。

實驗前的工序

1. 先準備大量乾的絲瓜絡，然後將這些絲瓜絡剪成碎塊(最大邊長為 10 mm)。

	
圖 2a. 一個完整的絲瓜絡	圖 2b. 剪碎後的絲瓜絡塊

測試物料

研究指出清洗衣物和布料過程產生的微塑膠以聚對苯二甲酸乙二酯（polyethylene terephthalate，下稱 PET）為最多[12]，因此我們選用 PET 作為實驗中的測試物料。而微塑膠是指大小介乎 0.1 微米與 5 毫米之間的不規則形狀塑膠混合物[1]，為了使實驗能一致且公平地進行，使結果較易量度，我們以單一大小的 PET 微塑膠粉來進行實驗，分別是 0.55mm(30 目)和 0.15mm(100 目)的 PET 塑膠粉。

	
圖 3a. 盛有 0.55mm(30 目)和 0.15mm(100 目)PET 塑膠粉的袋 (正面)	圖 3b. 盛有 0.55mm(30 目)和 0.15mm(100 目)PET 塑膠粉的袋 (背面)

測試系統

如圖 4 所示，一般的過濾系統都是把污水流經濾芯，然後濾芯會過濾部分污染物，淨化後的水會流出濾芯，形成較清澈的濾液。

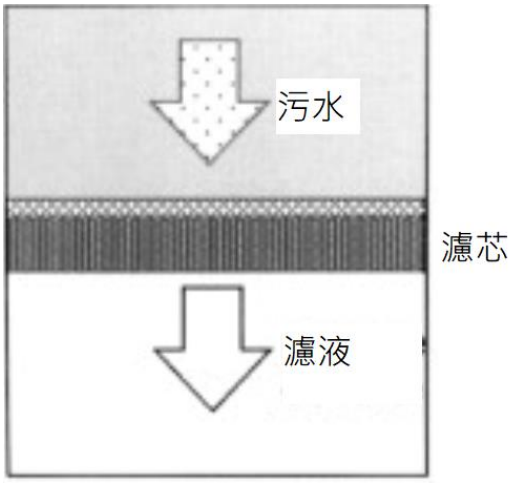


圖 4. 濾芯系統示意圖[13]

實驗工序及結果

一、探究以不同物料作為濾芯過濾微塑膠

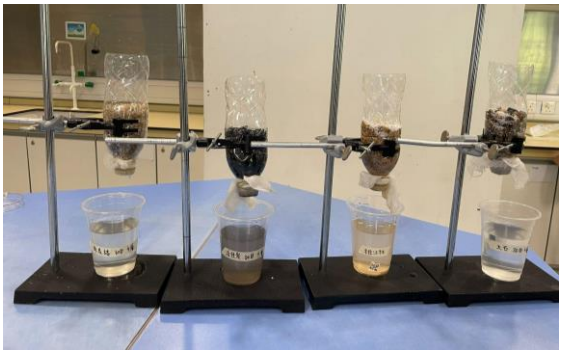
實驗目的：以絲瓜絡作為濾芯，以了解其過濾效能及過濾後的水(濾液)清澈度。也同時與一些常見過濾物料(活性碳、幼砂及小石粒)的效能作比較。

步驟：

1. 預備四個過濾器：剪去膠樽的底部，用四層紗布蓋着樽口。
2. 把四種過濾物料(絲瓜絡、活性碳、幼砂、小石粒)放入四個膠樽，直至到達距離樽口 8cm 的位置。
3. 將 1 克 0.55mm 的 PET 塑膠粉混入 250mL 水，然後倒入過濾器中，用杯盛載過濾後的水。

圖 5a. 量度 PET 微塑膠粉的重量

圖 5b. 以不同物料製作濾芯

	
圖 5c. 準備進行過濾測試	圖 5d. 四個過濾物料的過濾系統

結果:

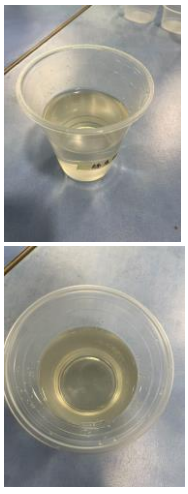
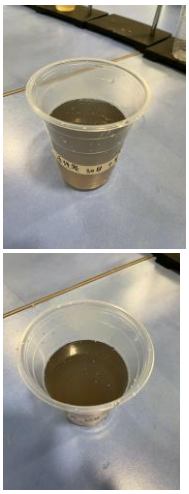
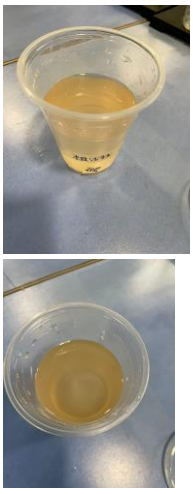
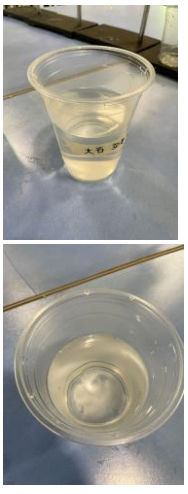
濾芯物料	絲瓜絡	活性碳	幼砂	小石粒
				
濾芯重量(g)	29.8	177.8	303.8	352.6
濾液的清澈度	清澈呈淡黃色	污濁呈灰黑色	污濁呈橙色	清澈
濾液含有顯見的塑膠	沒有	有	沒有	沒有

表 1. 四種濾芯物料的初步過濾結果

從觀察得知，經過活性碳和幼砂濾芯的濾液較污濁，而經過活性碳的濾液明顯有塑膠粒，因此活性碳和幼砂濾芯都不宜作為濾芯；而絲瓜絡和小石粒效果相近，但小石粒重量明顯大過絲瓜絡，對支架的負擔較大，因此之後的探究會以絲瓜絡作為濾芯。

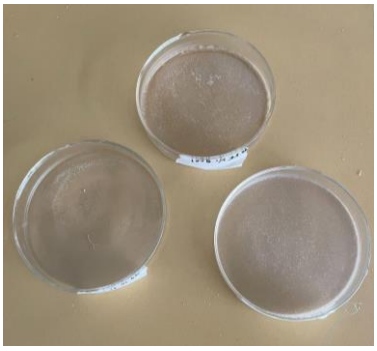
二、探究以絲瓜絡作為濾芯，過濾 0.55mm 的 PET 塑膠粉的效能

實驗目的：以量化方式探究絲瓜絡過濾 0.55mm 的 PET 塑膠粉的實際效能。

實驗方法修訂：
由於微塑膠粉太輕，直接把微塑膠加入水中，然後再把含微塑膠的水倒進濾芯，不少的微塑膠粉會依附在實驗用具的表面，所以不能完全測試濾芯的過濾效能，並造成數據上很大的誤差，為提升接下來的實驗數據的準確性，因此我們將 PET 塑膠粉直接倒入濾芯表面，然後再向濾芯倒入清水，以減低 PET 塑膠粉依附在實驗用具的機會。

步驟：

1. 預備過濾器外殼，剪去膠樽底部，使樽身剩下 15cm。
2. 為了防止絲瓜絡掉出膠樽，以四層紗布封着樽口。
3. 將剪碎的絲瓜絡放入膠樽，直至重量達 26g。擠壓絲瓜絡濾芯，使它使濾芯高度保持在 12cm。
4. 將 1 克 0.55mm 的 PET 塑膠粉倒入濾芯。
5. 加入 150mL 水，並利用玻璃碟(已量度淨重量)盛載濾液。
6. 將濾液放入攝氏 50 度的焗爐內，直至水份完全蒸發。
7. 量度玻璃碟重量，以計算出未被過濾的 PET 塑膠粉的重量。

	
圖 6a. 以絲瓜絡製作濾芯	圖 6b. 以玻璃碟盛載濾液
	
圖 6c. 盛載濾液的玻璃碟在 50°C 焗爐中	圖 6d. 濾液蒸發後的玻璃碟

結果:
我們運用了以下兩個公式計算第二及三部分的實驗結果。
公式 1. 穿過濾芯的微塑膠重量 = 濾液蒸發後的玻璃碟重量 - 玻璃碟的淨重量

公式 2. 過濾效能 = 成功過濾的微塑膠總重量 ÷ 加入的微塑膠重量 × 100%
= (加入的微塑膠重量 - 穿過濾芯的微塑膠重量)÷ 加入的微塑膠重量 × 100%

	第一隻破璃碟	第二隻破璃碟	第三隻破璃碟	穿過濾芯的微塑膠總重量(g)
淨重量(g)	41.64	33.33	33.50	
濾液蒸發後重量(g)	41.67	33.35	33.50	
穿過濾芯的微塑膠重量(g)	0.03	0.02	0	0.05

表 2. 絲瓜絡濾芯過濾 1 克 0.55mm 微塑膠的實驗數據

經過計算，穿過濾芯的 0.55mm 微塑膠總重量是 0.05g，而實驗時加入 0.55mm 微塑膠的重量是 1g，所以濾芯可過濾 0.95g 的 0.55mm 微塑膠，過濾 0.55mm 微塑膠的效能為 95%。

三、探究以絲瓜絡作為濾芯，過濾 0.15mm 的 PET 塑膠粉的效能

實驗目的: 以量化方式探究絲瓜絡過濾 0.15mm 的 PET 塑膠粉的實際效能，同時也可比較絲瓜絡過濾不同大小的 PET 塑膠粉的實際效能有甚麼分別。

步驟：
步驗與探究二相同，這次以 0.15mm 代替 0.55mm 的 PET 塑膠粉倒入濾芯。

結果:

	第一隻破璃碟	第二隻破璃碟	第三隻破璃碟	穿過濾芯的微塑膠總重量(g)
淨重量(g)	36.95	36.49	28.83	
濾液蒸發後重量(g)	33.98	36.52	28.83	
穿過濾芯的微塑膠重量(g)	0.03	0.03	0	0.06

表 3. 絲瓜絡濾芯過濾 1 克 0.15mm 微塑膠的實驗數據

在計算過後，穿過濾芯的 0.15mm 微塑膠總重量是 0.06g，而實驗時加入 0.15mm 微塑膠的重量是 1g，所以濾芯可過濾 0.94g 的 0.15mm 微塑膠，過濾效能為 94%。

四、探究絲瓜絡濾芯過濾 0.55mm PET 塑膠粉的效能與過濾次數的關係

實驗目的: 探討當絲瓜絡濾芯過濾多次含 0.55mm PET 塑膠粉的水後，其過濾效能會有甚麼變化。

步驟：
與探究二的實驗方法相同，同樣將 1 克 0.55mm 的 PET 塑膠粉倒入濾芯，然後加入 150mL 水，並利用玻璃碟(已量度淨重量)盛載濾液。利用這個濾芯，重覆實驗多兩次。

結果:
第一次加入 1 克 0.55mm PET 塑膠粉及 150mL 水

	第一隻玻璃碟	第二隻玻璃碟	第三隻玻璃碟	穿過濾芯的微塑膠總重量(g)
淨重量(g)	36.48	41.68	33.43	
濾液蒸發後重量(g)	36.52	41.70	33.48	
穿過濾芯的微塑膠重量(g)	0.04	0.02	0.05	0.11

表 4. 絲瓜絡濾芯過濾第一次 1 克 0.55mm 微塑膠的實驗數據

第二次加入 1 克 0.55mm PET 塑膠粉及 150mL 水

	第一隻玻璃碟	第二隻玻璃碟	第三隻玻璃碟	穿過濾芯的微塑膠總重量(g)
淨重量(g)	36.04	37.51	36.25	
濾液蒸發後重量(g)	36.08	37.55	36.26	
穿過濾芯的微塑膠重量(g)	0.04	0.04	0.01	0.09

表 5. 絲瓜絡濾芯過濾第二次 1 克 0.55mm 微塑膠的實驗數據

第三次加入 1 克 0.55mm PET 塑膠粉及 150mL 水

	第一隻破璃碟	第二隻破璃碟	第三隻破璃碟	穿過濾芯的微塑膠總重量(g)
淨重量(g)	33.69	40.77	36.55	
濾液蒸發後重量(g)	33.71	40.79	36.58	
穿過濾芯的微塑膠重量(g)	0.02	0.02	0.03	0.07

表 6. 絲瓜絡濾芯過濾第三次 1 克 0.55mm 微塑膠的實驗數據

五、探究絲瓜絡濾芯過濾 0.15mm PET 塑膠粉的效能與過濾次數的關係

實驗目的: 探討當絲瓜絡濾芯過濾多次含 0.15mm PET 塑膠粉的水後，其過濾效能會有甚麼變化。

步驟：
與探究三的實驗方法相同，同樣將 1 克 0.15mm 的 PET 塑膠粉倒入濾芯，然後加入 150mL 水，並利用玻璃碟(已量度淨重量)盛載濾液。利用這個濾芯，重覆實驗多兩次。

結果:
第一次加入 1 克 0.15mm PET 塑膠粉及 150mL 水

	第一隻破璃碟	第二隻破璃碟	第三隻破璃碟	穿過濾芯的微塑膠總重量(g)
淨重量(g)	28.84	33.35	36.96	
濾液蒸發後重量(g)	28.92	33.39	37.03	
穿過濾芯的微塑膠重量(g)	0.08	0.04	0.07	0.19

表 7. 絲瓜絡濾芯過濾第一次 1 克 0.15mm 微塑膠的實驗數據

第二次加入 1 克 0.15mm PET 塑膠粉及 150mL 水

	第一隻破璃碟	第二隻破璃碟	第三隻破璃碟	穿過濾芯的微塑膠總重量(g)
淨重量(g)	34.45	36.46	36.42	
濾液蒸發後重量(g)	34.60	36.53	36.53	
穿過濾芯的微塑膠重量(g)	0.15	0.07	0.11	0.33

表 8. 絲瓜絡濾芯過濾第二次 1 克 0.15mm 微塑膠的實驗數據

第三次加入 1 克 0.15mm PET 塑膠粉及 150mL 水

	第一隻破璃碟	第二隻破璃碟	第三隻破璃碟	穿過濾芯的微塑膠總重量(g)
淨重量(g)	34.83	37.02	36.96	
濾液蒸發後重量(g)	34.90	37.09	37.05	
穿過濾芯的微塑膠重量(g)	0.07	0.07	0.09	0.23

表 9. 絲瓜絡濾芯過濾第三次 1 克 0.15mm 微塑膠的實驗數據

分析

(二)和(三)的結果分析

根據圖 7，我們有兩項發現。第一，以絲瓜絡作為濾芯過濾 0.55mm 及 0.15mm PET 塑膠粉的效能不俗，都有 90%以上。第二，絲瓜絡濾芯過濾較大的微塑膠的效能較高。

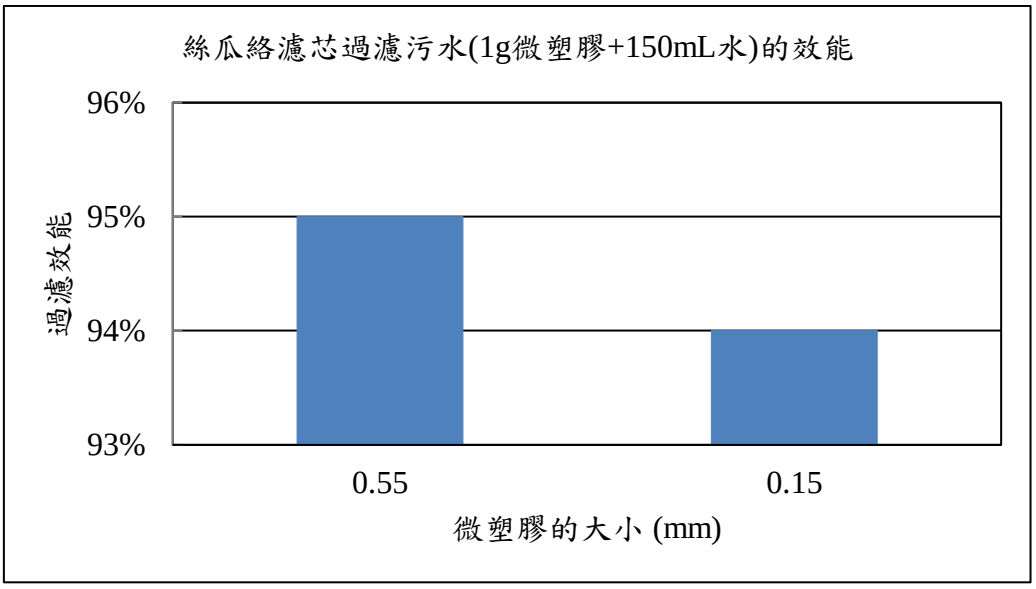


圖 7. 絲瓜絡濾芯過濾污水(1g 微塑膠+150mL 水)的效能

(四)和(五)的結果分析

在第四和五部分的實驗，隨著過濾次數增加，濾芯每次也會累積之前成功過濾的微塑膠粉，而每次實驗會再加 1 克的微塑膠粉，所以我們運用了以下兩個公式整合每部分的數據，以計算過濾效能。

公式 3. 殘留在濾芯的微塑膠總重量

= 上一次成功過濾的微塑膠總重量 + 新加入的微塑膠重量(1g)

公式 4. 成功過濾的微塑膠總重量

= 殘留在濾芯的微塑膠總重量 - 穿過濾芯的微塑膠總重量

(四) 加入 1 克 0.55mm PET 塑膠粉及 150mL 水	次數	原本殘留在濾芯的微塑膠總重量(g)	穿過濾芯的微塑膠總重量(g)	成功過濾的微塑膠總重量(g)	過濾效能
	第 1 次	1	0.11	0.89	89%
	第 2 次	1.89	0.09	1.8	95%
	第 3 次	2.8	0.07	2.73	98%

表 10. 絲瓜絡濾芯過濾三次 1 克 0.55mm PET 塑膠粉及 150mL 水的實驗數據

(五) 加入 1 克 0.15mm PET 塑膠粉及 150mL 水	次數	原本殘留在濾芯的微塑膠總重量(g)	穿過濾芯的微塑膠總重量(g)	成功過濾的微塑膠總重量(g)	過濾效能
	第 1 次	1	0.19	0.81	81%
	第 2 次	1.81	0.33	1.48	82%
	第 3 次	2.48	0.23	2.25	91%

表 11. 絲瓜絡濾芯過濾三次 1 克 0.15mm PET 塑膠粉及 150mL 水的實驗數據

將表 10 和表 11 的數據製成圖 8 後，我們有三個發現。

第一，絲瓜絡濾芯過濾 0.55mm 和 0.15mm PET 塑膠粉的效能都是 80%以上，表現不俗。

第二，在三次過濾 0.55mm 和 0.15mm PET 塑膠粉的過程當中，每次絲瓜絡濾芯過濾較大微塑膠的過濾效能都較高，這與第二及第三部分的結果分析相符。

第三，在三次過濾 0.55mm 和 0.15mm PET 塑膠粉的過程當中，隨著過濾次數越多，濾芯的過濾效能越高。從數學角度理解，原本殘留在濾芯的微塑膠總重量(公式 2 的分母)和成功過濾的微塑膠總重量(公式 2 的分子)都有提升，但因為後者的升幅比前者較大，所以過濾效能上升。

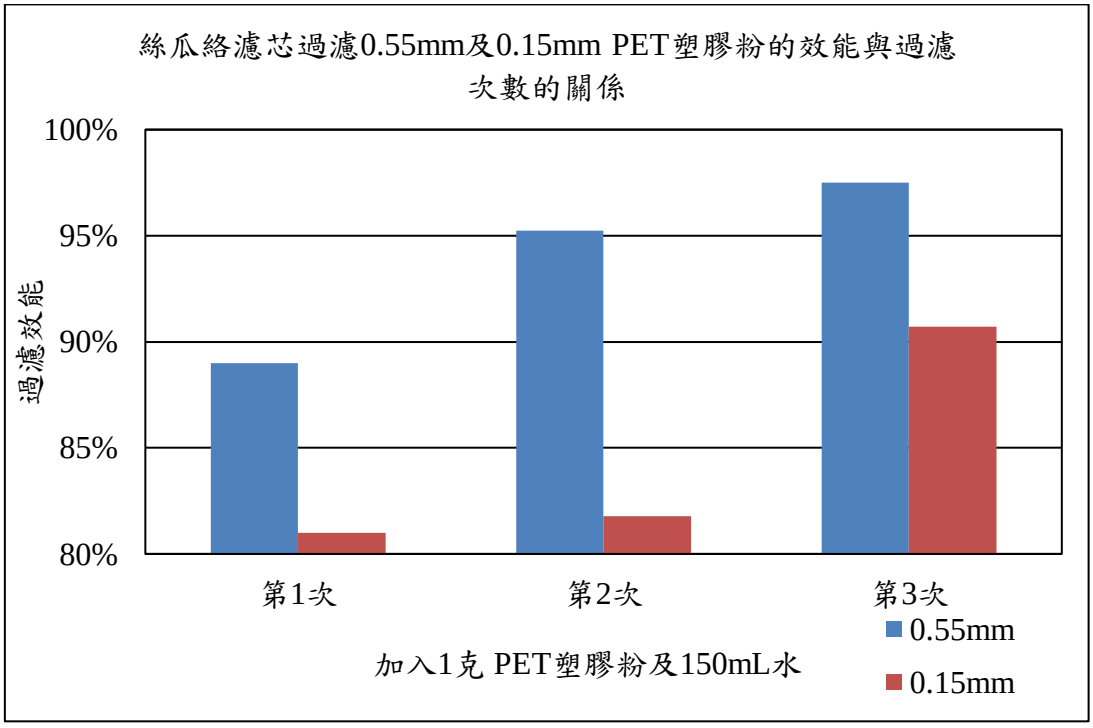


圖 8. 絲瓜絡過濾 0.55mm 及 0.15mm PET 塑膠粉的效能趨勢圖

總結

總括而言，以絲瓜絡作為濾芯過濾水中 0.55mm 和 0.15mm PET 塑膠粉的表現都有80%以上，但由於絲瓜絡是天然物料，所以每個濾芯的過濾效能都存在著一定的差異。雖然過濾後的水未達到可飲用級別，但也有一定的過濾功用。同時，即使以同一個濾芯過濾完三次微塑膠，過濾效能沒有下降的現象，證明了濾芯可重覆使用多次才更換，所以可以減少物料的消耗，符合環保的原則。再者，絲瓜絡不是一種昂貴的材料。所以若果在日後再加以測試及改良，相信推廣絲瓜絡濾芯至發展程度較低的地區使用也有一定的可行性。

限制及困難

1. 客觀因素: 因為絲瓜絡是來自天然的蔬果，所以每個絲瓜絡的結構都未必是完全相同，導致每次過濾的濾芯結構都不是完全相同，影響其過濾效能的穩定性。
2. 人為因素: 因為實驗所用的絲瓜絡是靠學生剪出來，每個絲瓜絡的碎塊的大小都可能不一，導致每次過濾的濾芯結構都未必完全相同，影響其過濾效能的穩定性。
3. 人為因素: 因為傾倒清水到濾芯的速度及範圍都未必一樣，所以會影響水流速度，令實際結果可能有誤差。
4. 器材限制: 因為學校的顯微鏡的影像解析度有限，未能清晰觀察到絲瓜絡碎塊的表面形態影像，所以未能將絲瓜絡碎塊的表面形態影像及其過濾效能作比對。
5. 規模限制: 本次實驗只以 150mL 及 250mL 水作污水樣本，污水份量可能不足以徹底測試濾芯的過濾效能，令實際結果可能有誤差。
6. 時間限制: 由於進行實驗的時間有限，所以未能每項探究都各進行多次實驗，從而計算出平均值及標準差，令實際結果可能有誤差。
7. 進行測試的方法：為免測試的微塑膠依附在實驗工具而無法進入過濾系統，我們將 PET 塑膠粉直接倒入濾芯表面，但此折衷方法與實際的污水排放情況並不相同。
8. 量度微塑膠的方法：由於實驗室儀器有限，我們無法用精密的儀器(例如: 傅立葉轉換紅外光譜儀)量度 PET 塑膠的含量，只能假設濾液只含有 PET 塑膠和水，蒸發後的重量便是 PET 塑膠粉末。

反思

雖然未有研究明確地指出微塑膠對人體健康的影響，但可以肯定的是微塑膠不易分解，所以會長時間殘留在大海，容易被海洋生物誤食而無法排出體外，而且在食物鏈中不斷累積，所以會令很多大型海洋生物甚至人類都受影響。

作為地球的一份子，我們可以減少使用塑膠產品及停用含有微膠粒的個人護理產品。其次，不要為了追求潮流而胡亂購買新衣服。

延伸思考

若果有足夠的資源及空間，可以從以下兩個方向繼續探討。

1. 增加濾芯高度再測試其過濾效能，從而探討不同濾芯高度的過濾效能及濾芯重量之組合，繼而計算出最佳濾芯高度和物料重量的比。
2. 在絲瓜絡濾芯加入其他物料，再測試其過濾效能，從而探討以多種物料及單一物料作為濾芯的過濾效能有甚麼分別。

參考資料

1. 海洋微塑膠的禍害參自
   https://www.edcity.hk/hq/zh-hant/content/%E8%AA%8D%E8%AD%98%E6%B5%B7%E6%B4%8B%E5%BE%AE%E5%A1%91%E8%86%A0%E7%9A%84%E7%A6%8D%E5%AE%B3
2. 微塑膠的基本資料參自
   https://www.indigowaters.org/microplastic-primary-school-zh
3. 海洋微塑膠的數量估計參自
   https://www.nytimes.com/wirecutter/blog/reduce-laundry-microfiber-pollution/
4. 微塑膠的分類參自
   https://www.britannica.com/technology/microplastic
5. 微塑膠的分類參自
   https://pubs.rsc.org/en/content/articlehtml/2019/na/c8na00210j
6. 清洗衣服對海洋的污染參自
   https://www.greenpeace.org/hongkong/issues/health/update/4769/%E5%BE%AE%E5%A1%91%E8%86%A0%E6%98%AF%E7%94%9A%E9%BA%BC%EF%BC%9F%E4%BD%A0%E7%9F%A5%E9%81%93%E6%88%91%E5%80%91%E8%BA%AB%E7%A9%BF%E7%9A%84%E8%A1%A3%E6%9C%8D%E6%AD%A3%E5%9C%A8%E6%B1%A1%E6%9F%93%E6%B5%B7/
7. 塑膠對人類的影響及國際對微塑膠的規管參自
   https://pubmed.ncbi.nlm.nih.gov/31476765/
8. 立法會環境事務委員會
   自願淘汰含微膠珠個人護理及化妝產品計劃的最新進展
   https://www.legco.gov.hk/yr2023/chinese/panels/ea/papers/ea20231215cb1-1107-3-c.pdf
9. RO 過濾膜的表面粗糙度特徵圖取自
   https://pubmed.ncbi.nlm.nih.gov/30660795/
10. RO 過濾膜的表面粗糙度示意圖取自
    https://www.semanticscholar.org/paper/Transport-through-composite-membranes%2C-part-2%3A-of-Ramon-Hoek/cf0d1b5a75c90610f9ab4a32472c8b6a241550ff
11. 薄膜複合材料 RO 過濾膜示意圖取自
    https://www.researchgate.net/publication/285287849_Membrane_Technology_for_Water_Microfiltration_Ultrafiltration_Nanofiltration_and_Reverse_Osmosis
12. 清洗衣服所產生的微塑膠種類參自
    https://www.sciencedirect.com/science/article/pii/S2405844021012081
13. 濾芯系統示意圖改自
    https://www.sciencedirect.com/topics/engineering/permeate-stream

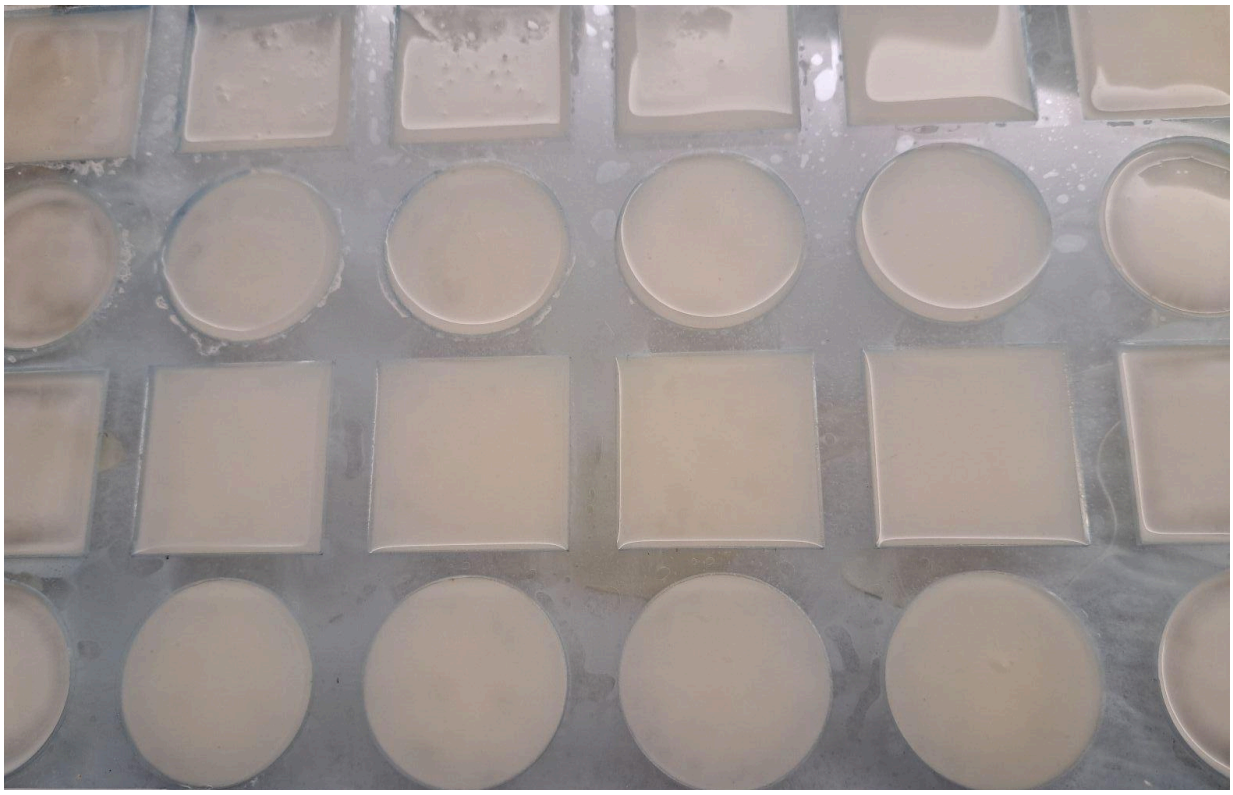
亞軍

優才(楊殷有娣)書院 - 小學部

第十七屆香港科學青苗獎

現實難題主題: 香港的海洋污染

題目 : 生物降解膠, save the ocean now!



指導老師 : 陳漢翹老師、鄭朗翹老師、林俊燊老師

參賽學生 : 梁天兒、康野行、邱灝晴、楊晞延、袁詩晴

目錄

一、簡介

「走塑」將於今年4月22日實施，禁止商戶及食肆提供或銷售即棄塑膠餐具。無可否認，一次性塑膠帶來很多方便，亦符合經濟效益，但同時亦對我們的環境造成很大負擔。一般塑膠進入海洋最少也需要數百年才能分解完成；有些海洋塑膠更可裂解成微粒，進入食物鏈，影響海洋生態。我們希望找到一次性塑膠的替代方案，解決海洋塑膠污染。

今年8月1日開始實行垃圾徵費，根據環保署的統計資料，廚餘是香港都市固體廢物中的最大類別。除了食剩飯菜或過期食品外，在食品生產、加工、批發、零售及預備過程中也會產生廚餘。「綠在區區」至今已有超過170個公共收集點，接收9種常見回收物，包括廚餘及塑膠。可是，很多屋苑的垃圾處理配套依然不足，只有少量屋苑設有廚餘機，回收廚餘一直都是難題，所以我們希望有效運用廚餘，減少浪費。

目前商業化生產的生物降解塑膠，主要有聚乙烯醇（PVA）以及聚乳酸（PLA）兩種，在微生物的幫助下，可轉化為水、二氧化碳和生物質。不過，一般需要在工業堆肥的環境下，才能夠完成可生物降解，對於土壤環境的酸鹼值、氧氣濃度、水分、溫度都有特定要求。所以我們的目標是製作出可以在一般泥土或海水中都能容易分解的生物降解塑膠，取代傳統塑膠。

當我們在網上搜尋資料時，發現可以利用澱粉基（Starch Blends）製作生物降解塑膠。有些組員分享，煮食時亦可加入粟粉勾芡，增加料理黏稠度；製作果凍時會加入魚膠粉達到凝固效果。於是，我們嘗試利用粟粉及魚膠粉製作生物降解塑膠，再加入不同廚餘，例如茶葉、薯皮、咖啡渣、蛋殼等，測試會否擁有傳統塑膠的特性。

我們想探討利用澱粉、魚膠粉和廚餘製作的生物降解塑膠，它們的強韌度、柔軟度、耐熱能力、防水性、降解能力，希望能把廚餘物盡其用，讓大家都善用資源，為環保出一分力。

二、科學原理

1) 塑膠的科學原理

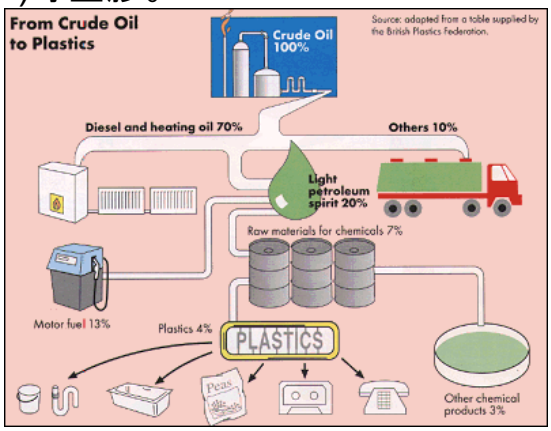
a) 塑膠的定義

根據美國材料試驗協會所下的定義，塑膠是一種以高分子量有機物質為主要成分的材料，它在加工完成時呈現固態形狀，在製造以及加工過程中，可以藉流動來造型。
根據國際純化學和應用化學聯合會的定義，塑膠一個用來指聚合材料的通用詞語，材料中可能包括其他可以提昇性能或降低成本的物質。
可見塑膠是一種由有機材料組成的聚合物。

b) 有機材料的定義

有機材料是指由含有碳元素的化合物組成的材料。
這些化合物通常包含碳和氫，並且可以具有其他元素，如氧、氮、硫等。
有機材料可以是天然的，如木材、棉花、羊毛等，也可以是人工合成的，如塑膠、橡膠、紡織品等。
製作塑膠的有機材料主要來自石油和天然氣等化石燃料。
以下是塑膠的主要原材料：

- 石油：石油是塑膠最常用的原材料之一。石油中含有化學物質，如烴類化合物，包括乙烯和丙烯等。這些烴類化合物是製造聚乙烯(PE)和聚丙烯(PP)等常見塑膠的關鍵成分。
- 天然氣：天然氣也是塑膠製造的重要原材料。天然氣中的甲烷可以經過化學反應轉化為乙烯。乙烯被廣泛用於製造聚乙烯(PE)等塑膠。
- 煤炭：雖然煤炭不是常見的塑膠原材料，但它可以通過煤焦油的提取得到一些塑膠材料。煤焦油中的化學物質可以經過裂解和聚合反應，形成聚苯乙烯(PS)等塑膠。



c) 聚合物的定義

聚合物是由許多相同或相似的單分子通過化學反應連接而成的大分子化合物。這種連接過程稱為聚合，通常涉及到將單體分子中的雙鍵或多鍵打開，使其與其他單體進行反應，形成長鏈或網狀結構。

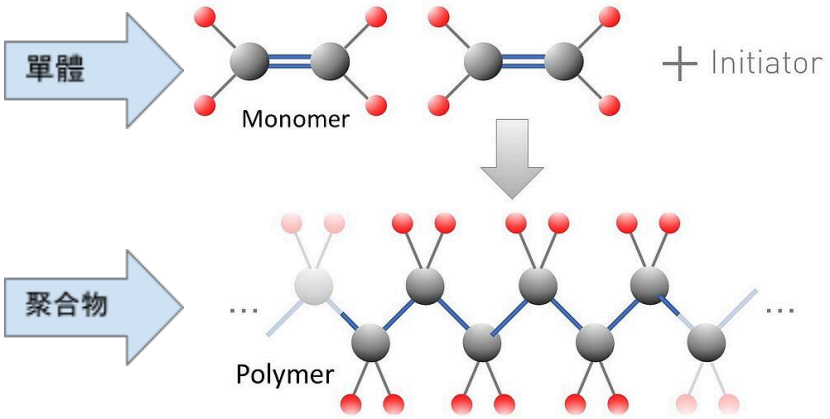
聚合物可以分為兩大類：

- 天然聚合物

天然聚合物是存在於自然界中的聚合物，如澱粉、天然橡膠和蛋白質。

- 合成聚合物。

合成聚合物是人工合成的聚合物，如聚乙烯、聚丙烯和聚苯乙烯。

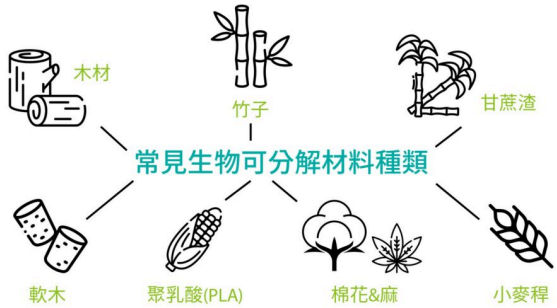


2) 生物可降解塑膠的科學原理

a) 生物可降解塑膠的定義

生物可分解塑膠是指一種可以被自然界中的微生物分解、降解並轉化為環境中的天然物質的塑膠材料。相比傳統的塑膠，生物可分解塑膠具有更高程度的可降解性，並且對環境造成的影響較小。

生物可分解塑膠通常使用可生物降解的材料，如澱粉、蛋白質、纖維素等，作為基材製成。這些材料可以在特定的環境條件下，如高溫、濕度和微生物的存在下，被微生物分解成水和二氧化碳等天然物質。

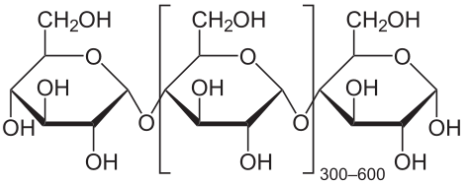


b) 生物可降解塑膠的材料

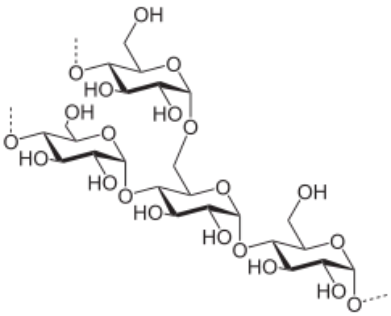
本次實驗以粟米粉和魚膠粉作為基材，加入不同份量的甘油、白醋和廚餘(紫薯皮、咖啡渣、蛋殼、茶葉)。

i) 粟米粉

主要成分是澱粉，澱粉是一種多糖，化學式為(C6H10O5)n。澱粉可分為直鏈澱粉(糖澱粉)和支鏈澱粉(膠澱粉)。直鏈澱粉是一種由葡萄糖組成的線性聚合物，每個直鏈澱粉分子通常含有數千個葡萄糖單體。支鏈澱粉是具分支的複雜結構。直鏈澱粉與支鏈澱粉組成生物中常見的澱粉。普通澱粉粒中，支鏈澱粉約佔80%，直鏈澱粉只約佔20%。



直鏈澱粉



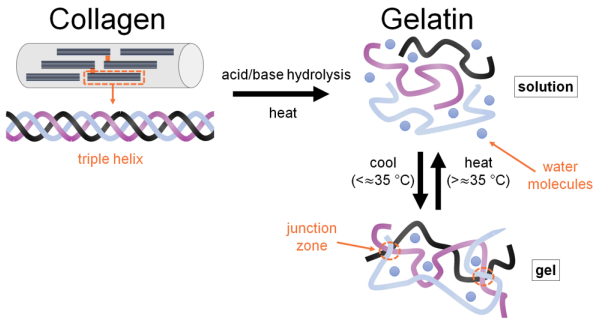
支鏈澱粉

澱粉的糊化作用及膠化作用

澱粉顆粒受熱吸水膨潤後會產生糊化作用，然後支鏈澱粉的結構能阻止直鏈澱粉緊密整齊的排列，形成類似塑膠的聚合物。而大多數糊化的澱粉在冷卻時使得纏繞現象增加，以及澱粉分子間的氫鍵形成，將許多水分子保留其中，失去其流動性，因而形成凝膠。

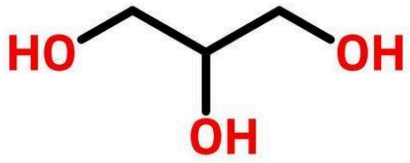
ii) 魚膠粉

它是以動物皮、骨內的蛋白質，亦即膠原蛋白製成。魚膠通常用於食物、藥物或化妝品的膠凝劑。它在高溫溶解後冷卻能形成複雜的結構，成為複雜的膠狀聚合物。



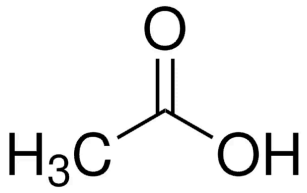
iii) 甘油

化學名稱為丙三醇，化學式為C3H8O3，是無色無臭有甜味的黏性液體，吸水性很強。添加它在聚合過程中，能增加分子和分子之間的空間，令聚合物的排列變得較鬆動，使其形成的生物可降解塑膠更富彈性及柔軟度。



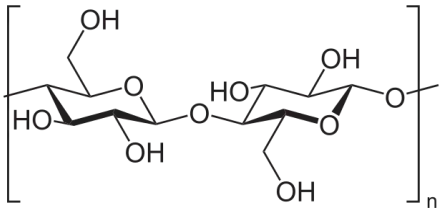
iv) 白醋

主要成分是水和3-5%的醋酸(CH_3COOH)。醋的pH值一般在2至3左右。醋通過保持較低的 pH 值來保存更長時間。添加它在生物可降解塑膠中，能延長生物可降解塑膠的保質期，增加使用壽命。



v) 紫薯皮、咖啡渣、茶葉碎

主要成分是纖維素（cellulose）是一類有機化合物，其化學式為(C6H10O5)n，是由幾百至幾千個葡萄糖組成的多醣。它們是植物細胞壁的主要成分，賦予植物結構強度和堅韌性。添加它在生物可降解塑膠中，能增加生物可降解塑膠的強度和韌性。



vi) 蛋殼

主要成分是碳酸鈣（Calcium carbonate），是一種化合物，化學式為CaCO3。它是一種無機鹽，是地球上最常見的礦物之一，也是許多生物體內骨骼、貝殼和蛋殼等的主要成分。碳酸鈣具有相對高的硬度，添加它在生物可降解塑膠中，能增加生物可降解塑膠硬度。

三、探究目的

探究以澱粉、魚膠粉和廚餘製作而成的生物降解塑膠的物理特性及降解能力。

1. 利用澱粉及魚膠粉，加入廚餘(紫薯皮、咖啡渣、蛋殼、茶葉)製成生物降解塑膠。
2. 測試加入不同份量的甘油及白醋和生物降解塑膠特性的關係。
3. 測試加入不同廚餘的生物降解塑膠的強韌度、耐熱度、防水性、降解能力。
4. 探究利用澱粉、魚膠粉和廚餘制作生物降解塑膠的可能性。

四、假設

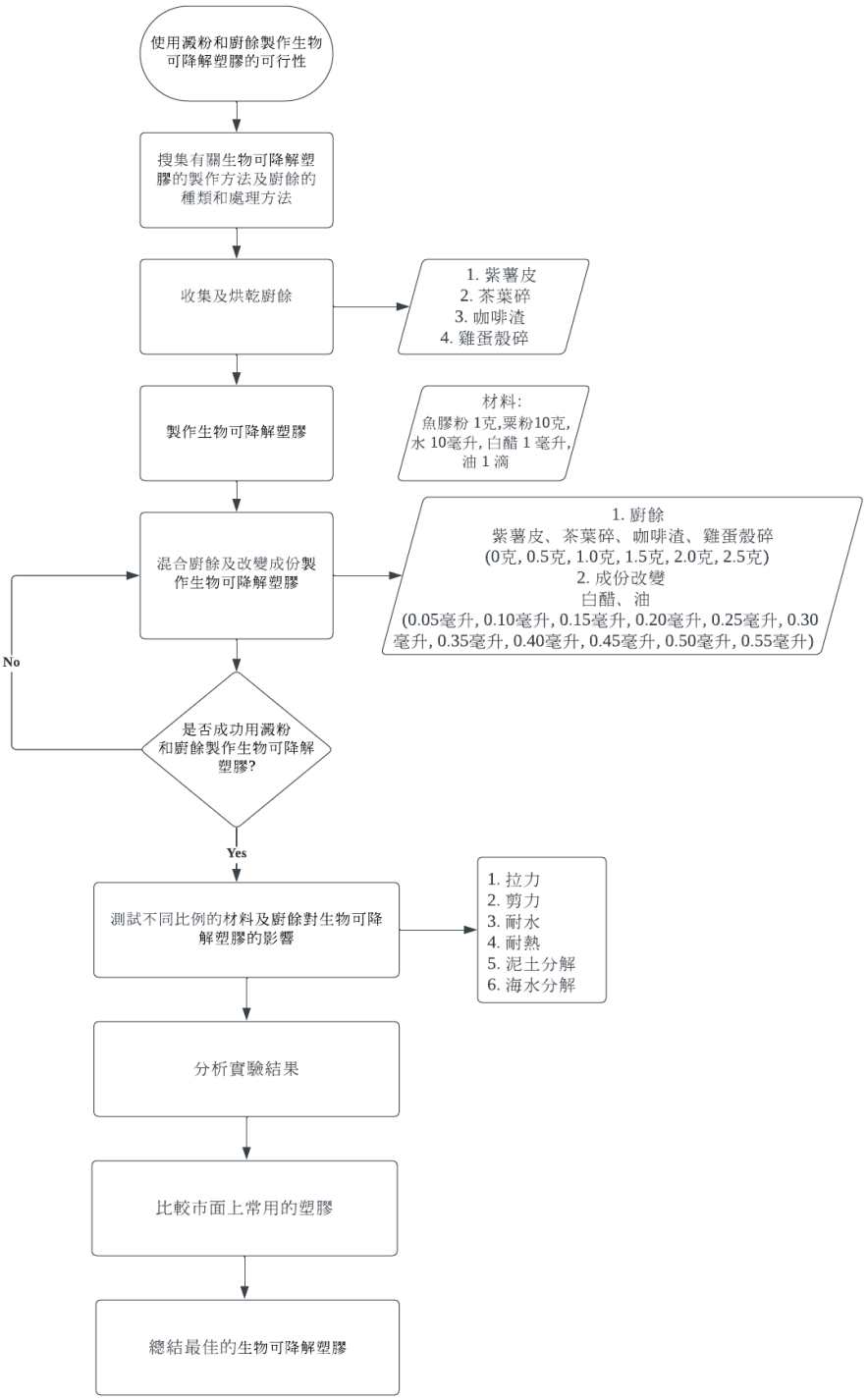
- 利用澱粉、魚膠粉和廚餘制作而成的生物降解塑膠，比起傳統塑膠的降解能力高，使用的材料原本都可用來製作食品，所以亦容易被微生物分解。
- 部分廚餘較硬，加入生物降解塑膠後，比傳統塑膠多出顆粒及粉末於物料之間，能增加強韌度 。
- 加入甘油，可以提高生物降解塑膠的防水性；但有些廚餘會吸入水份，加入過量廚餘會降低生物降解塑膠的防水性。
- 加入廚餘，估計塑膠會像平日高溫煮食時燒焦食物，降低生物降解塑膠的耐熱能力；甘油的熔點(17.8°C)及沸點(290°C)都比水高，應該能提高塑膠的耐熱能力。

五、實驗材料及用具

實驗材料			實驗用具			
粟米粉	紫薯皮	泥土	燒杯	研缽與杵	焗爐	磁力攪伴器
魚膠粉	蛋殼	海水	量筒	剪刀	雷射切割模具	電子計時器
甘油	茶葉	超市膠袋	滴管	電子秤	亞加力膠夾板	溫度計
白醋	咖啡渣	保鮮紙	攪拌棒	電磁爐	實驗鐵架台	
水		發泡膠盒	刮勺	煮食鍋	數顯推拉力計	

表格1：實驗材料和用具

六、研究過程及方法



圖片1：研究架構流程圖

七、實驗設計及步驟

1. 製作生物降解塑膠步驟

（一）準備廚餘

1. 紫薯皮：煮熟紫番薯後把它的外皮磨碎。
2. 茶葉碎：泡過茶後的茶葉烘乾後再磨碎。
3. 雞蛋殼碎：煮熟雞蛋後剝殼，磨成粉末。
4. 咖啡渣：直接取自咖啡店(Starbuck)或快餐店(大快活)。

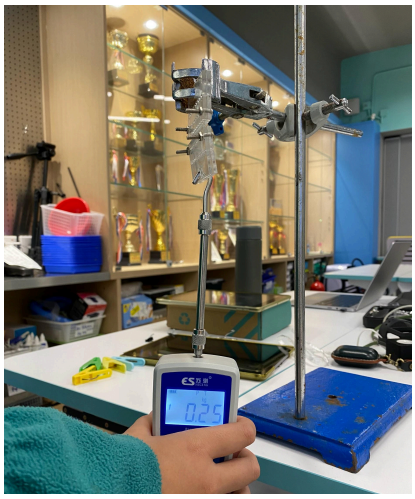
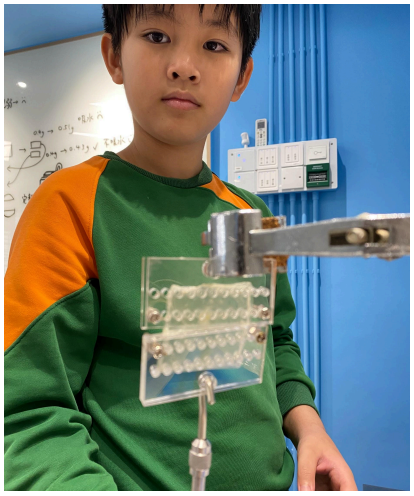
（二）製作生物降解塑膠

1. 把1g粟粉、1g魚膠粉放入量杯中混合。
2. 加入10ml水，攪拌至均勻混合。
3. 加入不同份量的甘油(0-5mL)、白醋(0-5mL)，有助於塑化混合物，使其更具彈性。
4. 加入不同份量的廚餘(0-2.5g)，增加生物塑膠的質感。
5. 煮沸混合物：將混合物放在電磁爐上，用70-90°C加熱至沸騰，不斷攪拌以避免結塊。煮至混合物變稠，類似於糊狀。
6. 入模：將濃稠狀的混合物用刮勺刮進模具，然後刮平表面。
7. 烘乾：把模具放進焗爐，在40°C中靜置3個小時。(如果沒有焗爐，可用風筒吹乾，不過難以平均控制溫度，亦有機會把塑膠樣本吹至飛脫，建議維持低風速。)
8. 脫模：等待混合物冷卻、凝固後，即可將塑膠片由模具中取出。

2. 實驗步驟

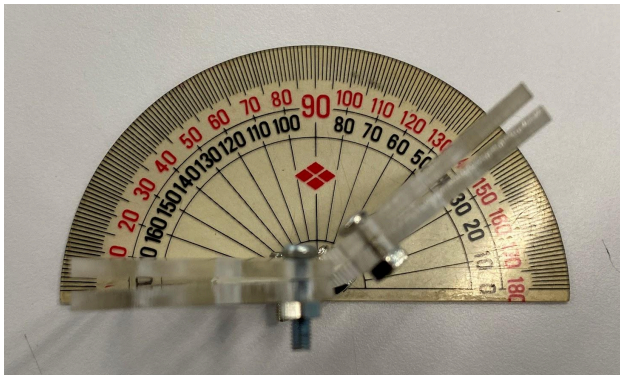
(一)垂直拉力(承重能力)

1. 取片狀(1x4cm)的塑膠樣本。
2. 利用4塊亞加力膠夾板把塑膠片夾在中間，中間留有1mm的間隙，以防塑膠片直接在固定過程中斷裂。
3. 扭緊螺絲及絲帽，讓塑膠樣本緊貼夾板。
4. 把夾板的一端固定於實驗鐵架台，使用數顯推拉力計的鐵鉤扣著夾板的另一端。
5. 往地面發力直至拉斷塑膠樣本，記錄數據顯示屏的重量(公斤)。

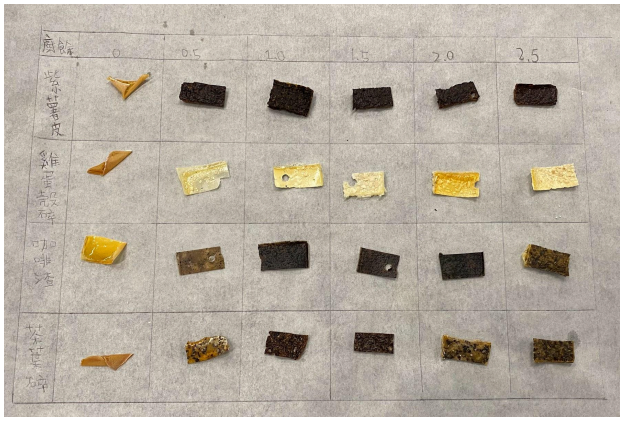

(二)剪力(屈曲及伸展能力)

1. 取片狀(1x4cm)的塑膠樣本。
2. 利用4塊亞加力膠夾板把塑膠片夾在中間，中間留有1mm的間隙，以防塑膠片直接在固定過程中斷裂，扭緊螺絲及絲帽，令樣本緊貼夾板。
3. 用手握著夾板的一端，夾板的間隙對準量角器的正中間。
4. 用推拉力計推另一端，直至塑膠樣本折斷，記錄最大的屈曲角度。




（三）耐熱能力

1. 取片狀(1x2cm)的塑膠樣本。
2. 預熱焗爐。
3. 使用鉛筆在牛油紙上標示不同塑膠樣本，然後放在托盤上。
4. 將塑膠樣本放在牛油紙適當的位置上。
5. 使用烘箱加熱樣本20分鐘。
6. 觀察及記錄其顏色及外觀變化。



（四）耐水能力（防水性）

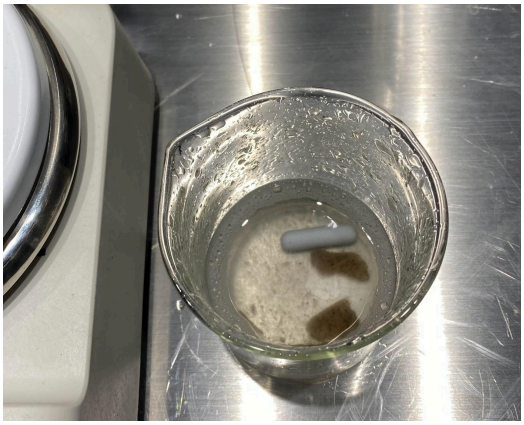
1. 取片狀(2x4cm)的塑膠樣本。
2. 量度樣本的起始重量。
3. 將樣本放在塑膠盒內，加入50ml水後密封起來。
4. 15分鐘後，量度樣本的最終重量，計算其百分比變化。

(五)泥土分解能力

1. 取片狀(2x4cm)的塑膠樣本。
2. 量度樣本的起始重量。
3. 量度70克的泥土並放在密實袋中。
4. 將樣本放入密實袋並標示其成分於袋上。
5. 每24小時量度樣本的重量，計算每天塑膠樣本的百分比變化。

(六)海水分解能力

1. 取片狀(2x4cm)的塑膠樣本。
2. 量度樣本的起始重量。
3. 從馬桶水缸中取出廁所鹹水。
4. 把120mL鹹水倒進量杯中。
5. 把生物可降解塑膠和磁石放進量杯內。
6. 把量杯放在電磁攪拌器上並啟動，每分鐘轉數為1500，模擬並加速海水流動分解塑膠的情況。
7. 記錄塑膠樣本的降解時間並測試其硬度。

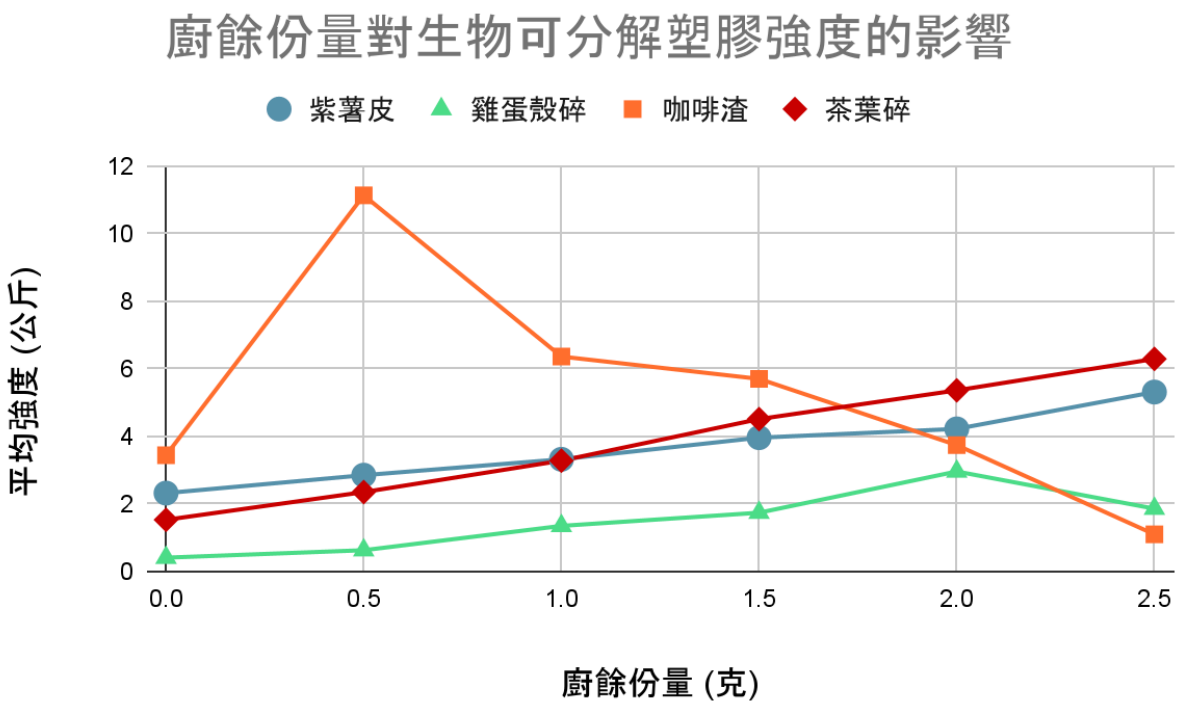


八、實驗結果及討論

I. 垂直拉力結果

表格2: 廚餘份量對生物可分解塑膠強度的影響

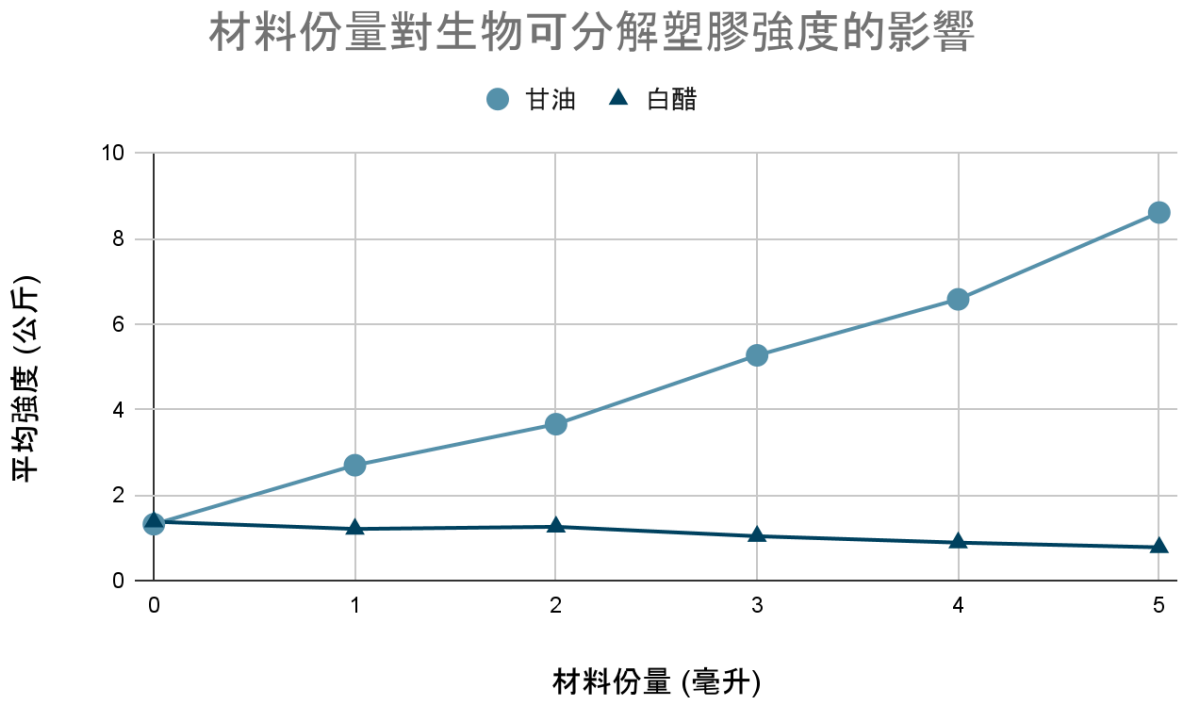
生物可分解塑膠	廚餘份量 (克)		平均強度 (公斤)
澱粉塑膠	紫薯皮	0	2.32
		0.5	2.85
		1.0	3.32
		1.5	3.96
		2.0	4.22
		2.5	5.31
	雞蛋殼碎	0	0.41
		0.5	0.63
		1.0	1.35
		1.5	1.74
		2.0	2.96
		2.5	1.86
	咖啡渣	0	3.44
		0.5	11.13
		1.0	6.36
		1.5	5.70
		2.0	3.74
		2.5	1.10
	茶葉碎	0	1.53
		0.5	2.35
		1.0	3.28
		1.5	4.51
		2.0	5.36
		2.5	6.29



加入少量咖啡渣可以加強塑膠的垂直強度，但是加太多咖啡渣反而令垂直強度大大下降，除此以外，其他的廚餘(紫薯皮、蛋殼碎、茶葉碎)都可以加強塑膠的垂直強度。由此可見，廚餘的加入對塑膠的正面影響。

表格3: 材料份量對生物可分解塑膠強度的影響

生物可分解塑膠	材料份量 (毫升)		平均強度 (公斤)
澱粉塑膠	甘油	0	1.32
		1	2.70
		2	3.66
		3	5.27
		4	6.58
		5	8.61
	白醋	0	1.38
		1	1.21
		2	1.26
		3	1.04
		4	0.89
		5	0.78



加入甘油可以讓塑膠的垂直拉力(承重能力)大幅度增加，但是加入白醋反而會讓塑膠的垂直拉力(承重能力)輕微下降。

表格4: 市面上常用的塑膠強度

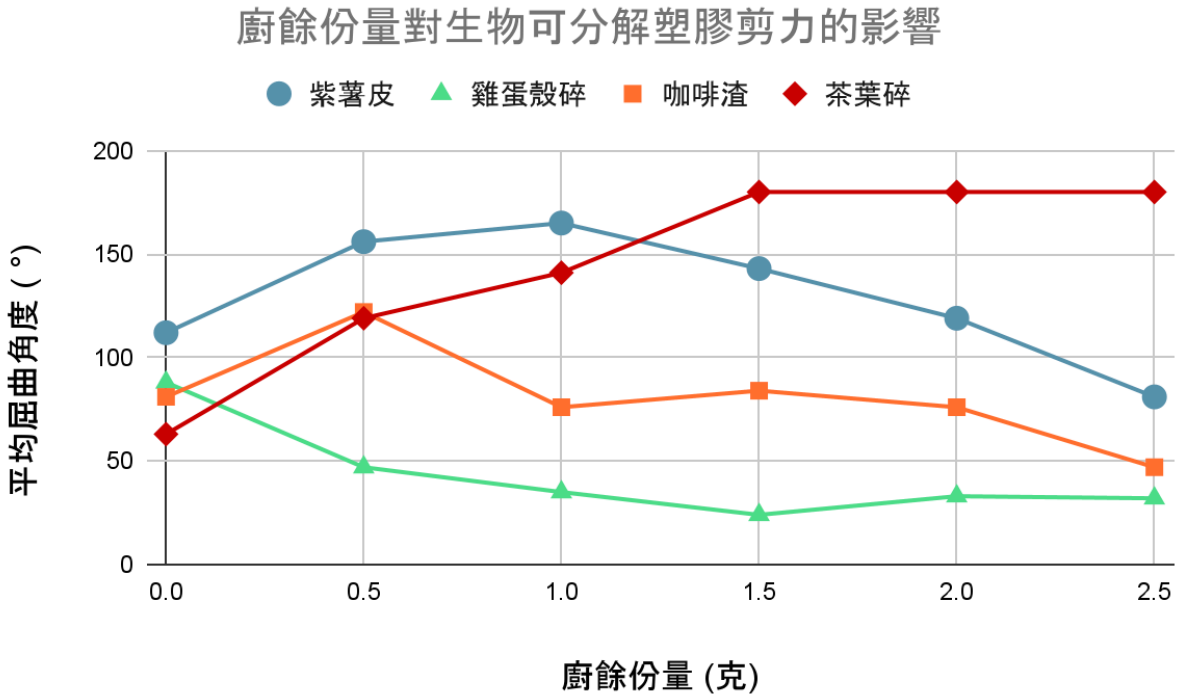
塑膠樣本	平均強度 (公斤)
保鮮紙	0.00
超市膠袋	0.00
發泡膠盒	0.26

對比起市面上常見的塑膠，我們製作的生物降解塑膠平均強度都比較高。

II. 剪力測試結果

表格5: 廚餘份量對生物可分解塑膠剪力的影響

生物可分解塑膠	廚餘份量 (克)		平均屈曲角度 (1-180°)
澱粉塑膠	紫薯皮	0	112
		0.5	156
		1.0	165
		1.5	143
		2.0	119
		2.5	81
	雞蛋殼碎	0	88
		0.5	47
		1.0	35
		1.5	24
		2.0	33
		2.5	32
	咖啡渣	0	81
		0.5	122
		1.0	76
		1.5	84
		2.0	76
		2.5	47
	茶葉碎	0	63
		0.5	119
		1.0	141
		1.5	180
		2.0	180
		2.5	180

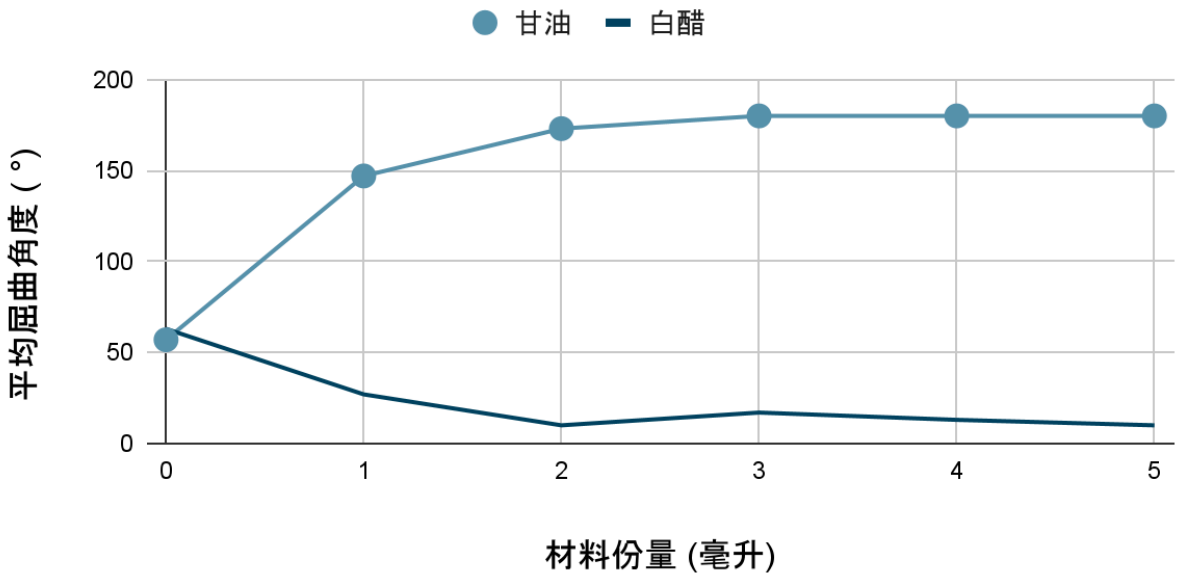


根據以上實驗結果，加入茶葉碎能有效提升生物降解塑膠的最大屈曲角度（柔軟度）；加入少量咖啡渣及紫薯皮(0.5g至1g)亦可以提升塑膠的柔軟度，但是加入蛋殼碎會減少塑膠的柔軟度。

表格6: 材料份量對生物可分解塑膠剪力的影響

生物可分解塑膠	材料份量 (毫升)		平均屈曲角度 (1-180°)
澱粉塑膠	甘油	0	57
		1	147
		2	173
		3	180
		4	180
		5	180
	白醋	0	43
		1	27
		2	10
		3	17
		4	13
		5	10

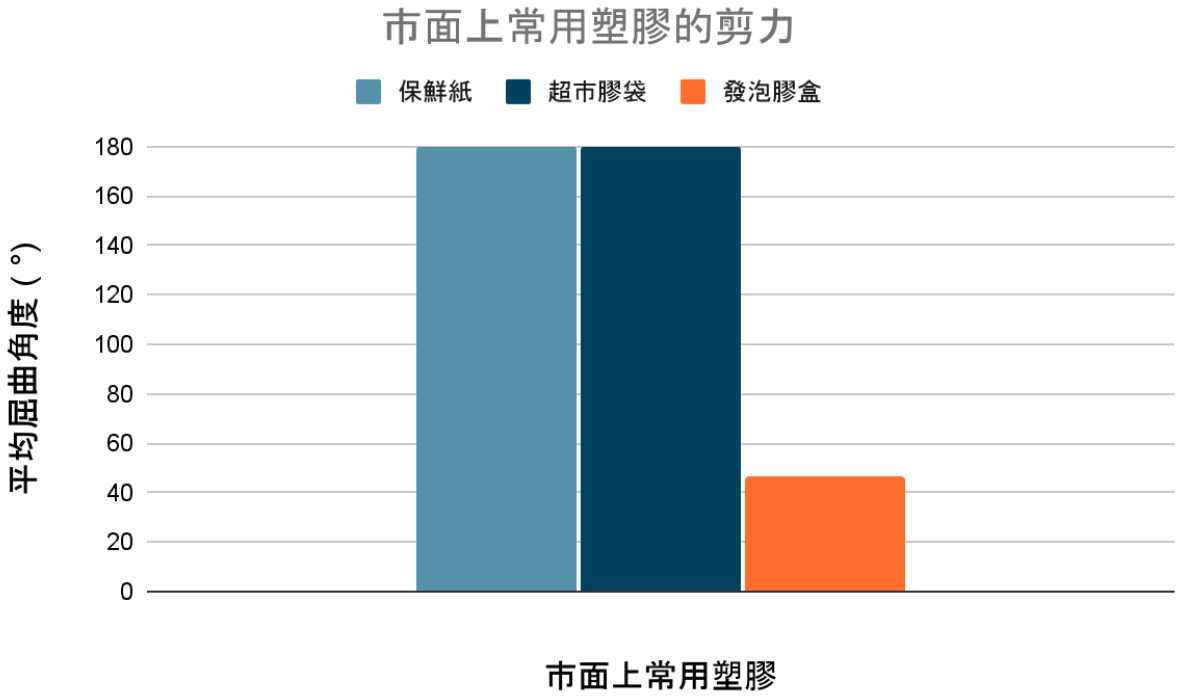
材料份量對生物可分解塑膠剪力的影響



根據以上結果，我們發現加入越多甘油能夠有效提升生物降解塑膠的剪力（即屈曲能力或柔軟度），相反加入白醋會減少生物降解塑膠的剪力，所以我們建議使用比例水:甘油的份量為5:1。

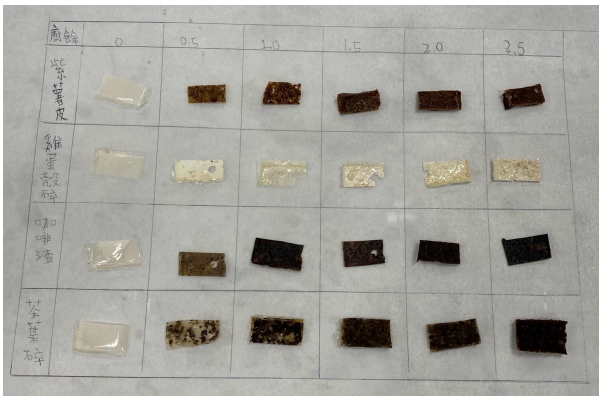
表格7: 市面上常用的塑膠**剪力**

塑膠樣本	平均屈曲角度 (1-180°)
保鮮紙	180
超市膠袋	180
發泡膠盒	47



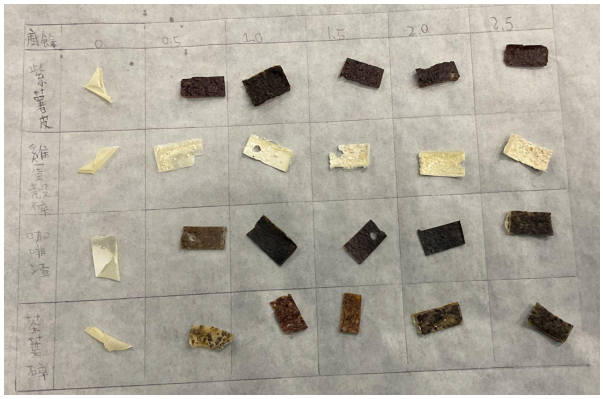
對比起市面上常見的塑膠，我們製作的生物降解塑膠的剪力（即屈曲能力或柔軟度）比較低，這個結果可能由於不同厚度，

III. 耐熱測試結果

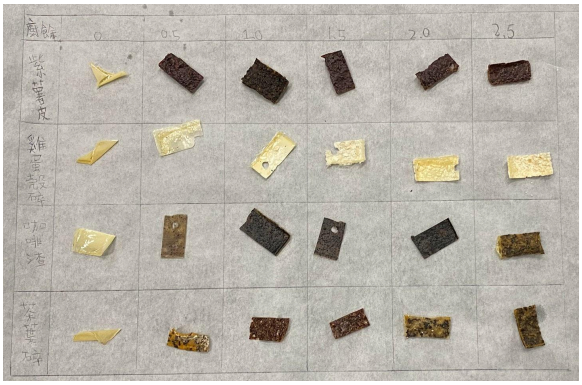


圖片2:起始情況各款廚餘生物降解塑膠情況

圖片3:烘烤80℃後，各款廚餘生物降解塑膠情況



圖片4:烘烤100℃後，各款廚餘生物降解塑膠情況

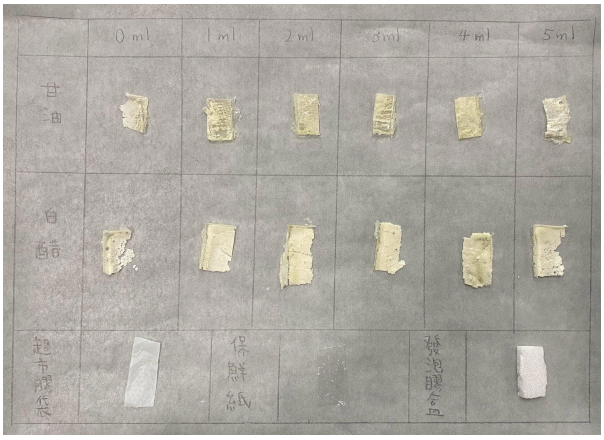


圖片5:烘烤120℃後，各款廚餘生物降解塑膠情況

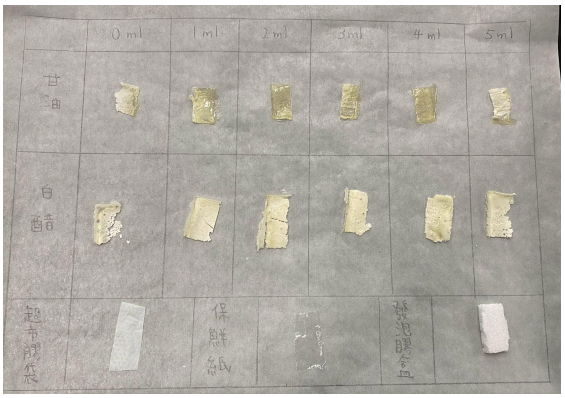
圖片6:烘烤140℃後，各款廚餘生物降解塑膠情況

表格8: 廚餘份量對生物可分解塑膠耐熱能力的影響

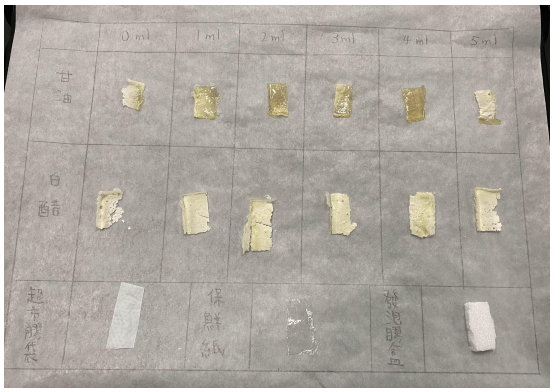
			溫度(℃)			
生物降解塑膠	廚餘份量 (克)		80	100	120	140
澱粉塑膠	紫薯皮	0	顏色不變	**開始卷曲，收縮**	**卷曲成一團，微焦**	**卷曲成一團，微焦**
		0.5	顏色不變	顏色不變	顏色不變	顏色不變
		1.0	顏色不變	顏色不變	顏色不變	顏色不變
		1.5	顏色不變	顏色不變	顏色不變	顏色不變
		2.0	顏色不變	顏色不變	顏色不變	顏色不變
		2.5	顏色不變	顏色不變	顏色不變	顏色不變
	雞蛋殼碎	0	顏色不變	顏色不變	**卷曲成一團，微焦**	**卷曲成一團，微焦**
		0.5	顏色不變	顏色不變	顏色不變	顏色不變
		1.0	顏色不變	顏色不變	顏色不變	顏色不變
		1.5	顏色不變	顏色不變	顏色不變	顏色不變
		2.0	顏色不變	顏色不變	顏色不變	**卷曲成一團，微焦**
		2.5	顏色不變	顏色不變	顏色不變	顏色不變
	咖啡渣	0	顏色不變	**開始卷曲，收縮**	**開始卷曲，收縮**	**卷曲成一團，微焦**
		0.5	顏色不變	顏色不變	顏色不變	顏色不變
		1.0	顏色不變	顏色不變	顏色不變	顏色不變
		1.5	顏色不變	顏色不變	顏色不變	顏色不變
		2.0	顏色不變	顏色不變	顏色不變	顏色不變
		2.5	顏色不變	顏色不變	顏色不變	顏色不變
	茶葉碎	0	顏色不變	**開始卷曲，收縮**	**卷曲成一團，微焦**	**卷曲成一團，微焦**
		0.5	顏色不變	顏色不變	顏色不變	顏色不變
		1.0	顏色不變	顏色不變	顏色不變	顏色不變
		1.5	顏色不變	顏色不變	顏色不變	顏色不變
		2.0	顏色不變	顏色不變	顏色不變	顏色不變
		2.5	顏色不變	顏色不變	顏色不變	顏色不變



圖片7:起始情況不同材料(甘油、白醋)的生物降解塑膠及市面上常用的塑膠情況



圖片8:烘烤80℃後，不同材料(甘油、白醋)的生物降解塑膠及市面上常用的塑膠情況



圖片9:烘烤100℃後，不同材料(甘油、白醋)的生物降解塑膠及市面上常用的塑膠情況

圖片10:烘烤120℃後，不同材料(甘油、白醋)的生物降解塑膠及市面上常用的塑膠情況

圖片11:烘烤140℃後，不同材料(甘油、白醋)的生物降解塑膠及市面上常用的塑膠情況

表格9: 材料份量對生物可分解塑膠耐熱能力的影響

			溫度(℃)			
生物降解塑膠	材料份量(毫升)		80	100	120	140
澱粉塑膠	甘油	0	顏色變黃，熔化	一部分顏色開始加深，熔化	一部分顏色開始加深，熔化	一部分顏色開始加深，熔化
		1	顏色變黃和熔化	一部分顏色開始加深，熔化	大約一半顏色開始加深，熔化	大部分顏色開始加深，熔化
		2	顏色變黃和熔化	一部分顏色開始加深，熔化	大約一半顏色開始加深，熔化	大部分顏色開始加深，熔化
		3	顏色變黃和熔化	一部分顏色開始加深，熔化	大約一半顏色開始加深，熔化	大部分顏色開始加深，熔化
		4	顏色變黃和熔化	一部分顏色開始加深，熔化	大約一半顏色開始加深，熔化	大部分顏色開始加深，熔化
		5	顏色變黃和熔化	一部分顏色開始加深，熔化	一部分顏色開始加深，熔化	一部分顏色開始加深，熔化
	白醋	0	顏色不變	顏色不變	顏色變黃	顏色變黃
		1	顏色不變	顏色不變	顏色變黃	顏色變黃
		2	顏色不變	顏色不變	顏色變黃	顏色變黃
		3	顏色不變	顏色不變	顏色變黃	顏色變黃
		4	顏色不變	顏色不變	顏色變黃	顏色變黃
		5	顏色不變	顏色不變	顏色變黃	顏色變黃

加入甘油的生物可降解塑膠耐熱程度較差，原因可能是因為甘油熔點較低(17.8°C)，加入白醋能提升生物降解塑膠的耐熱程度。

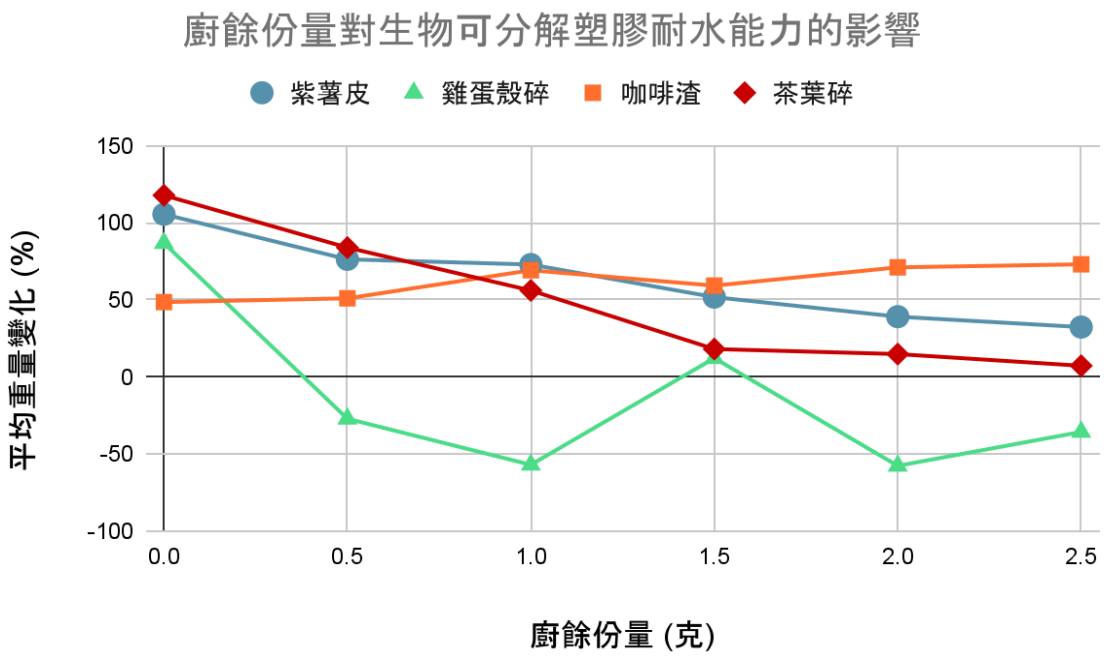
表格10: 市面上常用的塑膠耐熱能力

塑膠樣本	溫度(℃)			
	80	100	120	140
保鮮紙	形狀、顏色不變	形狀、顏色不變	縮小、明顯地溶解	近乎完全消失
超市膠袋	形狀、顏色不變	形狀、顏色不變	縮小，顏色不變	縮小，顏色不變
發泡膠盒	形狀、顏色不變	開始縮小，顏色不變	縮小，顏色不變	縮小，顏色不變

IV. 耐水測試結果

表格11: 廚餘份量對生物可分解塑膠耐水能力的影響

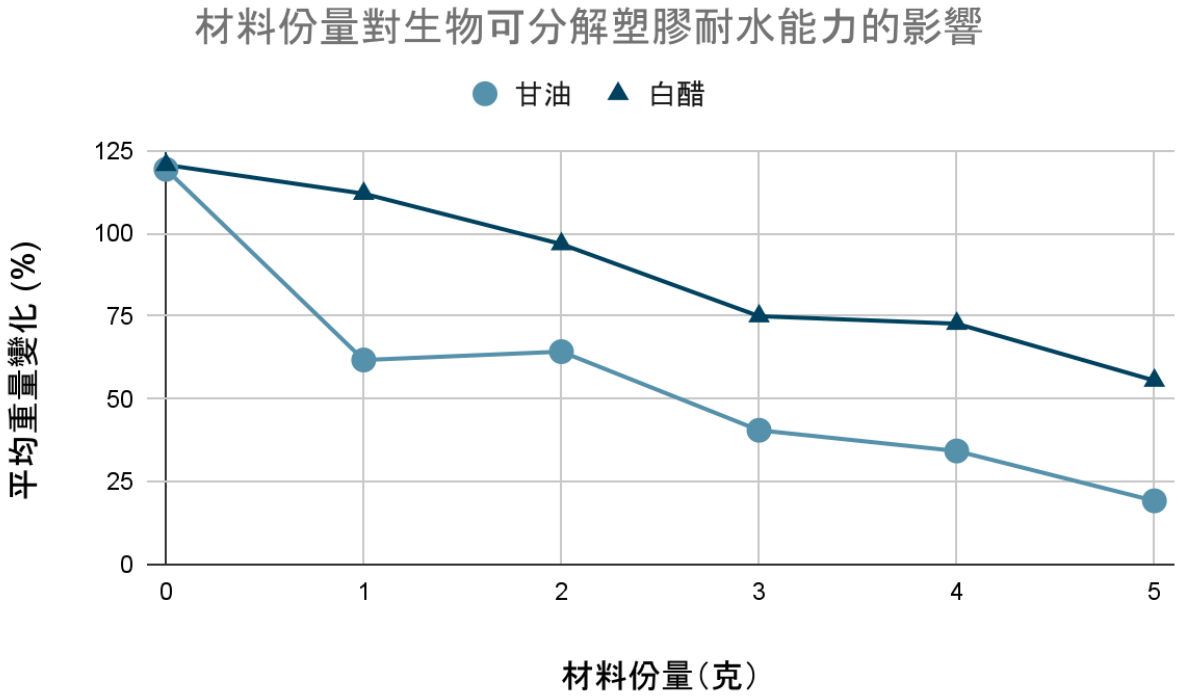
生物可分解塑膠	廚餘份量 (克)		最初重量 (克)	最終重量(克)	平均重量變化 (%)
澱粉塑膠	紫薯皮	0	0.36	0.74	105.56
		0.5	1.14	2.01	76.32
		1.0	1.22	2.11	72.95
		1.5	1.66	2.52	51.81
		2.0	1.84	2.56	39.13
		2.5	2.10	2.78	32.38
	雞蛋殼碎	0	0.38	0.71	86.84
		0.5	0.48	0.35	-27.08
		1.0	0.72	0.31	-56.94
		1.5	1.31	1.47	12.21
		2.0	1.84	0.78	-57.61
		2.5	2.47	1.59	-35.63
	咖啡渣	0	0.35	0.52	48.57
		0.5	0.49	0.74	51.02
		1.0	0.52	0.88	69.23
		1.5	0.54	0.86	59.26
		2.0	0.45	0.77	71.11
		2.5	0.51	0.90	73.08
	茶葉碎	0	0.28	0.61	117.86
		0.5	0.56	1.03	83.93
		1.0	0.98	1.53	56.12
		1.5	1.55	1.83	18.14
		2.0	1.95	2.24	14.87
		2.5	2.61	2.80	7.28



結果顯示，除了咖啡渣之外，加入所有的廚餘都能減少生物降解塑膠吸收水份，

表格12: 材料份量對生物可分解塑膠耐水能力的影響

生物可分解塑膠	材料份量(毫升)		最初重量 (克)	最終重量 (克)	平均重量變化 (%)
澱粉塑膠	甘油	0	0.31	0.68	119.35
		1	0.34	0.55	61.76
		2	0.28	0.46	64.29
		3	0.37	0.52	40.54
		4	0.35	0.47	34.29
		5	0.26	0.31	19.23
	白醋	0	0.29	0.64	120.69
		1	0.25	0.53	112.00
		2	0.31	0.61	96.77
		3	0.28	0.49	75.00
		4	0.33	0.57	72.73
		5	0.27	0.42	55.56



根據以上圖表我們可以發現加入更多甘油及白醋能夠減少生物降解塑膠吸收水份，加強塑膠的防水性。

表格13: 市面上常用塑膠**對生物可分解塑膠耐水能力的影響**

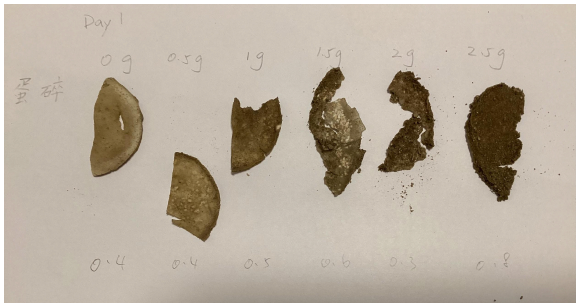
塑膠樣本	最初重量 (克)	最終重量(克)	平均重量變化 (%)
保鮮紙	1.0	1.0	0
超市膠袋	1.0	1.0	0
發泡膠盒	1.0	1.0	0

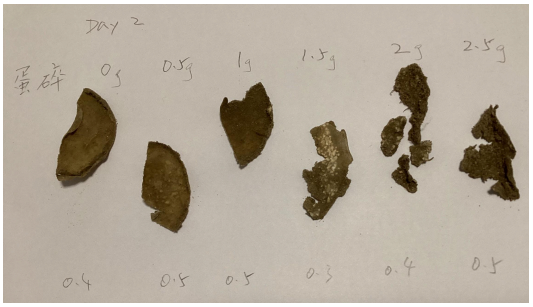
V. 泥土分解測試結果

表格14: 廚餘份量對生物可分解塑膠泥土分解的影響

生物可分解塑膠	廚餘份量 (克)		重量 (克)		
			第一天(19/3)	第二天(20/3)	第三天(21/3)
澱粉塑膠	紫薯皮	0	0.4	0.4	0.4
		0.5	0.4	0.4	0.5
		1.0	0.4	0.5	0.5
		1.5	0.4	0.6	0.3
		2.0	0.4	0.3	0.4
		2.5	0.4	0.8	0.5
	雞蛋殼碎	0	0.4	0.3	0.3
		0.5	0.4	0.7	0.7
		1.0	0.4	0.7	0.7
		1.5	0.4	0.9	0.9
		2.0	0.4	0.7	0.7
		2.5	0.4	0.8	0.8
	咖啡渣	0	0.4	0.4	0.3
		0.5	0.4	0.6	0.6
		1.0	0.4	0.4	0.5
		1.5	0.4	0.5	0.5
		2.0	0.4	0.6	0.5
		2.5	0.4	0.4	0.5
	茶葉碎	0	0.4	0.4	0.5
		0.5	0.4	0.3	0.3
		1.0	0.4	0.4	0.3
		1.5	0.4	0.6	0.7
		2.0	0.4	0.6	0.8
		2.5	0.4	0.7	0.8

因為時間關係，所以數據有所誤差，而塑膠重量增加可能是因為有些許泥土在塑膠表面。但從外觀上可以看到加入廚餘份量越多的生物降解塑膠，普遍在第二日已經開始變薄及碎裂。





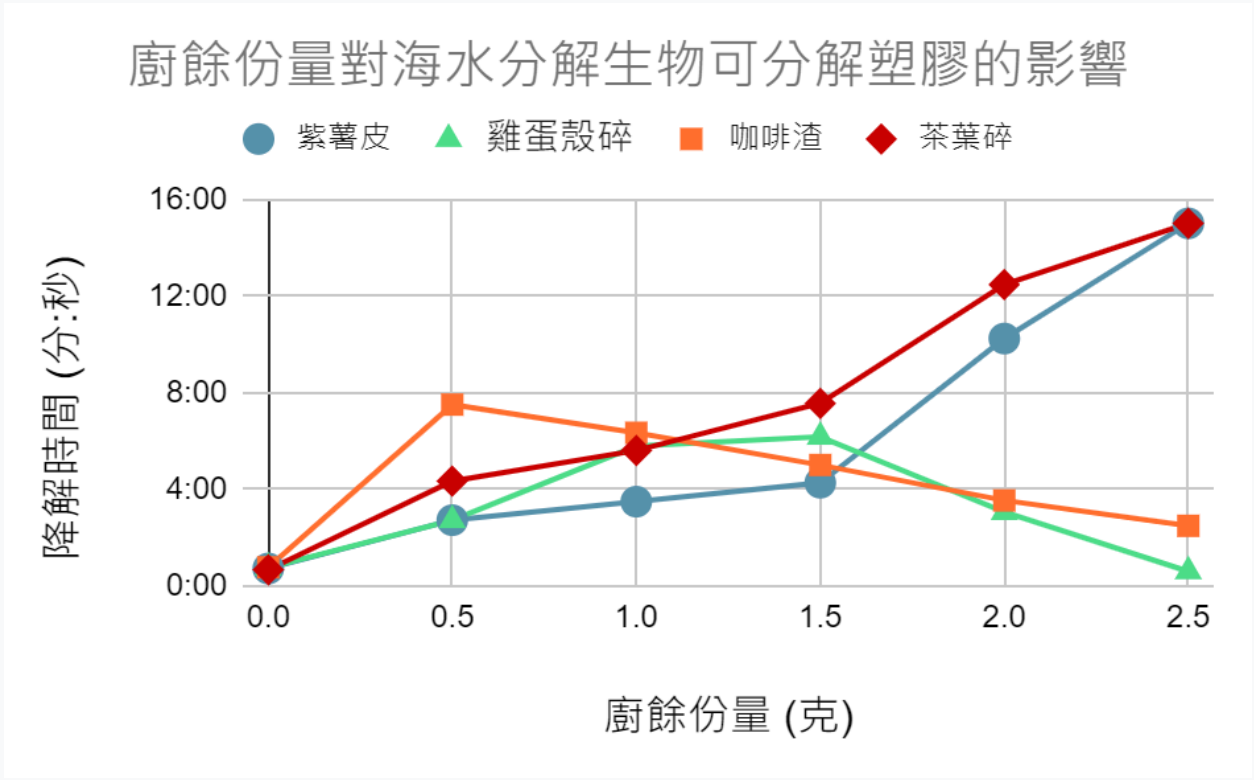
VI. 海水分解測試結果

降解能力評分:

(0-3分鐘碎開:⭐⭐⭐⭐⭐;3-6分鐘碎開:⭐⭐⭐⭐;
6-9分鐘碎開:⭐⭐⭐;9-12分鐘碎開:⭐⭐;12-15分鐘碎開:⭐;15分鐘也沒有碎開:X)

表格15: 廚餘份量對海水分解生物可分解塑膠的影響

生物可分解塑膠	廚餘份量(克)		降解時間(秒)	降解能力
澱粉塑膠	紫薯皮	0	0:43	⭐⭐⭐⭐⭐
		0.5	2:43	⭐⭐⭐⭐⭐
		1.0	3:29	⭐⭐⭐⭐
		1.5	4:16	⭐⭐⭐⭐
		2.0	10:14	⭐⭐
		2.5	>15:00	X
	雞蛋殼碎	0	0:45	⭐⭐⭐⭐⭐
		0.5	2:43	⭐⭐⭐⭐⭐
		1.0	5:47	⭐⭐⭐⭐
		1.5	6:10	⭐⭐⭐⭐
		2.0	3:03	⭐⭐⭐⭐⭐
		2.5	0:36	⭐⭐⭐⭐⭐
	咖啡渣	0	0:46	⭐⭐⭐⭐⭐
		0.5	2:39	⭐⭐⭐⭐⭐
		1.0	6:20	⭐⭐⭐
		1.5	5:00	⭐⭐⭐⭐
		2.0	3:32	⭐⭐⭐⭐
		2.5	2:29	⭐⭐⭐⭐⭐
	茶葉碎	0	0:40	⭐⭐⭐⭐⭐
		0.5	4:20	⭐⭐⭐⭐
		1.0	5:36	⭐⭐⭐⭐
		1.5	7:33	⭐⭐⭐
		2.0	12:28	⭐⭐
		2.5	>15:00	X

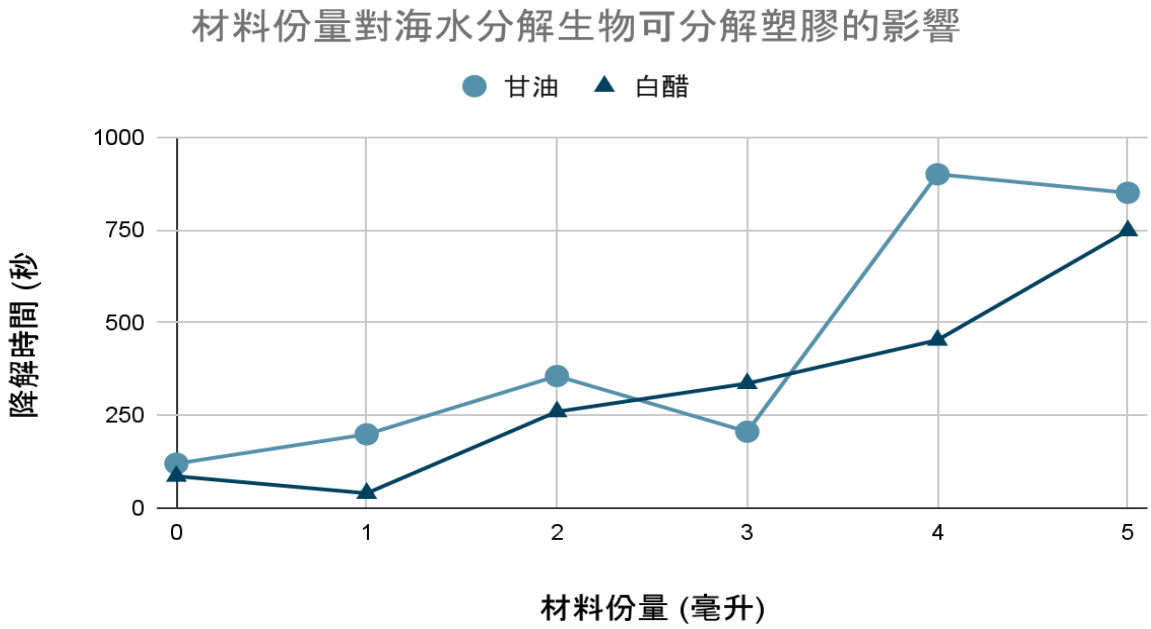


根據以上結果，發現加入了些咖啡渣和蛋殼碎可以明顯減低海水中降解時間，至於加入茶葉碎及紫薯皮則會增加海水分解時間。

生物可降解塑膠廚餘	平均降解時間比較	評級
雞蛋殼碎	3 min 29 sec	⭐⭐⭐⭐⭐
咖啡渣	4 min 20 sec	⭐⭐⭐⭐
紫薯皮	6 min 24 sec	⭐⭐⭐
甘油	7 min 20 sec	⭐⭐
茶葉碎	9 min 23 sec	⭐

表格16: 材料份量對海水分解生物可分解塑膠的影響

生物可分解塑膠	材料份量 (毫升)		降解時間 (秒)	降解能力
澱粉塑膠	甘油	0	2:00	★★★★★
		1	3:19	★★★★
		2	5:56	★★★★
		3	3:26	★★★★
		4	>15:00	★
		5	14:10	★★
	白醋	0	1:26	★★★★★
		1	0:40	★★★★★
		2	4:20	★★★★
		3	5:36	★★★★
		4	7:33	★★★★
		5	12:28	★★



根據以上資料，發現加入太多甘油及白醋的生物降解塑膠在海水中的降解速度越來越慢，不太適合造生物可降解塑膠，加入1毫升白醋在海水中的降解的效果最好。

表格17: 不同廚餘製作成生物可分解塑膠的綜合評級

生物可降解塑膠的廚餘	平均降解時間	評級
雞蛋殼碎	3 min 29 sec	⭐⭐⭐⭐⭐
咖啡渣	4 min 20 sec	⭐⭐⭐⭐
紫薯皮	6 min 24 sec	⭐⭐⭐
甘油	7 min 20 sec	⭐⭐
茶葉碎	9 min 23 sec	⭐

總括而言，雞蛋殼碎是解降的最快的，比其他更適合造生物可降解塑膠。

九、應用及建議

1. 一次性塑膠餐盒：咖啡渣及茶葉碎生物降解塑膠

   加入少量咖啡渣能夠令生物可降解塑膠的硬度大幅增加，所以做餐盒的時候不容易破裂，但如果要裝液體，就可以考慮使用茶葉碎生物降解塑膠，因為加入較多茶葉碎後防水性會更好。

2. 購物膠袋：茶葉碎生物降解塑膠

   加入茶葉碎能夠令生物可降解塑膠的柔軟度大幅增加，所以做購物膠袋的時候可以更柔軟。而且，它的拉力度比較好。還有，如果要裝液體的話，茶葉碎也能夠防水，使購物膠袋不容易濕。

3. 用完即棄塑膠餐具：咖啡渣生物降解塑膠

   加入咖啡渣能夠令生物可降解塑膠的硬度大幅增加，所以做即棄塑膠

餐具的時候不但夠硬身，而且不容易破裂，所以很適合作為即棄塑膠餐具。

4. 食物保鮮膜：甘油生物降解塑膠

加入少量甘油能夠令生物可降解塑膠的柔軟度大幅增加，所以做食物保鮮膜的時候可以令它更柔軟，還有，它的拉力能力不但比其他生物可降解塑膠較為好，而且它也不容易破裂／碎裂，所以非常適合作為食物保鮮膜。

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，所以製成之生物塑膠樣本，即使是相同的配方，它們的物理特性也不同。
- 製作生物塑膠過程份量誤差：當我們用刮匙刮平澱粉基凝固物，有機會殘留一些不能放進模具；甘油的黏度很高，會有一些留在量筒上，造成材料份量的誤差。
- 生物塑膠厚薄不一：在製作過程中，有時候因為好多因素，倒置塑膠厚薄不一，例如：在風干過程中，有些塑膠會起泡或者捲起，或者因為氣溫和濕度的影響導致塑膠有所改變，都會影響實驗的準確率。
- 測量誤差：
    - 量度材料的誤差：我們只需1g之生物塑膠的材料，由於我們的電子秤限制，所量度的份量會有誤差。
    - 重量誤差：在泥土分解測試中，有可能在量度重量時，重量會因為塑膠表面黏有泥土，而重量與實際不同。
    - 拉力測試：在拉力測試中，螺絲有可能會轉裂塑膠，導致實驗出現誤差。

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、量度材料、倒模及脫模時，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，例如我們需測試生物降解塑膠的屈曲角度，沒有精準的測量儀器，唯有使用簡單的量角尺，靠肉眼觀察，可能未必完全準確。
- 人力和時間限制：我們製作的生物降解塑膠最少都要烘乾數小時才能做測試，每次發現新問題後，重複製作塑膠樣本和實驗的過程十分費事。如有更多的資源和時間，我們期望在接下來幾個月，用來測試塑膠樣本的分解表現。

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，傳統塑膠因為難以在自然環境中分解，進入海洋後甚至可以化為微塑膠，在食物鏈中不斷累積，最終會被人類攝取；因此我們使用生物降解塑膠，保護海洋環境的生態。

我們測試了加入了不同的廚餘、材料份量的生物降解塑膠的強韌度、柔軟度、耐熱能力、防水性、降解能力等數據，發現加入廚餘做生物降解膠不僅環保，還有很多益處。例如：傳統塑膠的強韌度不足，但如果加了廚餘強韌度及耐熱能力。還有，加了廚餘的生物降解塑膠的分解能力也明顯比沒加的好。因此，我們非常建議加入廚餘做生物降解塑膠。

今年年底便實施垃圾徵費了。我們都十分推薦大家一起加入廚餘製作生物降解塑膠。它可以被生物分解，減低對海洋的污染，善用廚餘，一舉兩得。只要參考我們的製作流程及建議配方，齊來製作生物降解塑膠，save the ocean now！

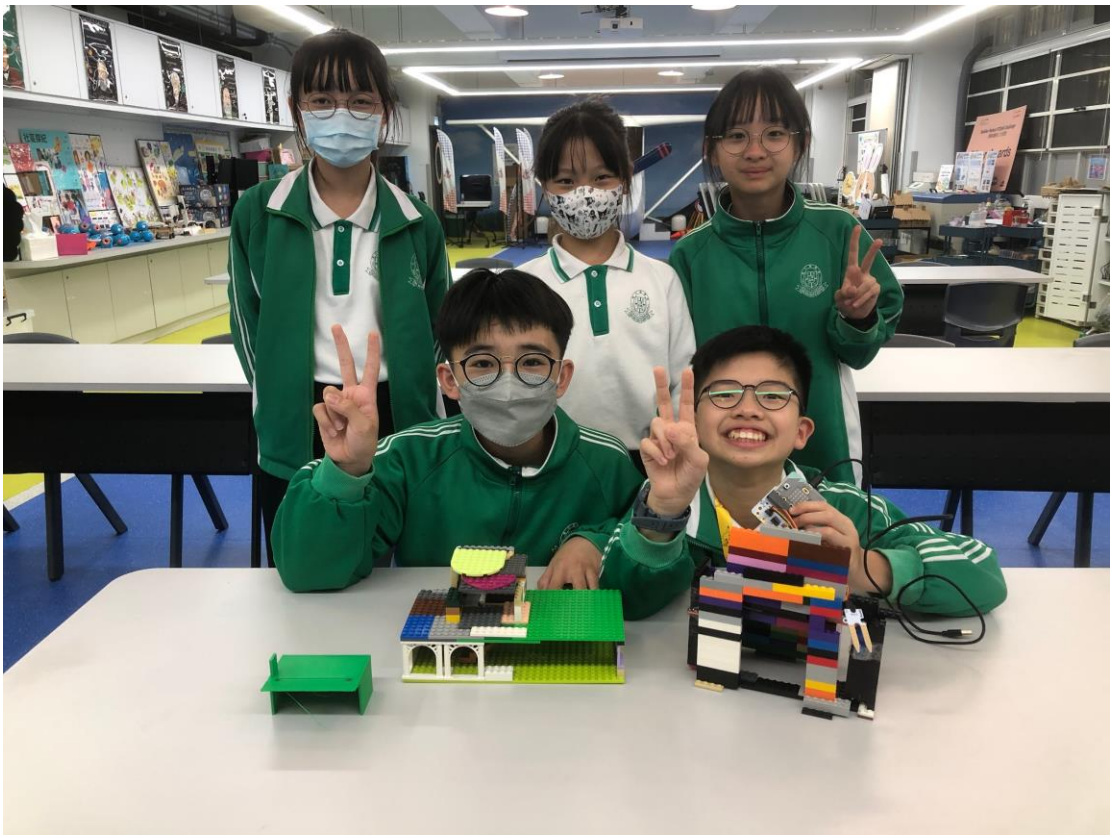
十二、參考資料

1. How It's Made (2024), Truth About Plastic.取自 https://truthaboutplastic.wordpress.com/how-its-made/
2. 矽膠工廠 (2024). 塑膠是什麼？深入瞭解塑膠原料的組成 .取自 https://dafeng360.com/silicone12kfsf/
3. 李柏廷 (2012). 甘油/TEC/DOS 與 PHBV/玉米澱粉混煉之最適配方及其生物可分解特性之研究.
4. 國立臺灣大學 (2020). 丙三醇（Glycerol) | 科學Online.取自 https://highscope.ch.ntu.edu.tw/wordpress/?p=4657
5. 彭德昌. (2003). 生物可分解資材在農業生產上之應用. 花蓮區農業專訊, (44), 20-22.
6. 洪福良, & 彭錦樵. (2010). 添加塑化劑對玉米澱粉/PHBV 塑膠粒熱特性及生物分解性之影響. 台灣農學會報, 11(3), 269-283.
7. 鄭文彥, 彭錦樵, & 洪福良. (2011). 添加酵素與甘油對 PHBV 塑膠原料粒熱特性及生物分解性之影響. 台灣農學會報, 12(5), 472-496.

季軍

第十七屆香港科學青苗獎

堅防洪閘



東華三院鄧肇堅小學

參賽學生：徐琬茜、張凱晴、林彥泰、梁研孜、陳晞曈

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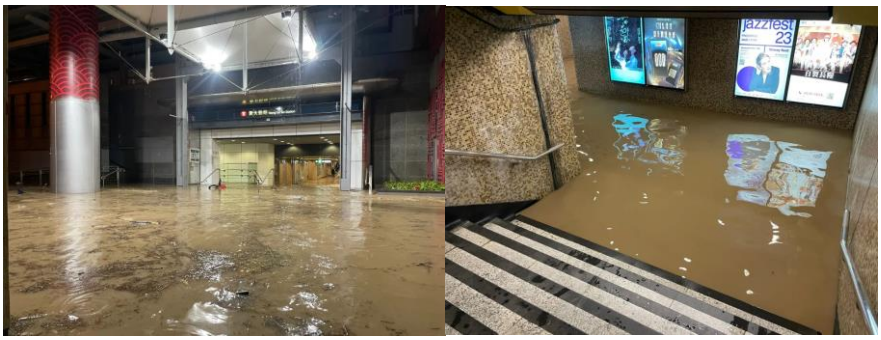
一. 所選難題的背景

探究靈感

黃大仙地鐵站嚴重水浸的成因，主要是兩處分別位於法藏寺及黃大仙祠的進水口，在大雨期間被塌陷的山泥阻塞，以至大量雨水無法及時排走，而隨山勢湧往沙田坳道及黃大仙中心北館，而地鐵站及商場入口未能阻截洪水，導致嚴重的水浸問題，給當地居民和建築物造成了很大的困擾和損失。所以我們設計一個裝置，於暴雨時可以於地鐵站或商場入口阻擋洪水，從而預防水浸事件的發生。

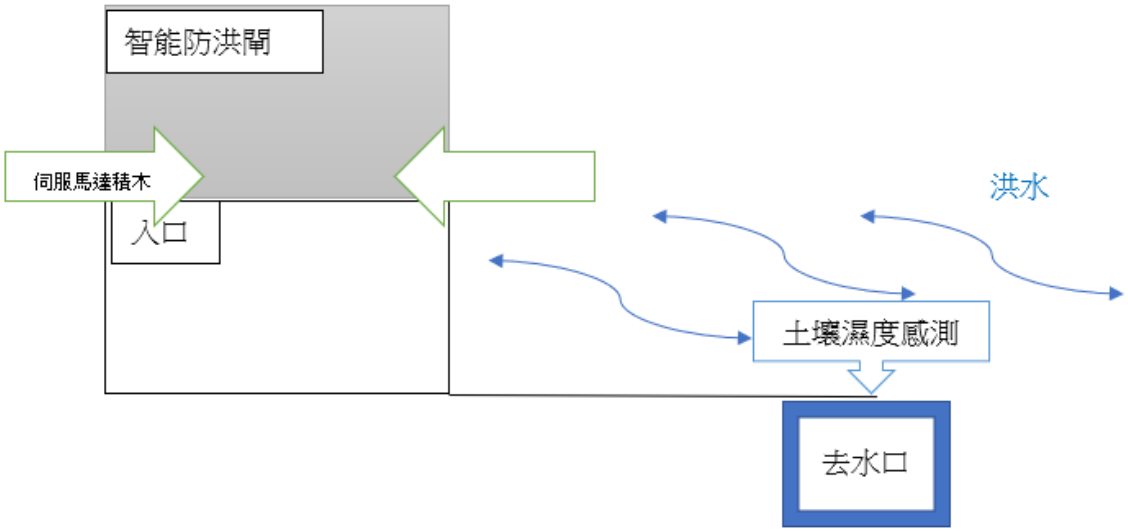


(照片來自 yahoo 新聞)

二. 解決方案

探究問題:

設計一個裝置，於暴雨時可以在地鐵站或商場入口阻擋洪水的水閘，而且能響起警報讓途人盡快進入安全的地方。



製作材料及過程:

智能防洪閘的模型是由 micro:bit、伺服馬達積木、土壤濕度感測棒，以及 lego 積木組成。

科學原理:

智能防洪閘中的土壤濕度感測棒 主要就是透過金屬表面線路去接受水滴，由於水本身具有導電的特性，因此水量愈多的時候，導電的部份就愈多，當水感應的濕度達至100%，代表附近的去水位置已經阻塞，引發警報響起，伺服馬達積木攔截水閘的角度旋轉，水閘落下。

探究方向

1. 我們使用 micro:bit 中 的編碼程式和土壤濕度感測棒(濕度感應)製定感應條件。

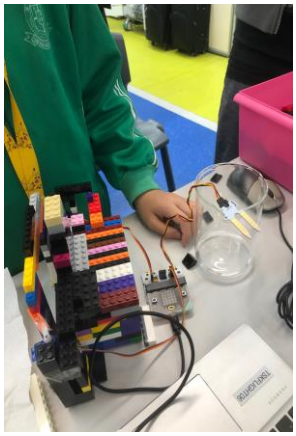
2. 編碼：我們預先設定土壤濕度感測棒的濕度，並記錄為常數。觸發伺服馬達積木的編碼於以下情況才會執行： 1.濕度大於 50%時，及 2.觸發警報響起三次後。

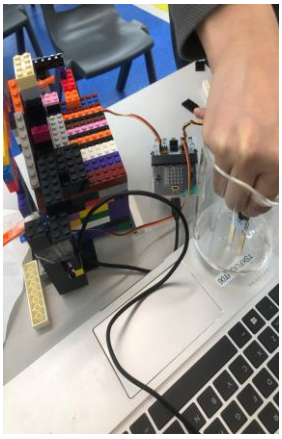
3. 研究防洪閘的最佳效果

- 測試土壤濕度感測棒的感應範圍
- 測試土壤濕度感測棒在不同天氣的感應效果
- 測試不同雜質的液體為感應目標會否影響土壤濕度感測棒的感應效果
- 測試防洪閘的最佳物料(防水性、堅固性)

三、測試步驟及結果

<u>1.測試土壤濕度感測棒的感應範圍及效果</u>



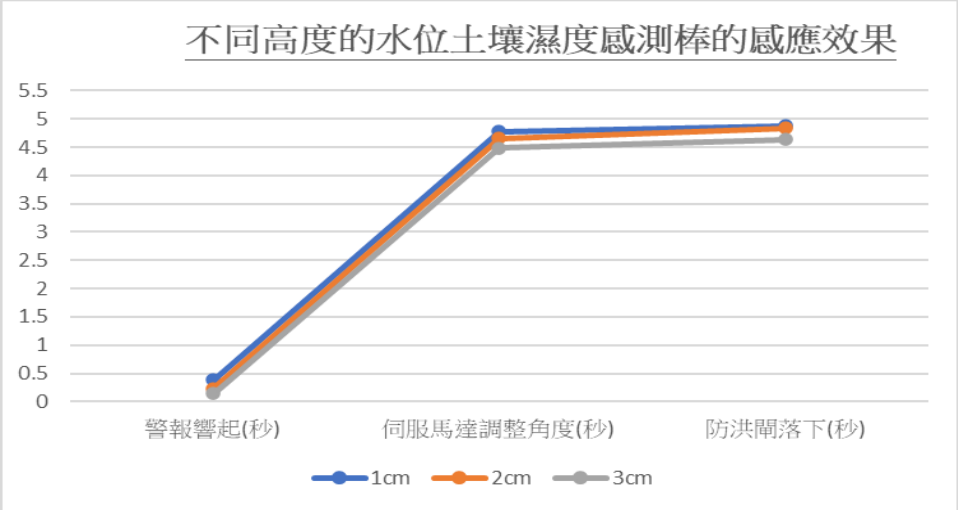


實驗步驟:

在相同大小的量杯內放置不同高度的水位（1cm, 2cm, 3cm)，將土壤濕度感測棒放於量杯內，測試警報響起、伺服馬達調整角度及防洪閘落下的所需時間。

實驗結果及紀錄:

	所需時間（單位：秒）		
水位高度	警報響起	伺服馬達調整角度	防洪閘落下
1cm	0.38s	4.78s	4.88s
2cm	0.23s	4.66s	4.84
3cm	0.14s	4.49s	4.64s



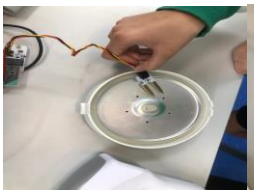
結論:

水位高度與所需時間成反比；由此可見，水位越高，感應器浸泡面積越大，反應越靈敏。

2.測試土壤濕度感測棒在不同天氣的感應效果

實驗步驟:

模擬不同的天氣情況(如下表)，觀察土壤濕度感測棒在不同天氣影響下的感應效果。

模擬天氣情況	使用工具及方法	實驗圖片
霧氣	把噴壺置於土壤濕度感測棒上方或側方，噴水於土壤濕度感測棒前方以製造噴霧。	
下雨	把灑水壺置於土壤濕度感測棒上方或側方，灑水於土壤濕度感測棒前方以製造雨水。	
打雷	把鼓和銅鈸置於土壤濕度感測棒後方或側方，敲打鼓和銅鈸以製造雷聲。	
強風	把電風扇置於土壤濕度感測棒上方或側方，開啟最強風速以製造強風。	
高溫	將土壤濕度感測棒放於置於攝氏 30 度以上熱氣的鐵盒上。	 

實驗結果及紀錄:

模擬天氣情況	警報響起	伺服馬達調整角度	防洪閘落下
霧氣	沒有	沒有	沒有
下雨	8 秒後響起	有	有
打雷	沒有	沒有	沒有
強風	沒有	沒有	沒有
高溫	沒有	沒有	沒有

結論:

只有雨天，有水觸碰到感應器的情況下，警報才會響起並且落閘。

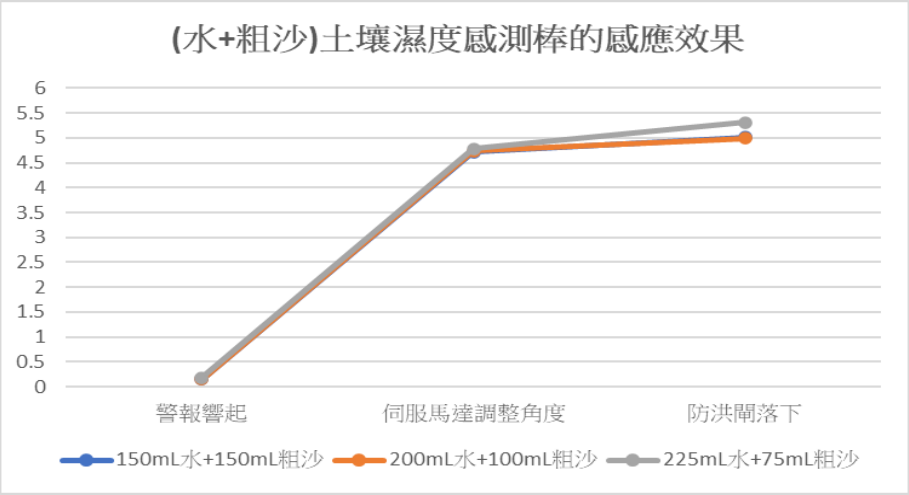
<u>3.測試不同雜質的液體為感應目標會否影響土壤濕度感測棒的感應效果</u>

實驗步驟:

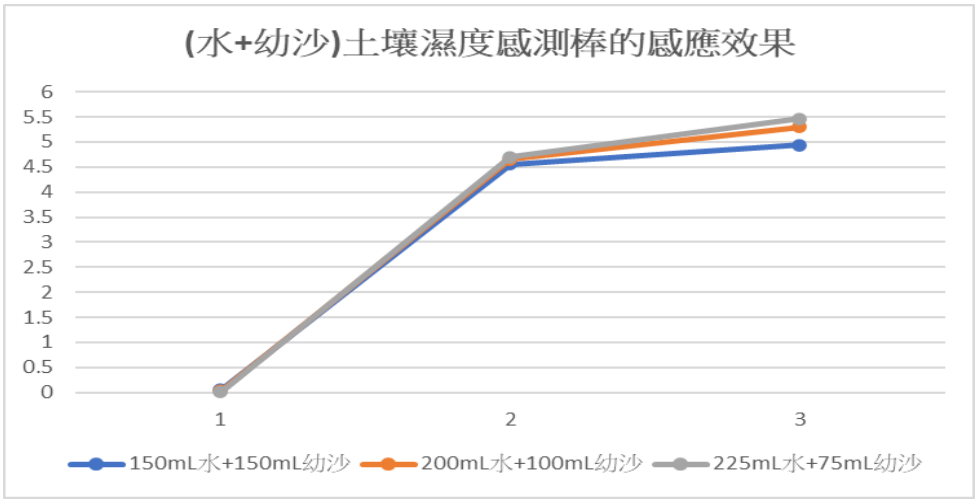
按比例混合水及泥沙， 將土壤濕度感測棒放置於已混合的水及泥沙中，觀察土壤濕度感測棒在不同密度液體下的感應效果。

實驗結果及紀錄:

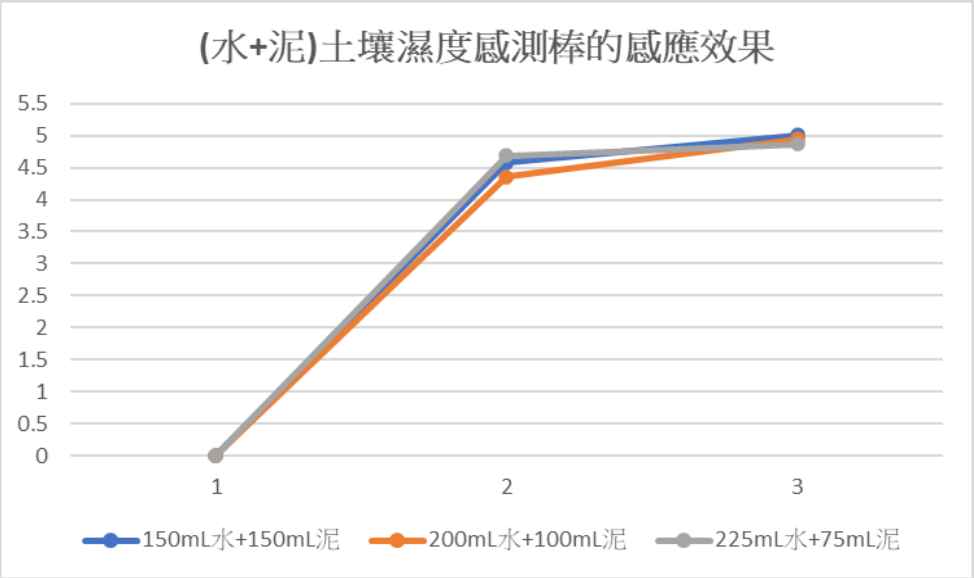
比例	水+泥沙份量	警報響起（秒）	伺服馬達調整角度（秒）	防洪閘落下（秒）
1:1	150mL 水+150mL 粗沙	0.15s	4.71s	5.01s
2:1	200mL 水+100mL 粗沙	0.15s	4.74s	4.99s
3:1	225mL 水+75mL 粗沙	0.18s	4.78s	5.31s



比例	水+泥沙份量	警報響起（秒）	伺服馬達調整角度（秒）	防洪閘落下（秒）
1:1	150mL 水+150mL 幼沙	0.05s	4.56s	4.94s
2:1	200mL 水+100mL 幼沙	0.03s	4.65s	5.30s
3:1	225mL 水+75mL 幼沙	0.01s	4.70s	5.46s



比例	水+泥沙份量	警報響起（秒）	伺服馬達調整角度（秒）	防洪閘落下（秒）
1:1	150mL 水+150mL 泥	0.01s	4.58s	5.01s
2:1	200mL 水+100mL 泥	0.01s	4.36s	4.95s
3:1	225mL 水+75mL 泥	0.01s	4.69s	4.87s



結論:

水中的雜質越多，水中物質越難溶解時，感應器的反應時間越長；反之，水的雜質越少，相對易溶解時，反應時間越短。

4.防洪閘的最佳物料(防水性、堅固性)

實驗步驟:

1.把放一張濾紙在不同物料(硬紙板、金屬、塑膠 PVC、木板)的背面，物料均為相同大小和厚度。

2. 指定容量(分別是 500mL、1500 mL、2500mL)的水注入水槍，以相同時間射在不同物料上。

3.測試物料被水射擊後的狀態和有沒有滲漏。

實驗結果及紀錄:

<table>
<tr><td>物料</td><td>硬紙板
  </td><td>金屬
  </td><td>塑膠 PVC
  </td><td>木板
  </td></tr>
<tr><td rowspan="4">500mL 水</td><td colspan="4">狀態:</td></tr>
<tr><td>有濕過的痕跡</td><td>沒有變化</td><td>沒有變化</td><td>有濕過的痕跡</td></tr>
<tr><td colspan="4">滲漏情況:</td></tr>
<tr><td>沒有</td><td>沒有</td><td>沒有</td><td>變濕</td></tr>
<tr><td rowspan="4">1500mL 水</td><td colspan="4">狀態:</td></tr>
<tr><td>部分變軟</td><td>沒有變化</td><td>輕微變形</td><td>有濕過的痕跡</td></tr>
<tr><td colspan="4">滲漏情況:</td></tr>
<tr><td>沒有</td><td>沒有</td><td>沒有</td><td>變濕</td></tr>
<tr><td rowspan="4">2500mL 水</td><td colspan="4">狀態:</td></tr>
<tr><td>部分變軟、表面有紙屑脫落
  </td><td>沒有變化
  </td><td>輕微變形
  </td><td>有濕過的痕跡
  </td></tr>
<tr><td colspan="4">滲漏情況:</td></tr>
<tr><td>沒有</td><td>沒有</td><td>沒有</td><td>變濕</td></tr>
</table>

結論:

木板因為纖維間有空隙，所以會導致滲水，不能防水。硬紙板雖然可以阻擋水，但仍會滲水，以及表面會變軟。 塑膠 PVC 可以防水，但遇到較大的水流撞擊會變形。因此金屬的防水性及堅固性最高，是作為感應防洪閘的最佳物料。

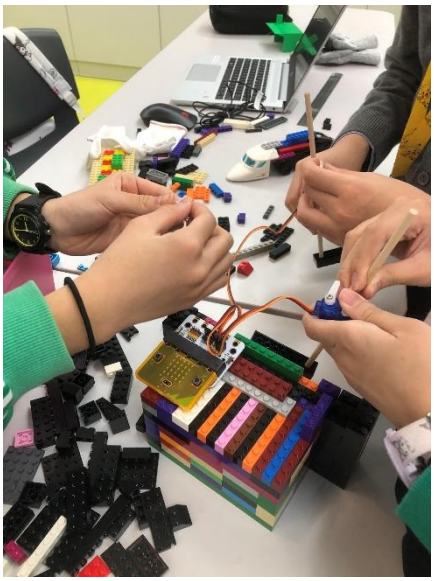
四. 解決方案的利與弊

總結與反思

感應器的反應時間包含「警報響起」、「伺服馬達調整角度」和「防洪閘落下」三個節點, 我們通過模擬不同的降雨量、水濃度和天氣來測試感應器的靈敏性。

- 降雨量的水高度和反應時間成反比;
- 水的雜質濃度和反應時間成反比;
- 在不同天氣之下，只有遇到雨天，感應器才會有反應。

因此我們必須小心考慮感應器的擺放位置，例如放在地鐵入口的附近去水位，位置須能在去水位淤塞時，接觸到最大的水浸面積，而去水位的積水也適宜分隔雜質，從而有效令感應器順利運作。另外可於感應器上方添置防雨的部分，以免於下雨時，未有水浸時會引起感應器運作，以致入口突然封閉。



我們原本使用 3D 打印技術去製作閘門，但發現製作時間較長，而且所能使用的物料有限制，所以先使用 lego 積木製作模型，以及分別測試哪種物料較佳。製作防洪閘的物料雖然金屬最為合適，但金屬也有很多種類（部分遇水會生鏽），可以再進一步測試不同類型的金屬，尋找最佳物料。另外我們發現在所有物料的下方仍會有水從隙縫流向背面，日後可研究防洪閘與地鐵閘口隙縫的結構及使用其他物料填補隙縫。

除此之外，警報響起及防洪閘落下的時間須再作調整，否則，警報響起及防洪閘落下的時間不足，途人不但未能盡快進入地鐵站內，而且也會容易發生意外。

五. 參考資料

1. 文匯報(2023)。《民建聯約見發展局跟進黃大仙嚴重水浸事宜》

https://www.wenweipo.com/a/202310/10/AP652521e0e4b0fdf828a22b90.html

2. Yahoo 新聞(2023) 。《黑雨｜黃大仙變泥濘汪洋 記者港鐵站直擊站內水深及膝》

https://hk.news.yahoo.com/%E9%BB%91%E9%9B%A8%EF%BD%9C%E9%BB%83%E5%A4%A7%E4%BB%99%E8%AE%8A%E6%B3%A5%E6%BF%98%E6%B1%AA%E6%B4%8B-%E8%A8%98%E8%80%85%E6%B8%AF%E9%90%B5%E7%AB%99%E7%9B%B4%E6%93%8A-%E7%AB%99%E5%85%A7%E6%B0%B4%E6%B7%B1%E5%8F%8A%E8%86%9D-165025500.html

3. Microsoft MakeCode(2022) 。《土壤濕度》
https://makecode.microbit.org/projects/soil-moisture

4.STEAM 教育學習網(2021-2023) 。《伺服馬達》
https://steam.oxxostudio.tw/category/microbit/sensor/servo.html

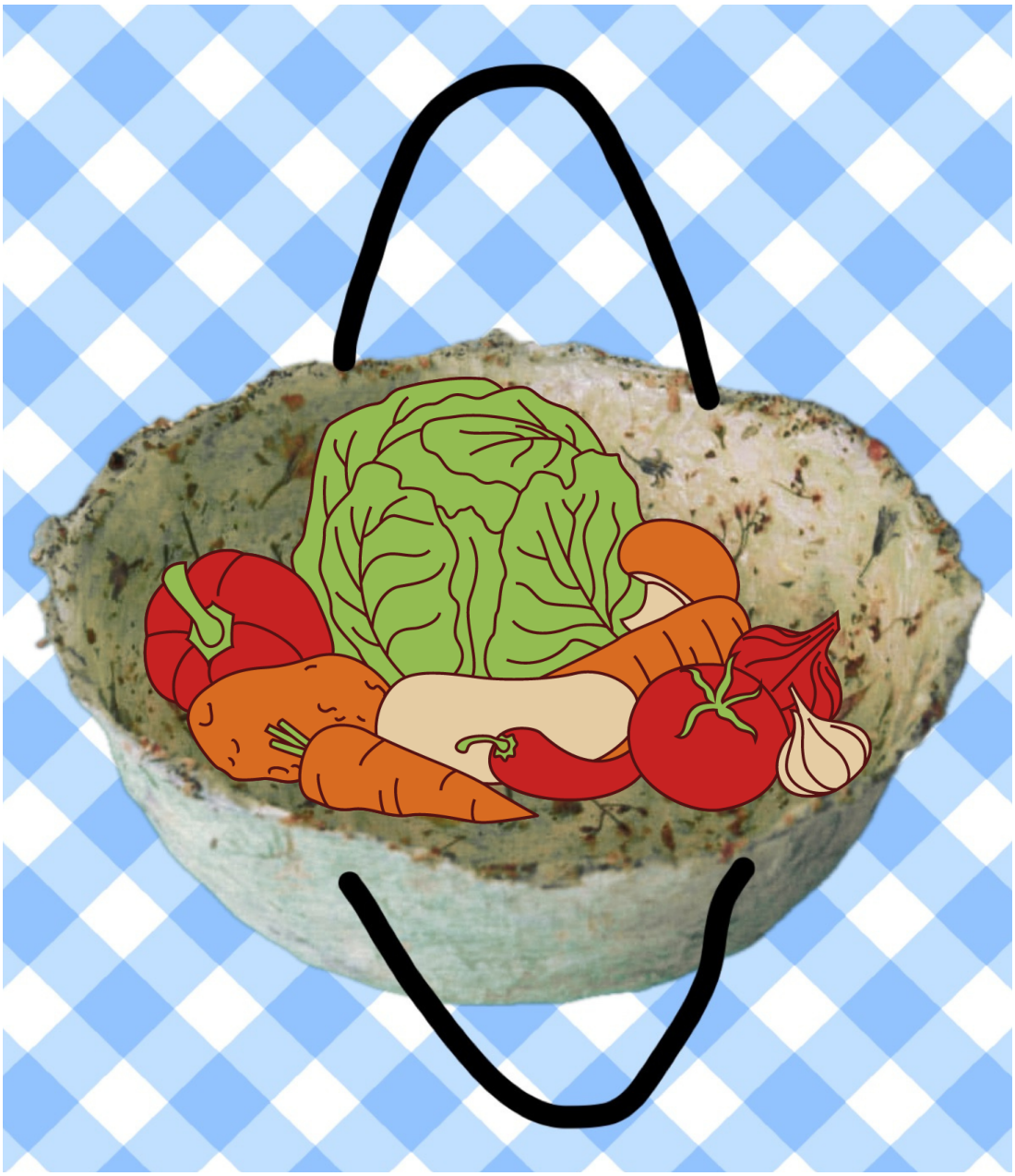
5. 渠務署(2019) 。《防洪標準》
https://www.dsd.gov.hk/TC/Flood_Prevention/Flood_Prevention_Strategy/Flood_Protection_Standards/index.html

6. Autodesk, Inc(2024) , 3D printing
https://www.tinkercad.com/

殿軍

第十七屆香港科學青苗獎

走「塑」分解再創新袋袋



青松侯寶垣小學

參賽學生：冼佳陽、梁芷澄、王天朗、何柏駿、顏僖賢

指導老師：李東樂老師、盧卓霆老師

引言

垃圾管理和環境保護已成為全球議題。而在本港，垃圾徵收費用的實施是一個重要的環保舉措。然而，政府派發的指定的塑膠袋，雖然有助於管理垃圾收集，卻存在無法完全降解的問題，對環境也會造成一些負擔。因此，提出利用製作合成紙袋來替代指定的塑膠袋的想法，不僅可以有效減少對環境的影響，更能提升環保成效。合成紙袋是利用一些可自然降解的循環再用物料加入廢紙而做成。合成紙袋作為一種可降解的替代品，具有更環保的特性，能夠有效減少對地球的塑膠污染，同時鼓勵市民採用更加可持續的方式用作垃圾處理。透過這項創新的做法，我們可以為環境保護盡一份心力，實現更清潔、更可持續發展的城市生活環境。

原理

紙是一種可降解的材料。紙張主要由植物纖維製成，如樹木、草類或竹子，因此在自然界中，紙張可以像植物的枝葉一樣自然分解，最終分解成二氧化碳和水。

枯葉是一種可生物降解的物質。枯葉主要由植物組成，因此在自然環境中，枯葉可以透過微生物和其他生物的作用進行分解，最終轉化為有機物質。這種自然的分解過程有助於土壤的營養循環，同時也符合生態系統的運作。因此，枯葉是一種能夠完全降解的有機物質，對環境的影響較小，並且有助於維持生態平衡。並且海藻具有固有的強度和柔韌性，使其成為製造耐用紙張的理想成分。

水藻是一種可完全生物降解的材料。全生物降解海藻地膜可以有效代替傳統塑料地膜，其最終降解的產物是水和二氧化碳，從源頭上消除了對環境的負面影響。因此，水藻作為一種可完全生物降解的材料，在適當的自然環境條件下，能夠被微生物完全分解成低分子化合物，符合生態環境保護的原則。並且含纖維素，有助於提高再生紙的強度和質地。

頭髮是一種不易完全降解的物質。頭髮主要由蛋白質組成，並且在自然環境中需要很長的時間才能完全分解。雖然頭髮是可生物降解的，但由於其結構複雜

且含有蛋白質，使得它在自然界中分解速度較慢。因此，頭髮不像紙張或其他可降解材料那樣容易迅速分解，而是需要更長的時間才能完全降解。頭髮纖維具有高抗拉強度，可以增強紙張結構的強度，並且可以提高紙張的抗撕裂性能，改善整體強度。

探究目標

一、探究不同再造紙的日照時間(時間)
二、探究不同纖維所合成的紙袋承重能力 (比例)
三、分析以不同物料製造紙張的效益

實驗前的工及製作紙袋方法

收集和預處理：

1. 收集水藻、頭髮、枯葉和紙碎
2. 以去除雜質
3. 並把這些材料切成小塊或剪碎

漿化：

1. 將收集到的材料(水藻、頭髮、枯葉和紙碎)按比例量度重量
2. 把材料按比例混合，並且加入清水
3. 再用攪拌器攪拌作進一步漿化，形成漿料(混合物)

製作紙袋：

1. 將漿料均勻放到一個隔網上
2. 進行壓制。(把多餘的水份擠壓出來，以加快乾透)
3. 放到暗涼處作自然風乾，直到完全乾透

實驗結果及分析

一、探究不同再造紙的日照時間(時間)

因為做紙袋需經過風乾過程才會變硬，所以要考慮製造一個紙袋的所需時間。為了確保溫度和濕地保持控制範圍之內，我們把漿料放在學校的雜物房中風乾，並利用房間中的冷氣機的抽濕功能，把房間的溫度和濕度控制在約25度和45%。

實驗結果:

	枯葉：紙碎(1:1)	枯葉：紙碎(1:5)	枯葉：紙碎(1:10)	枯葉：紙碎(1:15)
日照時間	約48小時	約60小時	約60小時	約72小時

	頭髮：紙碎(4:1)	頭髮：紙碎(2:1)	頭髮：紙碎(1:1)	頭髮：紙碎(1:2)
日照時間	約84小時	約72小時	約60小時	約60小時

	水藻：紙碎(9:1)	水藻：紙碎(6:1)	水藻：紙碎(3:1)	水藻：紙碎(1:1)
日照時間	約48小時	約48小時	約48小時	約48小時

由以上所見，以枯葉作原材料的日照時間隨紙碎的含量增加而下降，最短日照時間為枯葉與紙碎的比例1:1，只需48小時即可完全風乾。而以頭髮作原材料的日照時間則平均較長，最短的日照時間為頭髮和紙碎的比例1:1和1:2，也需要60小時，可見頭髮較難風乾。而以水藻作原材料的日照時間則最為平均，全部比例的實驗均只需48小時即可風乾，而48小時也是全部原材料中最短的日照時間。由此可見，以水藻為原材料的製作過程最為快捷。

二、探究不同纖維所合成的紙袋承重能力（比例）

我們利用紙混合不同的纖維所製成的紙袋，並檢測紙袋的承重能力。測試時會逐一利用法碼去增加重量，直到紙袋不能承重而破裂。



實驗結果:

	枯葉：紙碎(1:1)	枯葉：紙碎(1:5)	枯葉：紙碎(1:10)	枯葉：紙碎(1:15)
承重量(kg)	2.11	3.18	0.5	2.2

	頭髮：紙碎(4:1)	頭髮：紙碎(2:1)	頭髮：紙碎(1:1)	頭髮：紙碎(1:2)
承重量(kg)	3	4.48	1.5	3

	水藻：紙碎(9:1)	水藻：紙碎(6:1)	水藻：紙碎(3:1)	水藻：紙碎(1:1)
承重量(kg)	1.25	6.68	3.25	2.2

由以上的實驗可見，枯葉和紙碎所製成的紙袋的最佳承重量比例為1：5 （枯葉：紙碎），承重量為3.18kg；頭髮和紙碎所製成的紙袋的最佳承重量比例為2：1（頭髮:紙碎），承重量為4.48kg；水藻和紙碎所製成的紙袋的最佳承重量比例為6：1（水藻:紙碎），承重量為6.68kg。

三、分析以不同物料製造紙張的效益

紙碎 – 可以來自學生使用完的廢紙張或簿冊的內頁。

枯葉的效益

枯葉除了造紙外，本身更可作堆肥使用。根據本研究結果顯示，枯葉並不是一個很好的原材料來製作袋子。即使用枯葉中最佳承重的1:5 (枯葉比紙碎)，它的承重量只為3.18kg，比起水藻最高承重量的6:1(水藻比紙碎)，承重量為6.68 kg，仍少了超過一倍。

雖然枯葉隨處可見，但仍受季節影響，難以在秋季以外大量取得。此外，枯葉本身較為輕，但表面積比起植物纖維的成份差距較大，因此在處理過程中需要消耗大量空間。故此，本研究並不認為使用枯葉造紙具有較大效益，反而更應研究枯葉作為埋肥的效益性。

頭髮的效益

頭髮一般可在理髮店收集，現時除了棄置外，更多的用途是用作假髮的材料。此外，也有些公司正在研究利用頭髮作吸油墊、或是肥料使用。而在本研究中，頭髮中最佳承重為2:1(頭髮比紙碎)，承重量為4.48kg。在三種原材料中，頭髮的承重量比枯葉佳，而比水藻差。

可是，由頭髮所製成的袋子卻有一項另外兩項材料所沒有的缺點 – 頭髮更難被物理性破壞成微小份子。在實驗過程中，即使我們不斷把頭剪碎，但製成的袋仔仍可見到清晰的頭髮絲。這不但影響袋子的美觀，更在測量過程中不斷掉下頭髮碎，影響環境。因此，本研究認為即使頭髮易於取得，而且承重效果不俗，但如沒有透過化學降解，則不適合用作製造袋子。

水藻的效益

水藻可在海洋、湖泊或池塘等濕潤的地方找到。而為了容易取得樣子，本研究所用的水藻名為毬藻，是一種淡水海藻，多用作養殖之用。在本研究中，水藻中的最佳承重為6:1(水藻比紙碎)，承重量為6.68kg。在三種原材料中的承重量最佳。這主要可歸因於水藻中含有大量縱橫交錯的植物纖維，令它更為承受重量。

在完成袋子後，已可明顯看出水藻袋子的堅固程度比其他材料的袋子更高。此外，在製作過程和結果中，水藻袋子沒有明顯的缺點。可是，水藻也是三種原材料中最為有用的，分別可用作肥料、食用、養殖、藥用等。所以，如果要說水藻應大規模用作製作袋子，可能需要社會成本的考量。

不過，本研究引伸出使用紅潮或綠潮的海藻作為原材料的可能性。這些海藻因毒性較大，因此無法廣泛使用。但是，如能把紅潮或綠潮的海藻用作盛放物件的袋子，則未必需要去除大量的毒素，即可投入使用。

總結

綜合以為上的實驗結果和分析，在製作紙袋的過程中，選擇不同原材料會直接影響日照時間和承重能力。枯葉作為原材料的風乾時間隨著紙碎比例含量增加而減少，但其承重能力相對較低，並且受季節性影響。頭髮雖然具有較高的承重能力，但風乾時間較長且製作過程中容易出現美觀和環境問題。相比之下，水藻作為原材料具有快速風乾時間和優異的承重能力，並且在是一種可以完全生物降解的材料。但使用水藻可能需要考慮社會成本(如何大量種植或收集)和可持續性發展的問題。

限制及建議

環境因素	由於我們需要在不同時間進行多次實驗。因此我們製作紙袋時環境的溫度、濕度等外在因素都不一樣，所以製成紙袋的硬度、質量都可能有偏差。
製作紙袋時材料比例的誤差	當我們利用電動攪拌機混和材料時，有機會把材料濺出，而造成比例上的誤差。
測量誤差	由於電子秤只能準確至十分位，所以量會有誤差。
資源限制	沒有精細的測量工具，例如：壓力測試機。可以能以一個較客觀和準確去測量紙袋的承重量
時間限制	製作紙袋最少都需要一星期後才能做測試，每發現問題(例如：紙袋的密度不平均、風乾後出現一個大洞等)後，需要重新製作過程十分費時。

延伸

- 可以測試紙袋在濕潤環境下待承重能力有否改變
- 在第二或多次回收後，重製紙袋的承重能力有有改變
- 可到訪一些再造紙公司考察，以吸收更多的造紙技術去改良現有的方法

反思

我們認為製作這份報告比想像中困難，亦發現了一些重要的反思和教訓。首先，我們注意到在實驗設計階段，我們沒有充分考慮到量度比例上的重要性，這可能導致了一些實驗結果有太大的差異。這提醒了我們應該對實驗中所有的步驟更加細心和認真地執行，確保結果的準確性和可靠性。其次，我們在數據收集和分析過程中遇到了一些困難，例如：在承重能力測試時，法碼擺送的位置，可能會影響數據收集的準確性。因不小心弄破了，又要重新再造一個。這表明我們需要更好地準備和計劃數據處理的步驟，以確保結果的準確性和一致性。最後，通過這次實驗，我們意識到了團隊合作和溝通的重要性，這有助於提高工作效率和結果的品質。總括而言，這次實驗為我們了解科學家對所有研究認真的態度，為我們獲得了寶貴的做研究體驗，亦在搜尋資料時，發掘了很多我們未知的環保新知識，亦令我們更加肯定環保的重要性。

參考資料

https://tools.city/q-and-a/icpnxnzz
https://www.seinsights.asia/article/9309
https://www.tfrin.gov.tw/News_Content.aspx?n=309&s=33951

The 17th Hong Kong Budding Scientists Award
Interview with a local scientist

Diocesan Boys' School (Primary Division)

Student contestants: Chan Harold Connor (5J), Woo Hong Ching (5S), Lai Yau Chai (6D), Cheng Ching Kiu (6M)

Teacher advisors: Ms. Ingrid Wong, Ms. Salina Lui

Scientist: Prof. Chau Sze Yiu
Assistant Professor,
Department of
Information Engineering,
CUHK

Research area: Network Security, Protocol Implementations, Embedded System Security, Crypto. Engineering, Formal Verification

Was Professor Chau Born to “Hack the Hacker”?

Since his early childhood, Professor Chau has displayed an extraordinary fascination for Mathematics and computer studies. His curiosity and determination led him to excel in these topics, earning him various awards and achievements. This early passion laid the foundation for his future endeavors in the field.

During his secondary school years, Professor Chau actively engaged in extracurricular activities related to computer studies. Notably, he joined the DBS OI (Olympiad in Informatics) team, where he tackled complex programming challenges with like-minded individuals. Additionally, he frequently hosted informal programming contests with students from other schools, fostering a competitive spirit and further sharpening his programming skills.

Professor Chau also delved into the intriguing world of hacking by that time. Throughout his mischievous days, he and his peers engaged in harmless attempts to "hack" one another's systems, driven by a sense of playful exploration. He once even attempted to hack his beloved Biology teacher! However, his intentions were not malicious; rather, he secured the teacher's email address. These events made him realize the fragility of information security barriers and sparked his curiosity to further research: “How can we do better, help the people around us, and assist people from different social classes?”

When the time came for Prof. Chau to select a topic for his graduate studies, he faced a significant dilemma. Despite his love for Computer Science as a whole, he ultimately opted to specialize in Network Security. This choice allowed him to become a White Hat Hacker, dedicated to safeguarding digital systems and protecting against unauthorized intruders.

Danger Lurking in the Virtual and Real Worlds

In Prof. Chau and his team's research, they discovered that it was fairly easy to steal usernames and passwords when logging into a company’s intranet in the modern world.

They would do daily analysis on code used by companies to identify and fix their cybersecurity vulnerabilities.

Prof. Chau consistently emphasized the grave consequences of cybersecurity incidents on society. For instance, a single breach in the public water supply network system could result in the destruction of a water pump that serves thousands of households, or the contamination of water with sodium hydroxide levels exceeding the safe limit by over 100 times. Similarly, a ransomware attack on a power company could bring about a city-wide blackout lasting half a day. The theft of data from a major institution, which stores vast amounts of information, could lead to the commodification of hundreds of gigabytes of personal data with extreme prices. Successful cybersecurity breaches have the potential to indiscriminately trample on people's privacy and, in extreme cases, even endanger lives.

The Sweet and Sour of Professor Chau

At the beginning of the interview, Prof. Chau shared his motto with us: "Only people with determination and patience will succeed."

According to Professor Chau, “The code online is not something you write, which means you have to spend a lot of time guessing and trying. This process takes a lot of time and tests your patience.” He further emphasizes that lacking sufficient patience can put you at a disadvantage compared to hackers, who may possess more patience than you do. As a result, the team often immerses themselves in experiments, sacrificing sleep and meals to delve deeper into their research. However, despite Prof. Chau's dedicated research efforts, there is no guarantee of reaping benefits.

During his time as a PhD student, Prof. Chau had to identify vulnerabilities in the Android app for Amazon Music. Specifically, he aimed to address the issue where hackers could decrypt and illegally copy songs for free. Despite months of experimenting with various approaches, he was unsuccessful. Nevertheless, Prof. Chau refused to give up. One day, while waiting for his flight to New York for a meeting, he decided to utilize the spare time and boredom to try out another method on his laptop. To his astonishment, he achieved

a breakthrough! Overwhelmed with joy, he couldn't contain his excitement and jumped with glee.

Prof. Chau told us the above story not to share about the moment of triumph, but rather the underlying message of determination and patience. He wanted to convey the importance of persisting in the face of challenges and dedicating oneself to the process. Despite encountering multiple setbacks in his journey, he remained unwavering in his commitment and succeeded in his task at the end. Sometimes, despite one's determination and patience, success may not be guaranteed, but without them, success will definitely be unattainable.

Our Reflection of the Interview

Throughout the course of this interview, we have gained a wealth of knowledge on cybersecurity and blockchain technology and pertaining to the subject of white hat hacking. While listening to Prof Chau recount his journey in white hat hacking, it seems like a resemble of the classic movie *Catch Me If You Can*, that the protagonist, a cunning criminal, adeptly assumed multiple identities, including those of a doctor, a lawyer, and even a co-pilot at a major airline. As Prof Chau mentioned, hackers employ similar techniques to deceive unsuspecting people into clicking malicious links or downloading harmful files. These cyber criminals might pose as bankers, government employees, or even the esteemed principal of a local university, luring their victims into a false sense of security with enticing offers that appear too good to be true. It really does serve as a stark reminder that in today's digital landscape, skepticism and constant vigilance are paramount to safeguarding ourselves in the face of ever-evolving threats online.

During the interview, Professor Chau made a thought-provoking statement, stating that "real-life cases were never as simple and straightforward as textbook examples." It emphasized the complexities that often arise in practical situations. It served as a reminder that real-life scenarios demand a deeper understanding and a flexible approach, requiring individuals to navigate through uncertainty and adapt to the ever-evolving challenges. This reminder reinforced the importance of critical thinking, problem-solving skills, and the ability to think beyond the confines of theoretical knowledge.

第十七屆香港科學青苗獎

科學家專訪報告

聖保羅男女中學附屬小學

參賽學生：　周奕樂、何沐珈、杜星、李悅情、陳弘銳

指導老師:　陳穗雯老師、黃旭霖老師

受訪科學家：　周達誠教授

職銜：　香港中文大學地球與環境科學教授及課程主任

《Journal of Environmental Quality》技術主編

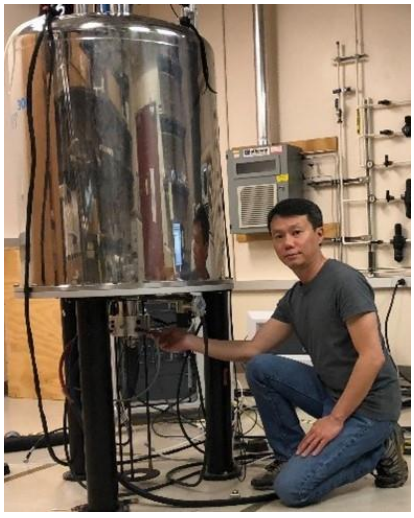
《Water Research X》副主編

研究範圍：　土壤和水化學

本年度我們的研究以微塑膠作為參賽主題。在初步認識微塑膠後，我們對處理微塑膠有很多疑問和好奇，因此我們特意邀請環境化學專家周達誠教授作為我們的訪問對象。我們先向他了解現時研究和處理微塑膠的現況及困難，然後了解他作為科學家的生活和深刻經歷。

研究微塑膠的困難

根據歐洲食物安全局的定義，微塑膠泛指微細的膠粒，其直徑少於 5 毫米[2]。周教授向我們表示現時有關微塑膠的研究最大的困難是如何定量，由於微塑膠太輕，所以無法精準地量度它的重量，現時只能在顯微鏡裏數微塑膠的數量，但數量增加又不代表質量增加，因為塑膠可以不斷地分解成更小的碎片，因此難以精準測量微塑膠到底增加了，還是減少了。



周達誠教授
香港中文大學地球與環境科學課程主任[1]

除了重量外，量度微塑膠的表面積亦是研究的難點。有些污染物會黏附在微塑膠上，對環境造成更大的損害，當塑膠分裂得更小，雖然質量相同，但表面積卻會增加，造成黏附微塑膠的污染物增加。可是，微塑膠實在太小而且不規則，令科學家難以計算它的表面積。

處理水中微塑膠

周教授主要研究的是可溶解有機碳(dissolved organic carbon，下稱 DOC)，他和研究團隊曾經發明了一種去除水中污染物的技術 P-SMFC （Plant Settlement Microbial Fuel Cells），即利用微生物「吃掉」天然有機污染物。我們好奇可否用此方法來清理微塑膠，他認為是有可能，但需要使用能夠「吃」到微塑膠的細菌，

而細菌「吃掉」微塑膠後，亦需要再進行處理。周教授表示 DOC 與微塑膠其中一個最大的不同是，微塑膠不能溶於水而 DOC 能溶於水，所以，基本上可利用過濾的形式把微塑膠從水中分離。

有報導估計現時海床有高達千萬噸的微塑膠，而每年從家居/城市排出的污水有 2.2 百萬噸的微塑膠[3]，所以我們都想知道可以用什麼方法過濾污水中的微塑膠。我們從網上資源認識到反向滲透過濾技術(Reverse Osmosis，下稱 RO 技術)[4]，這是一種海水化淡技術，有效的過濾水中的細菌和病毒。按技術原理而言應該可以過濾食水中的微塑膠，哪麼人們為甚麼還要研究其他處理微塑膠的方法呢？

周教授讓我們了解到 RO 技術成本較高、速度較慢，不是每個家庭或城市都能負擔。其次，水中不止有微塑膠，還有其他的水溶性污染物需要同步處理的，RO 技術並不是去除這些污染物最好的方法。

此外，雖然目前 RO 技術越來越普及，成本也逐漸降低，但是 RO 技術始終要消耗能源，如果我們能研究出一個以自然為本的水淨化方法，便可以減少碳排放。周教授提醒我們應當關注水淨化過程中所產生的環境問題。很多人以為技術越來越先進，不管多污染的水也可以淨化，但卻忽略了社會效益問題。周教授反問我們，如果能減少水源頭的污染，再運用天然的方法來處理污水，豈不是更節省能源，更保護環境麼？

周教授耐心地向我們解釋科學概念

科研工作的點滴

周教授雖是環境化學專家，但在大學工作有相當的學術自由，令他不受限於特定範疇的研究。工作的彈性令他可以從事很多他有興趣，而又造福社區甚至世界的研究。他關注到東南亞比較落後的地區，常常面臨洪水的威脅，令人們的生活十分困難。於是，教授帶領一班青年科學家到東南亞，協助當地的人解決洪水問題。不單培育青年科學家，更改善落後地區人們的生活。

周教授熱愛動物和環境生態，所以他最喜歡的研究都與此有關。其中一個深刻的研究，是他於十多年前參與海洋公園一個保育龜的項目。這項目是和國內大學合作，與一些研究生去廣東省市場假扮遊客，觀察市場上有什麼野生動物被非法售賣。雖然過程中看到很多野生動物被出售令人難過，但此研究讓人們了解非法販賣野生動物的現況，亦讓其他人可以利用他們的數據進行更多研究。

周教授還向我們介紹其他有關動物的研究，包括以海獅居住的水族館為研究對象，研究如何利用細菌過濾污水，去除排泄物；在美國研究螢火蟲出現的條件；配合人工智能辨認青蛙的叫聲，了解特定生態中有哪些品種的青蛙，同樣的技術將來亦能應用在蟬的研究。

參觀地球系統科學課程的實驗室

周教授的寄語

我們都對科學充滿興趣和好奇心，不知將來可否成為一個科學家。周教授向我們分享，科學家的成長道路很漫長，他從讀大學、碩士、博士到從事研究工作，一路上充滿了挑戰和困難。如果長大以後想成為科學家，便要從小就學懂取捨，並且要明白從事科學研究未必能帶來名利。

此外，周教授認為生涯規劃方面不需要過於強求，可以順其自然，追隨自己的興趣。他笑言自己小時候每天都被父母催他學習，勸他不要看電視；但長大了，卻每天都被父母催他睡覺，不要通宵達旦的學習，因為他長大後對科學產生濃厚的興趣，推動他每天努力學習，令他廢寢忘餐。如果真的熱衷於科學研究，自然會投入其中，享受科研帶來的樂趣，令工作都變成娛樂，而他相信他的工作帶來的自主性和成就感是其他工作不能賦予的。

經過一番訪問，我們認識到興趣是最好的老師。興趣就如燈塔，它指引著我們前進的方向。若你對科學研究有濃厚的興趣，你就會努力不斷向前進，未來一定可以成為一個偉大的科學家!

參考資料:

[1] 香港中文大學地球與環境科學課程

https://www.cuhk.edu.hk/sci/essc/people/chow_alex.html

[2] 教城電子報《認識海洋微塑膠的禍害》

https://www.edcity.hk/hq/zh-hant/content/%E8%AA%8D%E8%AD%98%E6%B5%B7%E6%B4%8B%E5%BE%AE%E5%A1%91%E8%86%A0%E7%9A%84%E7%A6%8D%E5%AE%B3

[3] Your Laundry Sheds Harmful Microfibers. Here's What You Can Do About It.

https://www.nytimes.com/wirecutter/blog/reduce-laundry-microfiber-pollution/

[4] What Is a Reverse Osmosis System and How Does It Work?

https://www.freshwatersystems.com/blogs/blog/what-is-reverse-osmosis

優才(楊殷有娣)書院 - 小學部

第十七屆香港科學青苗獎

科學家專訪報告 – 陳鍵林博士

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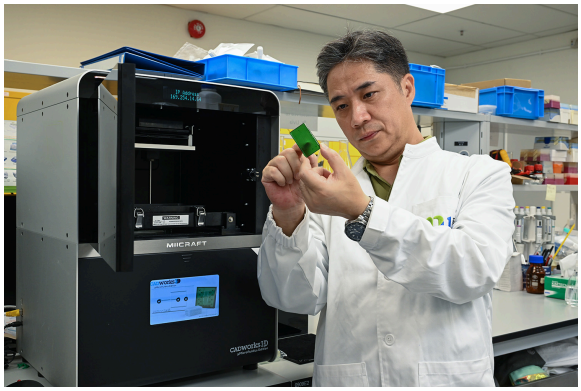
職銜：香港都會大學科技學院應用科學系助理教授
研究範圍：跨環境科學，材料科學，化學工程
研究方向：

- 生物傳感器設計：生物毒性檢測、單芯片實驗室、非匀相納米催化特性
- 綠色化學：H_2O_2催化氧化、綠色納米顆粒
- 環境(生物)化學：厭氧消化、高級催化氧化、生物降解、生態遙感

研究歷程及成就

陳鍵林博士現職香港都會大學科技學院應用科學系助理教授；1998年及2003年獲天津大學先後頒授化學工程學士學位及生物化工碩士學位，2008年獲香港城市大學頒授環境科學博士學位。在2009年，他獲得瑪麗居里主持獎學金，擔任以色列本古里安大學的博士後職位。於2011年，他獲得教職員研究發展獎學金，擔任紐西蘭奧克蘭大學的博士後研究員。2012年末，他加入David Stuckey教授在新加坡南洋理工大學的實驗室，專攻用於檢測厭氧消化毒性的生物傳感器設計。2016年，陳博士加入香港城市大學擔任訪問助理教授，主力研究綠色及環境生物化學，使用無人機及AI人工智能技術對海岸上垃圾進行調查，並建立數據庫協助清理海廢。



鑑於他的研究成果對社會及環保都有貢獻，陳博士於2021年獲大學教育資助委員會的教員資助，以支持用於細菌檢測和毒性測量的紙芯片上刃天青生物還原反應的非均相反應動力學研究。同年，獲環境及自然保育基金資助，推展有關廚餘處理的研究。他發現大量加入廚餘於「厭氧消化」系統會改變酸鹼值，導致微生物群落失調，影響微生物

處理垃圾成效，於是他與研究團隊設計出「微流控監測裝置」實時監察垃圾分解，幫助提高廚餘處理的穩定性和產生可再生能源的效率。

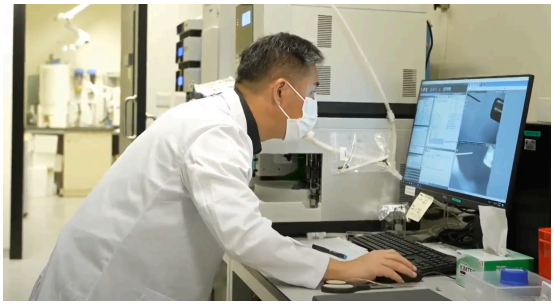
展望未來：實踐轉廢為能，解決塑料污染

陳博士希望他能更有效善用廚餘實踐轉廢為能，目前正在研究「共厭氧消化」的生物活性監測，然後可以把他們的研究結果應用到環境保護裏面去。他希望他能夠為世界貢獻他的一點力量，讓地球變得越來越好。他更期望他們的發明能夠把研究結果投入社區應用，並把技術延伸至多個化驗領域，為垃圾處理和環境保護作出貢獻。

在環境科學領域，陳博士接下來想研究如何減少塑料的使用、如何消除塑料的影響、如何替代塑料的使用等等，若為我們今年的科學青苗獎題目快提供了建議。

成為科學家的深刻經歷

在陳鍵林博士的成長軌跡中，科學旅途的每一步都刻畫著深刻的印記。在他大學最後一年致力於final year project的時期，他對科學研究的熱情被徹底點燃，從而鞏固了他成為科學家的決心。這段經歷不僅是一段學術探索，更是他職業生涯的里程碑。

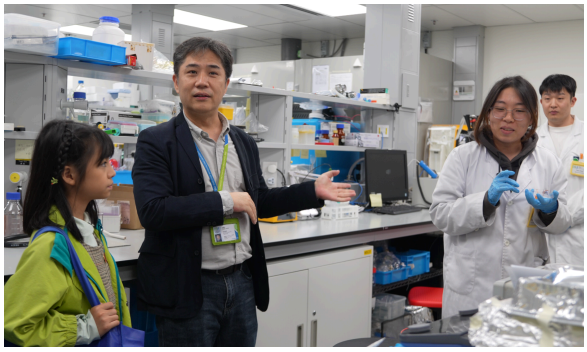


在他的中學時期，一次使用碘來檢測澱粉的實驗令他震撼。澱粉與碘反應展現出的顏色變化，對他來說不僅是化學反應的神秘，更是一扇窗，透過它他能洞悉自然界的奧秘。這一趣味橫生的實驗種下了他對化學魅力的終生追求。

陳博士專攻化學工程，在他的專業生涯中，對他影響深遠的是利用蒸餾法來分離原油的各種組分的實驗。當他從精餾塔中提煉出汽油，並且見證這些汽油能夠直接驅動汽車時，實驗室裡的成就感和實用價值讓他對科學的熱愛達到了新的高峰。

畢業後，陳博士在中國內地的貧困地區擔任了一年的志願者，這段經歷讓他深刻地理解到教育在幫助人們擺脫貧困中的關鍵作用。因此，他決定留在學界，一方面通過教學傳遞知識，一方面透過研究為社會做出貢獻。這些經歷，無論是充滿好奇的實驗還是令人振奮的志願服務，都是他科學之旅中不可或缺的一部分，塑造了他今日的科學家形象。

科學研究的艱辛旅途:「謙卑」才能走得更遠



科學家的發明不應該被分為厲害或不厲害，因為每一個發明都代表著科學家們的努力和創造力，都有其獨特的價值和貢獻。

科學家們致力於解決各種難題和挑戰，他們不斷尋求新的知識和理解，並將其應用於實際問題的解決。無論是一個小而精巧的發明，還是一個重大的突破性發現，每個科學家的貢獻都是不可或缺的。

每一個發明都有其特殊的背景和意義。它可能是一項改進現有技術的創新，也可能是全新領域的突破。有些發明改變了我們的日常生活，提高了生活品質，有些則推動了整個產業的發展，甚至改變了社會的運作方式。然而，無論其規模大小，每一個發明都是科學家們努力的結晶，都值表揚的。

科學家必要特質— 失敗乃成功之母

陳博士啟發我們想成為真正的科學家要有堅持和永不放棄的決心，也令我們領悟到「失敗乃成功之母」的意義，一定要懂得堅持，哪怕第99次摔倒，也要第100次的站起來，只要有一次成功，已經是成功了！他也告訴我們:「每一次的成功都是建立於無數次失敗之上。」

我們的反思

這次的訪問和參觀讓我們學會了許多知識和道理，我們認識生物可降解塑膠的好處和壞處及製作可降解塑膠時的成功秘訣。例如學會了藻類的繁殖率很高，如果有太多的藻類會對海洋生態構成很大的影響，而且我们也學會了原來「生物可降解塑膠」也可能會放釋放一些微塑膠，但不知道會不會對人類造成影響。

陳博士問了我們一個問題:「發明還是發現較偉大呢？」我們都異口同聲地說:「發明！」但其實是發現偉大一點。因為如果沒有發現，就沒有發明，例如:我們沒有發現水的形成，有科學家需要用類似水的物質來完成發明品，但不知道水是由氧氣及氫氣結合而成的。有很多科學家都很想在他人的心裏種下一顆做科學家的種子，陳博士也是其中一位，他也很希望可以把科學家精神傳承下去。

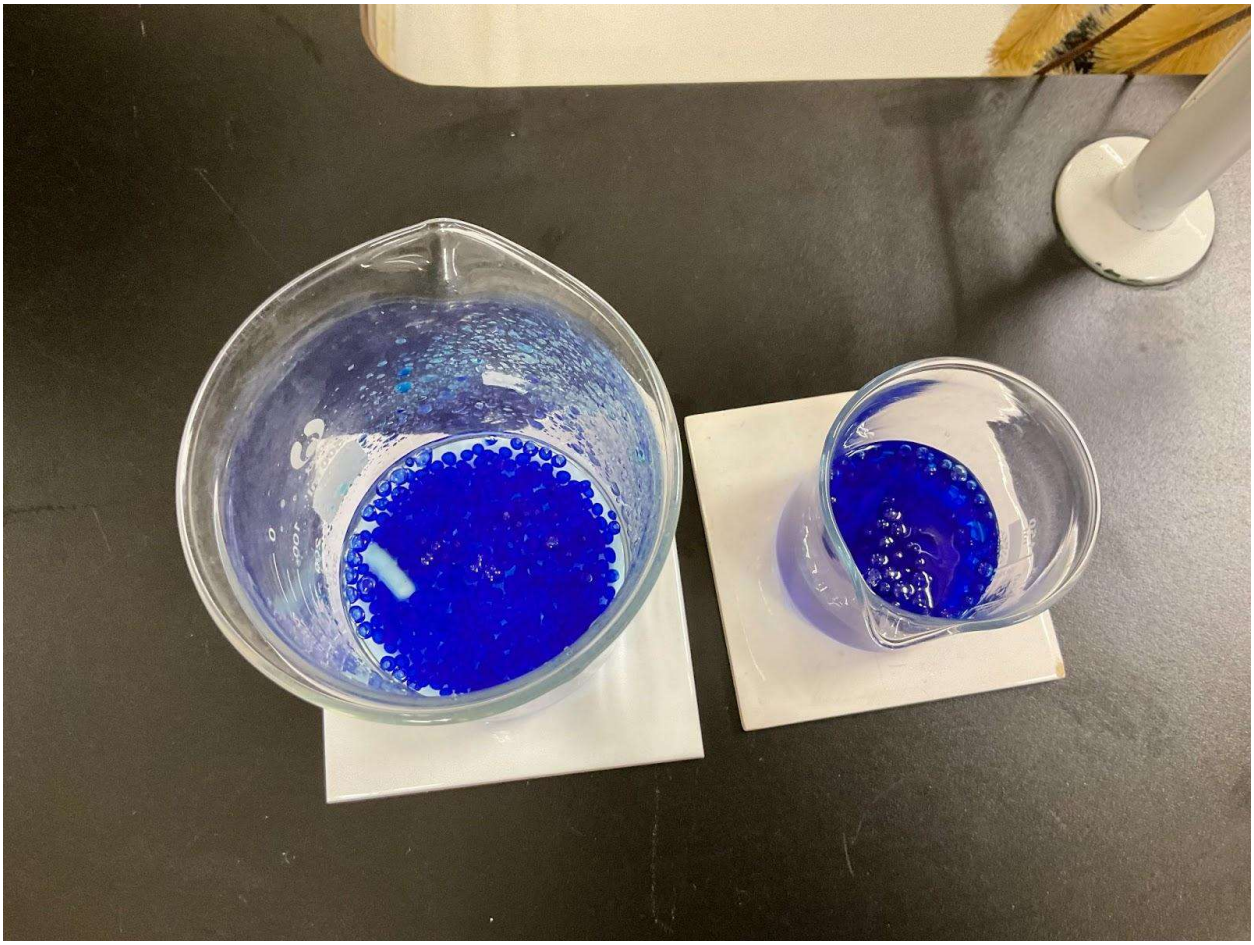
在這段旅程中，我們面臨了無數挑戰，從研究主題的選擇到實驗的挫敗，每一步都可能讓我們心灰意冷。然而，正是透過團隊成員間的緊密合作與相互討論，我們最終能夠克服這些試煉，並順利完成我們的實驗任務。

訪問的過程中讓我們深刻體會到，科學探索之路遠非易事。成功往往是在經歷無數失敗之後才得來的，這要求我們學會如何有效地分配資源和精煉我們的研究設計。儘管途徑重重困難，我們的決心不減，我們將持續努力，直至成為出色的科學家。

中學組:

冠軍

Investigation on dye absorption properties of alginate-based hydrogel beads



Diocesan Girls' School
Chu Tin Wing
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Investigation on dye absorption properties of alginate-based hydrogel beads

Diocesan Girls' School

Content

Investigation on dye absorption properties of alginate-based hydrogel beads

Diocesan Girls' School

Abstract

With the rapid demand of the fast fashion industry, fueled by the convenience of online consumption, the use of synthetic dyes has been steadily increasing not only in the textile industry, but also in paper production, food technology and hair colorings. Amidst the overwhelming amount of synthetic dyes produced per year, most of which are disposed through wastewater, substantial environmental pollution is created, putting the public's health at significant risk. However, due to the diverse chemical structure and stability of these dyes, traditional technologies used to treat and decolorize them in wastewater are largely ineffective, and current methods are often environmentally harmful and unsustainable. Thus, we have looked into the various factors that contribute to maximizing the effectiveness of more sustainable materials, specifically sodium alginate from marine brown algae, in absorbing synthetic dyes through our scientific investigation.

Investigation on dye absorption properties of alginate-based hydrogel beads

Diocesan Girls' School

1. Introduction

Synthetic dyes, such as methylene blue (MB), are potentially carcinogenic, toxic and environmentally unfriendly, decreasing water transparency and reducing oxygen in water when discharged. However, due to its low cost and easy adherence to fabric, it is popular among manufacturers.

Sodium alginate ($NaC_6H_7O_6$) is a polysaccharide present in the cell wall of seawater brown algae. Due to its biodegradable nature and relatively low cost, along with its presence of anionic groups (carboxylate), it is suitable for absorbing cationic groups of waste.

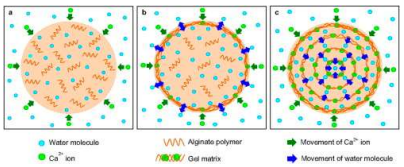
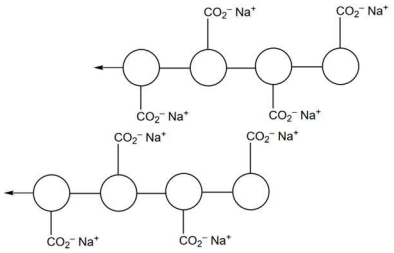


Fig. 1: Graphical formation of alginate-based hydrogel beads[1]

2. Scientific principles

2.1 Formation of alginate-based hydrogel beads from sodium alginate



Sodium alginate has a linear structure consisting of repeating monosaccharide units ($CO_2^-Na^+$), with free hydroxyl and carboxyl groups distributed along a polymer chain backbone.

Fig. 2: Molecular structure of sodium alginate[2]

During the cross-linking of alginate hydrogels, the sodium ions of the alginate aqueous solution finds divalent cations such as Ca^{2+}, Zn^{2+} or Fe^{2+}, interacting with carboxylic acids on the macromer backbone to cross-link polymer chains[3]. This forms a three-dimensional alginate-based bead, which has a diffusion barrier allowing molecules of a certain size threshold passage.

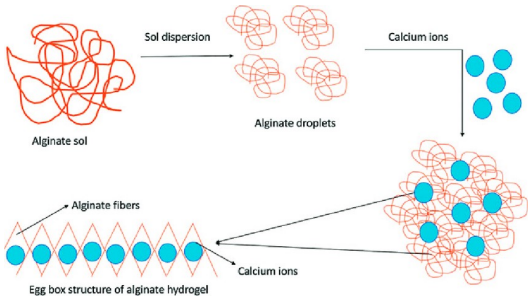


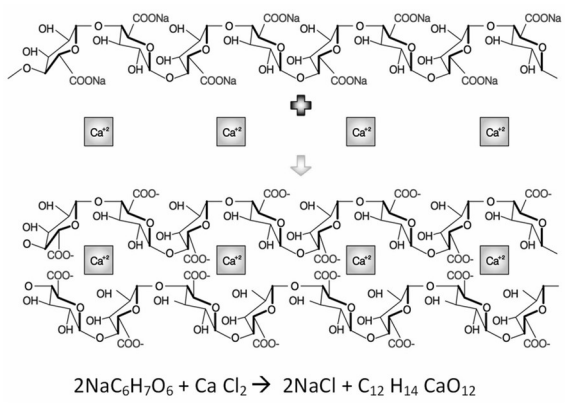
Fig. 3: Schematic representation of fabrication of alginate-based hydrogels[4]

[1] Voo, W.-P., Ooi, C.-W., Islam, A., Tey, B.-T., & Chan, E.-S. (2016, January 2). *Graphical representation of calcium alginate hydrogel beads with high stiffness and extended dissolution behaviour.* European Polymer Journal. https://www.sciencedirect.com/science/article/abs/pii/S0014305715301087

[2] The Royal Society of Chemistry. *Structure of sodium alginate.* Inspirational chemistry: Cross-linking polymers – alginate worms. https://edu.rsc.org/download?ac=15046

[3] Malektaj, H., Drozdov, A. D., & deClaville Christiansen, J. *Mechanical Properties of Alginate Hydrogels Cross-Linked with Multivalent Cations.* Polymers. https://pubmed.ncbi.nlm.nih.gov/37514402/

[4] Mustafa, K. *Schematic representation of fabrication of alginate-based hydrogels*. ResearchGate. https://www.researchgate.net/figure/Schematic-representation-of-fabrication-of-alginate-based-hydrogels_fig2_326213831



These porous polymeric networks can adjust itself with external stimulus, maintaining their chemical structure when infiltrated with high amounts of water.

Fig. 4: Structure of a cross-linked alginate hydrogel network[5]

2.2 Dye absorption characteristics of alginate-based hydrogel beads

The hydrogel formulation is a negatively charged gel network since alginate is an anionic polysaccharide, allowing hydrogel beads to predominantly absorb cationic dyes through ionic attraction.

When beads are submerged into dye solution, swelling occurs. The porous structure of beads provides a route for dye molecules to diffuse into them. With attractive electrostatic interactions and positive molecular sieving, certain dyes can be encapsulated with higher ease within the hydrogel matrix.

[5] Lu, H., Britten, N., Venkatraman, P., & Butler, J. *Crosslinking of sodium alginate with calcium chloride - Natural Antimicrobial Nano Composite Fibres Manufactured from a Combination of Alginate and Oregano Essential Oil.* Nanomaterials; ResearchGate. https://www.researchgate.net/figure/Crosslinking-of-sodium-alginate-with-calcium-chloride_fig3_353930285

3. Experiment details

Objective: Making alginate-based hydrogel beads and immersing them in dye solution to test their absorption capabilities and behaviour.

3.1 Making alginate-based hydrogel beads

1. 2g of sodium alginate (SA) powder is dissolved in 100g of deionized water under heating.
2. At room temperature, without stirring, 2 wt% alginate solution is added dropwise to a polyvalent cationic solution $CaCl_2$ to prepare alginate-based hydrogel beads.
3. 20g of alginate-based hydrogel beads are fully immersed in 40mL of dye solution.
4. Mixtures are transferred to a hot-plate stirrer and set to stir inside a fume cupboard.
5. Results are recorded on a 1-hour, 3-hour or 12-hour basis.

3.2 Test on the influence of cross-linking agents

6. 1g, 2g, 4g, 10g and 20g of calcium chloride powder are each dissolved in 100mL of deionized water.
7. A polyvalent cationic solution $CaCl_2$ is prepared at different concentrations (1 wt%, 2 wt% 4 wt%, 10 wt% and 20 wt% respectively).

3.3 Preparation of alginate-based hydrogel beads of varied surface areas

8. 2 wt% alginate solution (Section 3.1) is prepared.
9. 2 wt% alginate solution is added with pipette droppers to a 4 wt% polyvalent cationic solution $CaCl_2$ to prepare alginate-based hydrogel beads with smaller total surface area.
10. 2 wt% alginate solution is added with micropipettes to a 4 wt% polyvalent cationic solution $CaCl_2$ to prepare alginate-based hydrogel beads with larger total surface area.

Fig. 5: Performing step 10

3.4 Test on the performance of alginate-based composites*:* preparation of a sodium alginate (SA) / iron (Fe)-based composite solution

11. An iron-based mixture (containing iron powder, activated carbon and calcium chloride) is ground using a pestle and mortar.
12. 2g and 4g of the iron-based mixture are measured and immediately added to the prepared 2 wt% alginate solutions (Section 3.1) respectively to minimize the oxidation of iron.
13. Sodium alginate / iron-based composite solutions at SA:Fe ratios of 1:1 and 1:2 are prepared.
14. The solutions are added dropwise into a polyvalent cationic solution $CaCl_2$ to prepare alginate-based hydrogel beads.

3.5 Removal of cationic and anionic dyes: preparation of a cationic methylene blue (MB) and anionic methyl orange (MO) solution

15. 10mL of a MB and MO of 0.1% concentration is diluted in 200mL of deionised water (concentration 0.0048% per solution).
16. Light absorption of the MB and MO solutions are measured using a colorimeter.

4. Results and analysis

4.1 Standard absorption performance and influence of cross-linking agents of alginate-based hydrogel beads (Section 3.1)

Table 1: Light absorbency based on solution

Solution	Light absorbency
Deionised water	0.00
Methylene blue solution	1.93

Table 2: Light absorbency based on presence of stirring

Presence of stirring	Light absorbency	Difference in light absorbency
Stirred	0.08	-1.85
Unstirred	0.77	-1.16

Summary on dye absorption capabilities:
Alginate-based hydrogel beads absorb notable amounts of MB dye from MB solution, decreasing the presence of dye and increasing water's decolorization.

4.2 Test on the influence of cross-linking agents (Section 3.2)

Table 1: Light absorbency based on solution

Solution	Light absorbency
Deionised water	0.00
Methylene blue solution	1.93

Table 3: Light absorbency based on concentration of $CaCl_2$ solution

Concentration of $CaCl_2$ solution	Light absorbency		Difference in light absorbency	
	After 1 hour	After 3 hours	After 1 hour	After 3 hours
1 wt% $CaCl_2$	0.18	0.15	-1.75	-1.78
2 wt% $CaCl_2$	0.14	0.07	-1.79	-1.86
4 wt% $CaCl_2$	0.18	0.04	-1.75	-1.89
10 wt% $CaCl_2$	/	0.05	/	-1.88
20 wt% $CaCl_2$	/	0.08	/	-1.85

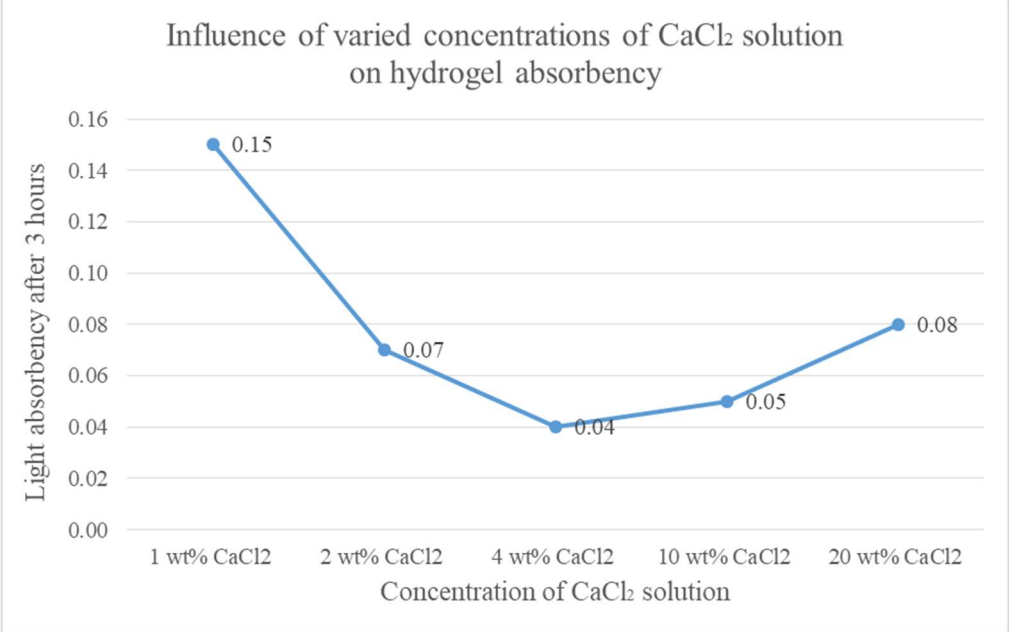


Fig. 6: Influence of varied concentrations of $CaCl_2$ solution on hydrogel absorbency

Summary on the influence of different concentrations in cross-linking agents:

The lowest and highest concentrations of $CaCl_2$ during cross-linking have adverse effects on the absorption capacity of alginate-based hydrogel beads, suggesting that highly cross-linked structures, or vice versa, adversely impact the mechanical properties of hydrogels due to changes in the formation of the hydrogel matrix.

Furthermore, there are higher levels of fragmentation observed for beads cross-linked in higher concentrations of $CaCl_2$, suggesting that cross-linking agents affect the durability of the hydrogel structure. This is further discussed in Section 5.

Fig 7: 4 wt% $CaCl_2$ after 3 hours

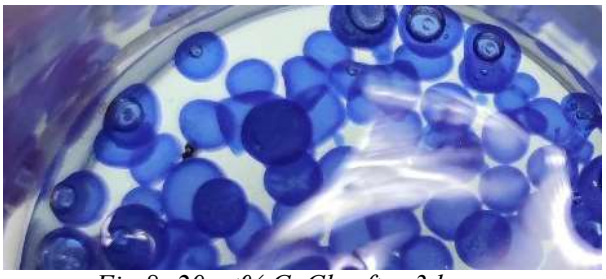


Fig 8: 20 wt% $CaCl_2$ after 3 hours

Small fragments of alginate can be observed to have broken off of hydrogel beads in the 20 wt% $CaCl_2$ solution, which are absent in the 4 wt% $CaCl_2$ solution.

4.3 Test on the influence of varied bead surface area (Section 3.3)

Table 1: Light absorbency based on solution

Solution	Light absorbency
Deionised water	0.00
Methylene blue solution	1.93

Table 4: Light absorbency based on the diameter of alginate-based hydrogel (SA) beads

Diameter of SA beads	Light absorbency	Difference in light absorbency
31.6 mm *(pipette dropper)*	0.05	-1.88
0.16 mm *(micropipette)*	0.05	-1.88

Summary on the influence of varied bead surface areas on structural integrity and mechanical properties:
The overall surface area of the alginate-based hydrogel beads has no significant impact on the absorption of MB. However, smaller beads (with larger total surface area) produced by a micropipette exhibit less fragmentation and are more resistant. It can be concluded that smaller beads have higher structural integrity and mechanical strength.

Due to the minimal impact of surface areas and the lengthier process required for preparing smaller beads, larger hydrogel beads remain the optimal choice for large quantities under time constraints.

4.4 Test on the performance of alginate-based composites (Section 3.4)

Table 1: Light absorbency based on solution

Solution	Light absorbency
Deionised water	0.00
Methylene blue solution	1.93

Table 5: Light absorbency based on composition of beads

Composition of beads (SA:Fe / FeO)	Light absorbency		Difference in light absorbency	
	After 3 hours	After 3 days	After 3 hours	After 3 days
1:1 Fe	0.08	0.02	-1.85	-1.91
1:2 Fe	0.07	0.01	-1.86	-1.92
1:1 FeO	0.07	0.05	-1.86	-1.88

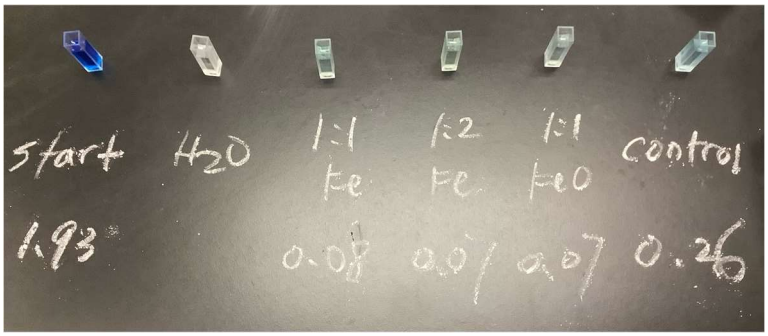


Fig. 9: Results of experiment 4.4

Fig. 10: iron-based composites are observed to have oxidised
(*Order of composites from left to right: 1:1 FeO, 1:2 Fe, 1:1 Fe.)*

Summary on the influence of alginate-based composites and varied concentrations on absorption capabilities:

Iron-based composite yields a 60% higher absorbency of MB compared to the iron oxide-based composite. A higher concentration of the iron-based composite also results in a higher dye absorbance increase by 100%. However, it is harder to preserve as metallic iron oxidizes rapidly. After 72 hours, the iron-based composite turns reddish-brown, signifying the oxidation of iron components.

Note: The sodium alginate (SA) /iron (Fe) -based composite consists of iron powder, activated carbon and calcium chloride. However, for clarity and to minimise redundancy, the iron-based composite will be referred to as "*Fe*" as iron is the primary ingredient. The same is to be applied to the sodium alginate (SA) / iron oxide ($Fe2O_3$) -based composite, which will be referred to as "*FeO*".

Iron oxide can be obtained from used hand warmers, thus remaining the optimal choice for environmental concerns.

Further investigations with varying concentrations of iron oxide-mixture on the absorption capacity of the sodium alginate / iron based composite hydrogel demonstrate that a higher concentration of iron can improve absorption, possibly due to mechanical or chemical changes. This is discussed further in Section 5.

4.5 Test on selective dye absorption (Section 3.5)

Table 1: Light absorbency based on solution

Solution	Light absorbency
Deionised water	0.00
Methylene blue solution	1.93
Methyl orange solution	1.84

Table 5: Light absorbency based on type of synthetic dye

Type of synthetic dye	Light absorbency		Difference in light absorbency	
	After 3 hours	After 12 hours	After 3 hours	After 12 hours
Methylene blue	0.07	-1.86	0.06	-1.87
Methyl orange	1.63	-0.21	1.81	-0.03

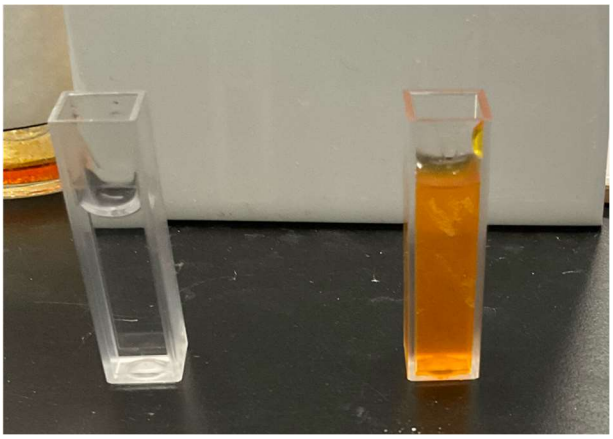


Fig. 11: Results of methyl orange after 3 hour

Summary on selective dye absorption behaviour:
Sodium alginate (SA) / iron oxide (Fe_2O_3)-based composite does not have a good absorption of MO. In fact, there is a negative relationship between the light absorbency of the MO and duration of time, suggesting that the beads are unable to retain the dye. This selective dye absorption behaviour may be due to differences in ionic attraction, which is discussed further in Section 5.

5. Discussion

5.1 Properties

5.1.1 Influence of cross-linking agents on dye absorption performance and durability of alginate-based hydrogel beads

Relatively lowest and highest concentrations of $CaCl_2$ during the cross-linking process negatively impact the absorption capabilities and structural stability of alginate-based hydrogel beads. Low concentrations of $CaCl_2$ suggests that interaction between polymer bonds breaks easily, adversely affecting the stable formation of cross-linked networks and leads to a loose hydrogel structure. It can be hypothesized that whilst having higher viscosity, the decreased stability of the structure may negatively impact mechanical strength and retention ability.

Conversely, high concentrations of cross-linking agents, whilst improving mechanical strength, lead to higher gel fraction and a decrease in the porosity of the capillary structures with reduced sizes of interconnecting pores[6]. A diminished network space thus leads to low media absorbency. High cross-linking densities also lead to glassy structures, making hydrogel beads susceptible to fragmentation, as observed when cross-linked in 20 wt% $CaCl_2$ solution.

The bimodal distribution of results suggests that an optimal concentration of cross-linking agents for beads can be achieved with further testing.

5.1.2 Influence of varied bead surface areas on absorption performance

No significant impact on the absorption performance for alginate-based hydrogel beads of varied surface areas has been observed.

However, beads of smaller volume demonstrated less fragmenting and higher mechanical strength. This may be due to a higher surface-to-volume ratio, where forces acting on the cross-linked polymer are distributed over a larger area. However, the Young modulus and thickness of the beads remain the same regardless of size and swelling. Therefore, it can be hypothesized that the walls of larger beads are less capable of retaining absorbed content without risk of rupture. It can be concluded that smaller beads have higher mechanical strength than larger beads.

[6] Chavda, H., & Patel, C. (2011, January). *Effect of crosslinker concentration on characteristics of superporous hydrogel.* International journal of pharmaceutical investigation. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3465110/

5.1.3 Performance of alginate-based composites

Sodium alginate / iron-based composites yield a higher absorbency, which may be due to the effects of components such as activated carbon and the nature of iron / iron-oxide.

Through surface interactions between MB and carbon graphite platelet surfaces of activated carbon, the beads' absorption ability is elevated. Van der Waal forces make the activated carbon graphitic platelets induce neutral organic molecules into intra-molecular dipoles. Hence, the molecules attract and stick together, precipitating out of MB solution and into the carbon's nano-sized pores, facilitating the process of premature condensation[7]. With the electrostatic attractions between hydrogels and contaminants during the dye absorption process, the process of dye removal is further enhanced[8].

Sodium alginate / iron-based based composites with higher concentrations of iron are shown to have the best performance. The anionic chloride ions released during the dissociation of MB[9] in aqueous solutions are attracted by the cationic ferric ions (Fe^{3+}) present in iron's +3 oxidation state. This electrostatic reaction between absorbants and contaminants further enhances the absorption performance of hydrogel.

Iron-based composites had a better absorption performance compared to iron(III) oxides. However, because MB discoloration cannot be induced by redox transformation, its discoloration due to metallic iron is hypothesized to be caused by changes in the mechanical structure of hydrogel beads due to composites, or that FeO may act as a reducing or absorption agent, which is still contested in the scientific community[10].

[7] Nowicki, H). *The basics of activated carbon adsorption.* Water Technology. https://www.watertechonline.com/wastewater/article/15549902/the-basics-of-activated-carbon-adsorption

[8] Asadi, S., Eris, S., & Azizian, S.. *Alginate-Based Hydrogel Beads as a Biocompatible and Efficient Adsorbent for Dye Removal from Aqueous Solutions*. ACS Omega. https://doi.org/10.1021/acsomega.8b02498

[9] Al-Ghouti, M. A., & Al-Absi, R. S. *Mechanistic understanding of the adsorption and thermodynamic aspects of cationic methylene blue dye onto cellulosic olive stones biomass from wastewater*. Nature, Scientific reports. https://www.nature.com/articles/s41598-020-72996-3#:~:text=Methylene%20blue%20(MB)%2C%20commonly,%2C%20biology%2C%20and%20chemistry10

[10] Konadu-Amoah, B., Ndé-Tchoupé, A., Hu, R., Gwenzi, W., & Noubactep, C. *Investigating the Fe0/H2O systems using the methylene blue method: Validity, applications, and future directions*. ScienceDirect. https://www.sciencedirect.com/science/article/abs/pii/S004565352103385

5.1.4 Charge-based absorbency of alginate-based hydrogel beads

Absorption performance of hydrogel beads varies for different dyes, such as anionic MO, and cationic MB. This could be affected by electrostatic attractions. Electrostatic repulsion between MO and anionic hydrogel causes absorption of the dye to be comparatively weaker, unlike that for MB, where beads employ a negatively charged gel network to readily attract the cationic MB molecules (Section 2.2). This can explain the beads' poor absorption of MO, as an ionic bond cannot be established between dyes and hydrogels.

It may also be hypothesized that weak electrostatic attractions between MO and hydrogels lead to a poorer retention of MO in hydrogels, as witnessed by the increased colorization of the 12-hour MO compared to that of 3 hours.

5.1.5 Application in the waste treatment industry

As dye absorbents, alginate-based hydrogel beads can be used to remove pollutants from wastewater inexpensively, as means to combat marine pollution in Hong Kong. This can be an additional step in the water filtration process, through reducing the amount of pollutants and dyes before wastewater is discharged.

Additionally, hydrophilic hydrogel beads can be utilized as an absorbent material for water-soluble wastes, and be deployed in extremely polluted regions to effectively contain pollutants.

5.2 Major challenges

Whilst using hydrogels for dye absorption is dubbed more "biocompatible", alginate hydrogels have relatively weak mechanical properties and are susceptible to fast degradation with inefficient encapsulation of loaded cargos[11]. Furthermore, hydrogels are observed to only absorb specific types of dye. Hydrogels are also hard to shape in designated geometries[13], and are prone to swelling in humid environments. The use of irritating cross-linking agents such as calcium chloride to produce synthetic hydrogels also raise safety concerns. These challenges underscore the difficulties in mass-producing hydrogels whilst maintaining satisfactory quality.

[11] Serpico, L., Dello Iacono, S., Cammarano, A., & De Stefano, L. *Recent Advances in Stimuli-Responsive Hydrogel-Based Wound Dressing.* Gels, SciSpace. https://www.mdpi.com/2310-2861/9/6/45
[12] Billiet, T., Vandenhaute, M., Schelfhout, J., Van Vlierberghe, S., & Dubruel, P. *A review of trends and limitations in hydrogel-rapid prototyping for tissue engineering.* Biomaterials, ScienceDirect. https://www.sciencedirect.com/science/article/pii/S0142961212004899

5.3 Areas of improvement

5.3.1 Limitations and possible errors

A few notable possible errors and limitations in our experiment are observed:

a. Due to time constraints, we were unable to produce multiple batches of alginate-based hydrogel beads for each experiment to draw an average, affecting the results' accuracy.
b. The variety of dyes tested on is fairly limited. Though it can be concluded that alginate-based hydrogel beads have a low absorbency of anionic dyes, it is unclear whether they can readily absorb all cationic dyes due to the differences in molecular size, chemical structure and substituents.
c. MB solution cannot accurately reflect pollution due to factors like temperature, pH, salinity, and water flow. This creates a possible difference in the beads' behaviour when applied to the real world.
d. There is possible water loss during heating of sodium alginate solution which slightly alters its concentration.
e. Due to its extreme hydrophilic property, alginate absorbs water vapour in air at exponential rates. The hydrogel beads cannot be exposed at room temperature for a long period of time due to swelling, which may hinder their absorption abilities.

5.3.2 Suggestions for follow-up tests

a. Use tensile tests to assess the mechanical strength and structural integrity of the alginate-based hydrogel beads, measuring the breaking strength, bead viscosity and maximum elongation.
b. Use a larger variety of anionic or cationic dyes, such as methylene green, alizarin yellow or orange G, and different cross-linking agents, such as Fe^{3+}, to further test the dye absorption capabilities and differences in mechanical and chemical properties of hydrogels.
c. Use data loggers to determine changes overtime for more in-depth investigations and improve the overall accuracy of results, such as investigations on the influence of varying bead surface areas since absorption reactions and significant differences may occur in a short time frame.
d. Produce larger sample sizes to obtain more observable and consistent results.

6. Conclusion

Adding iron oxide to sodium alginate in the ratio of 1:1 produces the best results in terms of storage life and light absorption of anionic synthetic dyes. Sodium alginate's biodegradable nature, ability to absorb dyes in a relatively short period of time, and ease of production makes it an environmentally friendly and cost effective option to combat marine pollution in Hong Kong.

亞軍

The 17th Hong Kong Budding Scientists Award 2023-2024

Topic 1 - Environmental Science

Investigation on Reducing Screen Light Pollution with Angulated Privacy Filter

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1. Abstract

In Hong Kong, the problem of light pollution has been disturbing residents for years. Although the iconic neon advertising boards are being removed from the city, LED billboards have emerged as a new advertising board. This study aims to solve the problem while maintaining the advertising use of LED screen billboards and giving the residents an undisturbed sleep.

2. Introduction

In recent decades, light pollution has emerged as a significant environmental pollution caused by excessive artificial lighting. Hong Kong is often seen as one of the most light-polluted cities in the world. Ongoing research conducted by the Department of Physics of the University of Hong Kong initiated in 2003[1], found that the light intensity of the urban night sky in Hong Kong is 30 times more intense than that of its rural counterparts.

The repercussions of light pollution are felt by the residents and disturb the natural circadian rhythm of humans. This disruption may result in insomnia, mental problems, cancers and other health concerns[2].

One of the primary contributors to the brightness is the advertising billboards. Examples are easily found in Causeway Bay, Tsim Sha Tsui, and Mok Kok, the most bustling districts in Hong Kong. Meanwhile, the LED screen billboards are becoming a new trend. The absence of a policy regulating the brightness of outdoor billboards perpetuates the problem[3]. This situation needs to be solved for residents' restful sleep.

In this investigation, a privacy filter was studied and used to design a device that minimized the effects of light pollution caused by LED screens on the residents.

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[1] HKU Light Pollution Research. (n.d.). The Seriousness of Light Pollution in Hong Kong. Retrieved from https://nightsky.physics.hku.hk/en-hk/light-pollution-resources/educational-resources/seriousness-light-pollution-hong-kong

[2] Lau, S. Y., Ng, K. L., Tsang, H. T., & Vong, Y. C. C. (2014). Light pollution in Hong Kong (Outstanding Academic Papers by Students (OAPS)). Retrieved from City University of Hong Kong, CityU Institutional Repository.

[3] Hong Kong Free Press. (2022). Hong Kong urged to legislate against light pollution as green group calls voluntary charter a 'toothless tiger'. Retrieved from https://hongkongfp.com/2022/11/28/hong-kong-urged-to-legislate-against-light-pollution-as-green-group-calls-voluntary-charter-a-toothless-tiger/%5C

3. Objectives

3.1 Case Study

The LED screen billboard outside Cheung Sha Wan Plaza is chosen as a reference for the design.

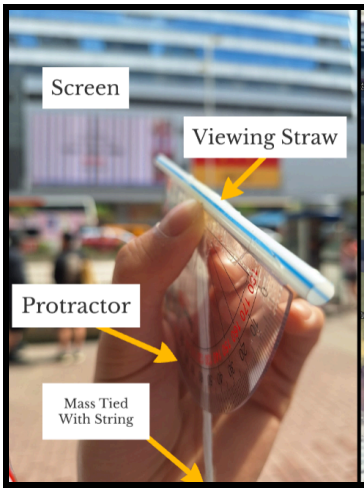
Fig.1: Night photo of the LED screen outside Cheung Sha Wan Plaza on Cheung Sha Wan Road

Relevant data of the screen collected are the following:

1. The angles from the ground to the bottom and the top of the screen are measured by a protractor with a mass tied on, an instrument for measuring the angle of evaluation. The measuring position is at eye level, around 1.6 m above the ground. The former angle is measured as 10° and the latter is 20°.

2. The width of the street is measured as about 40m through Google Earth.

3. The target area immunizing the effects of light pollution by the screen is set as 1/F or above, while 1/F is assumed as 3.5 m above the ground.



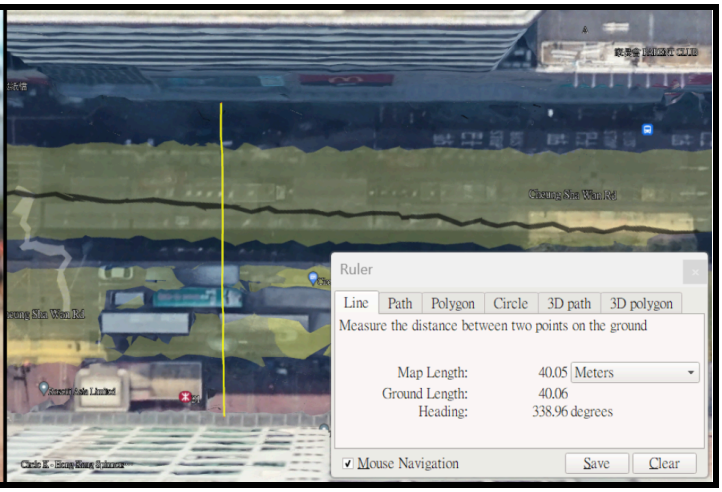


Fig.2a(left): Instrument for measuring the angle of evaluation Fig.2b(right): Measuring the street width by Google Earth

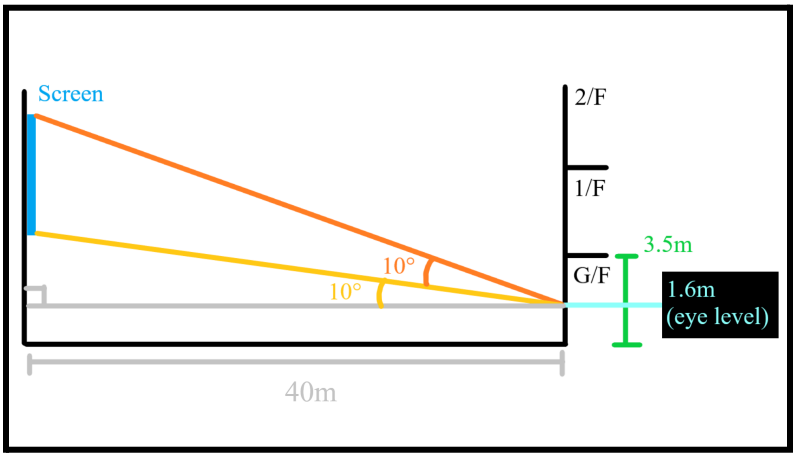


Fig.2c: Diagram of the collected data

3.2 Objectives

The objective of this investigation is to eliminate the disturbing effects of light pollution from LED screen billboards to residents. Specifically, we aim to:

1. Minimize the luminosity of light resulting from the emission of the TV billboard onto the residential area. (i.e. starting from 3.5m and above (1/F or above), and at a horizontal distance of 40m from the screen (across the street).)

2. Redirect the light from the screen to the target audience (pedestrians) without having a huge depreciation on the image clarity. (i.e. Pedestrians at a horizontal distance of 40m from the screen (across the street) and with an altitude of 2m (below 1/F).)

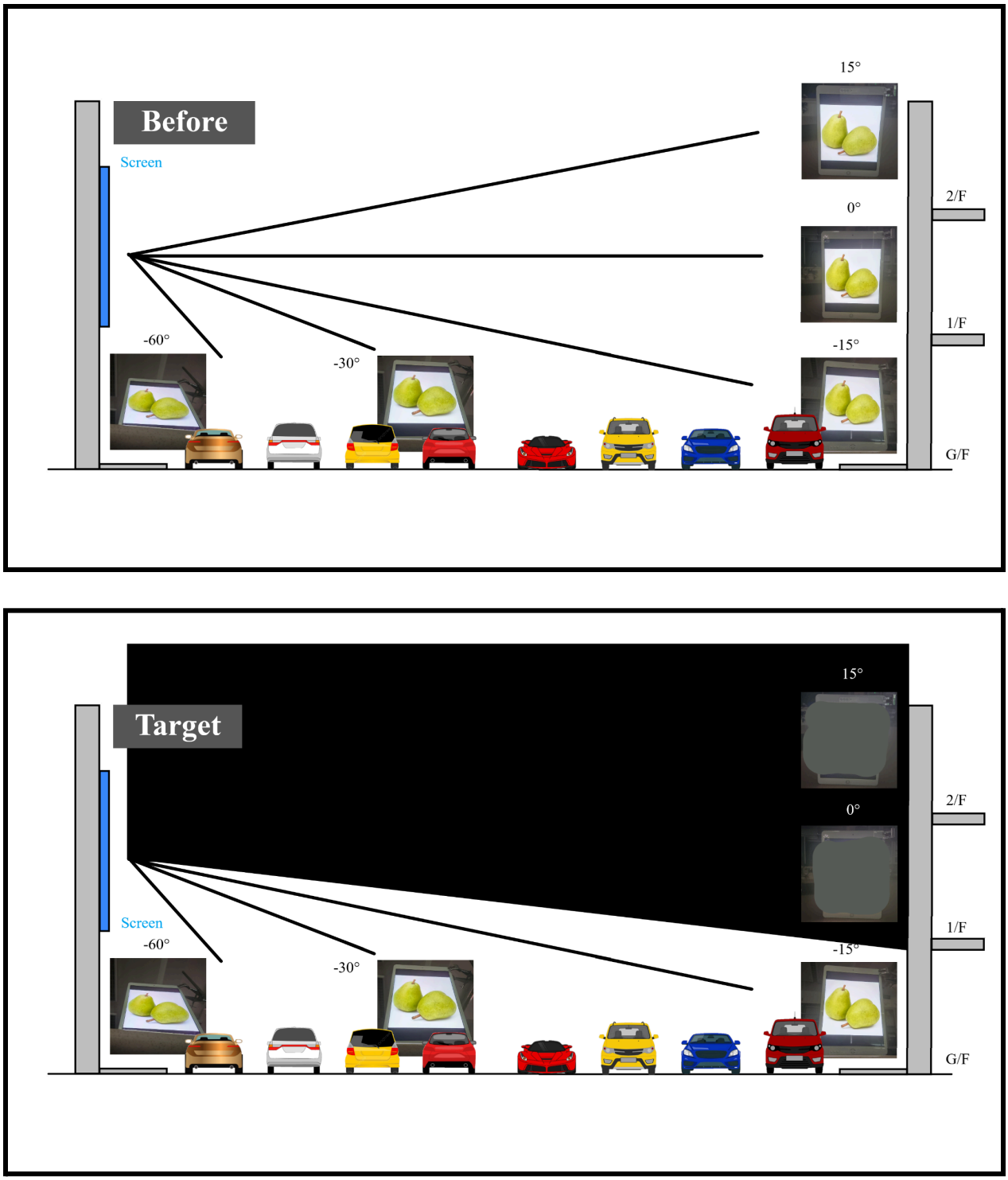


Fig.3a&3b: Before and target graph showing the objectives

4. Proposed Solution

4.1 Screen Privacy Filter

After initial research, screen privacy filters are selected as a component of the solution device. Privacy filters are commonly used nowadays. They narrow the viewing angle, effectively blocking viewing from the surroundings to protect privacy.

4.1.1 Diffraction Grating Experiment

The purchased filter is believed to be a diffraction grating. Hence, a diffraction grating experiment was conducted to verify the hypothesis and find the slit distance of the filter if the hypothesis was confirmed.

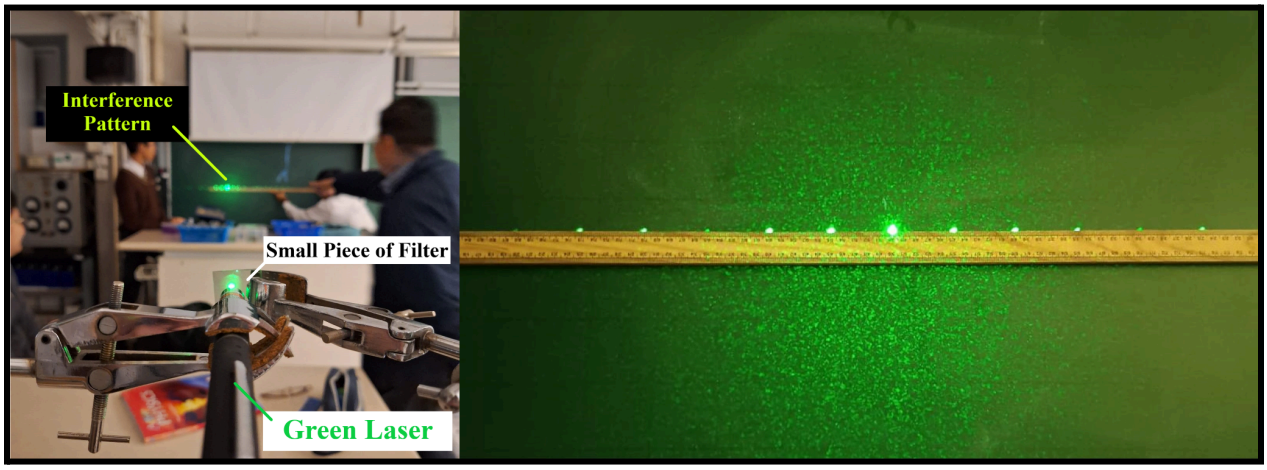


Fig.4a(left): The experiment set-up

Fig.4b(right): A close-up of the interference pattern

In optics, a diffraction grating is an optical grating with a periodic structure that diffracts light into several beams travelling in different directions. Light passing through a diffraction grating splits into multiple beams due to interference effects. The directions of these beams depend on the light incident angle to the diffraction grating, the spacing or distance between parallel slits, and the wavelength of the incident light. When a parallel beam of monochromatic light is from the normal directed at a diffraction grating, light is transmitted only by the grating in certain directions. This is because the diffracted light waves from adjacent slits reinforce each other in

certain directions only, including the incident light direction, and cancel out in all other directions, forming different orders of light (n).

In the experiment, the interference pattern occurred when a parallel monochromatic green laser was directed from the normal at the small piece of the filter. Hence, the filter was proved as a diffraction grating.

To find the slit distance of the filter then, the diffraction grating equation was used.

$$d \cdot sin\theta = n\lambda$$

In the equation, λ refers to the wavelength of the input light. Wavelength is the distance at a given instant in time between successive identical points on a wave, for example, the distance between two successive maxima.

Consider the first maximum (n=1), which happens at the angle when the wave from one slit line-up with the waves from the next slit that are exactly one wavelength behind. The angle between the first order and the incoming light is θ, while it can be obtained by d, the slit spacing, and the path difference, λ.

Therefore $d \cdot sin\theta = \lambda$ when there is a path difference. To make the equation general, an n is put in front where n is an integer. By making use of the diffracted light spots, we can find out the angle θ with d, λ and n provided through observations.

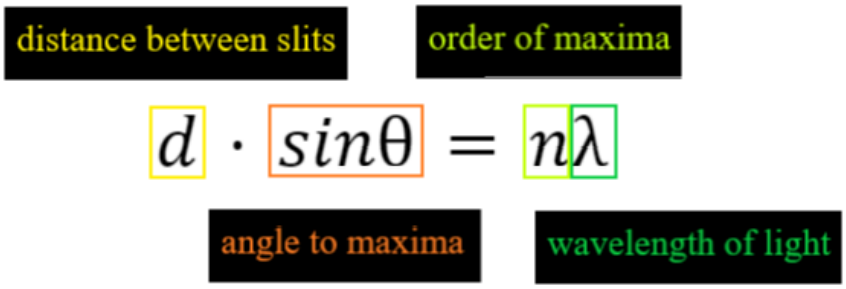


Fig.5a: Explanation of the diffraction grating equation

In the calculation, the distance between two 4th-order maxima was measured as 40.2 cm. The horizontal distance between the filter and the interference pattern is 384 cm. Then, the angle of diffraction could be found as 3.01°. A monochromatic green laser with 532 nm was used.

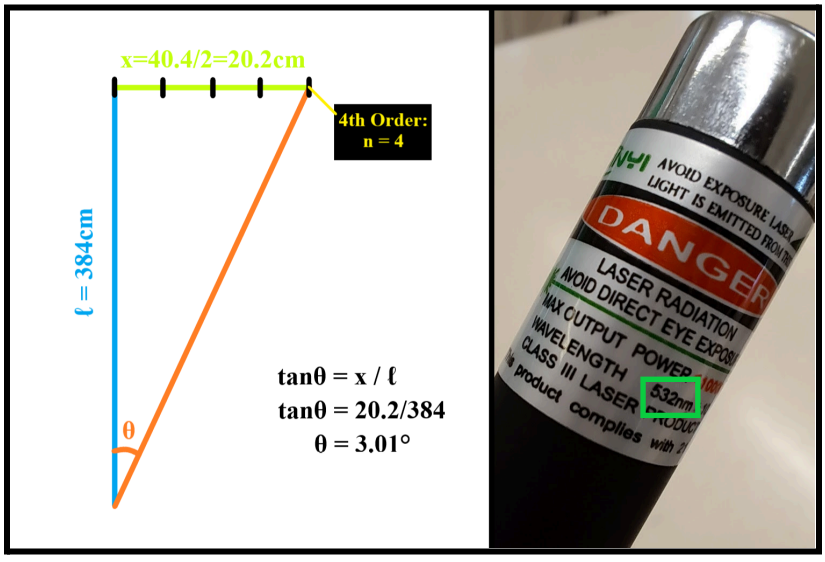


Fig.5b(left): Calculation of the angle of diffraction for 4th-order maxima

Fig.5c(right): Wavelength of the green monochromatic laser labelled

The calculation of the slit distance of the filter is shown below:

For 4th order maximum:

$$d \cdot sin\theta = n\lambda$$

$$d \cdot sin3.01° = 4 \cdot 5.32 \cdot 10^{-7}$$

$$d = 4.02 \cdot 10^{-5} \text{ m}$$

The density of slits was found as 25 silts/mm by the equation.

4.1.2 Viewing via Microscope

To further investigate the structure of the filter, two samples of the filter, a small square and a thin cut were cut and viewed under a microscope.

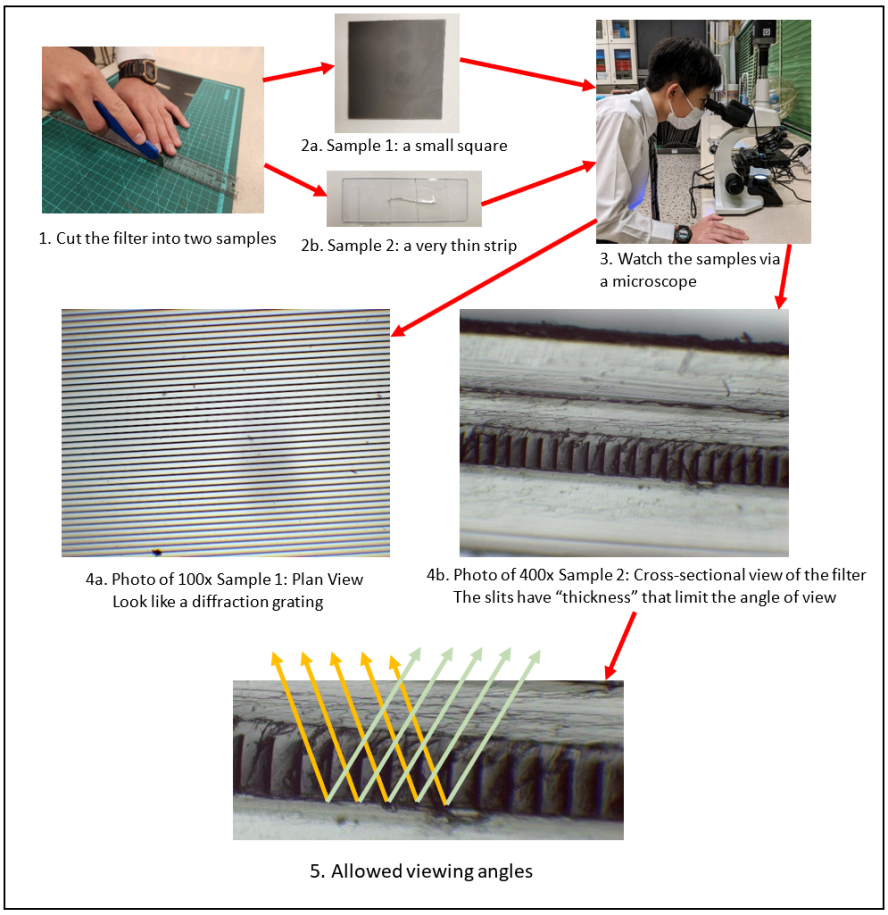


Fig.6: Studying how the filter works by viewing via microscope

By viewing the small piece under a microscope, the filter looked similar to a diffraction grating. The density of slits was counted as 25 slits per mm by a ruler aside from the sample. This matched the result in the calculation of the diffraction grating experiment.

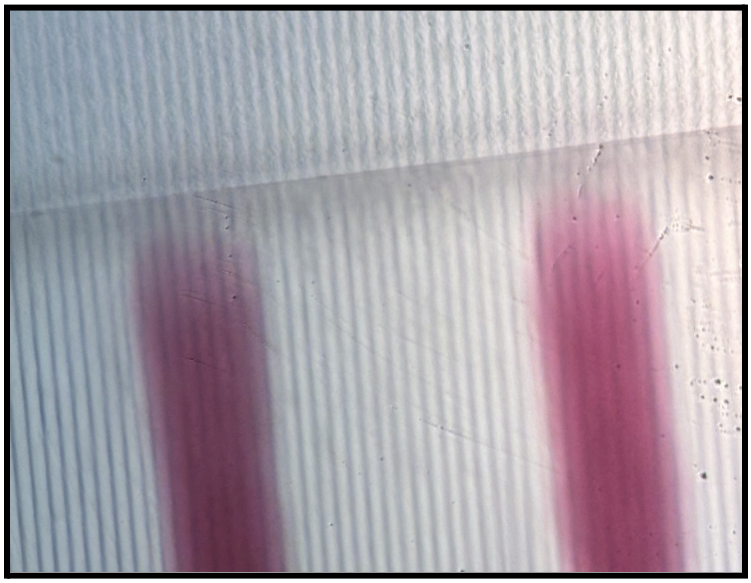


Fig.7: Plan view of the small piece of the filter under a microscope

By viewing the thin cut under a microscope, the cross-sectional view of the filter could be seen. The slits had “thickness” that limits the visual angle. The visual angle was measured as 60°.

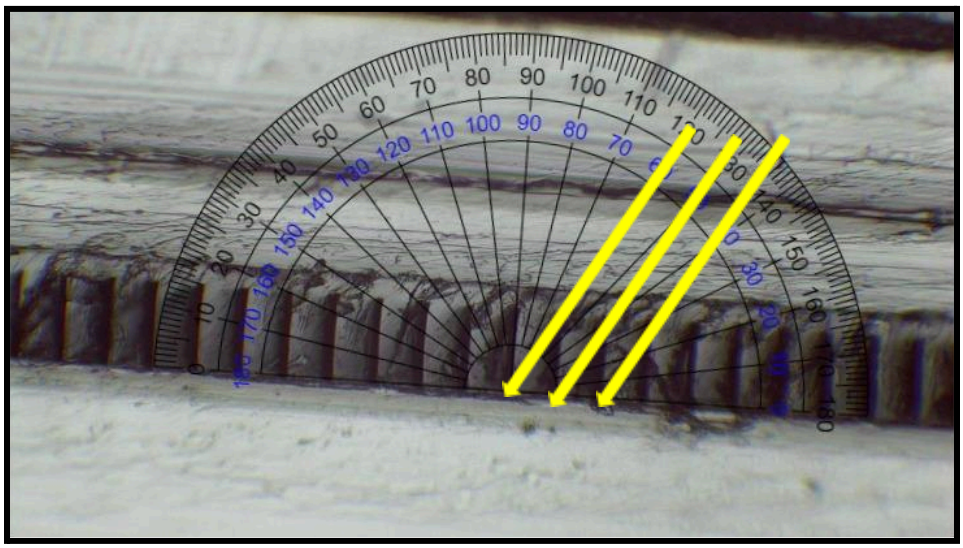


Fig.8: Cross-sectional view of the thin cut of the filter under a microscope with a protractor

4.1.3 Verification of Visual Angle

To verify the visual angle of the filter, light intensity at different viewing angles was measured on a filter-installed screen.

Instruments

1. A lazy Susan was used to route the screen.
2. A lux meter (Lutron LX-113S) was used to measure light intensity.
3. An iPad Air (5th gen) was used as a screen.

Precautions

1. The verification should be conducted in complete darkness.
2. The lux meter should be lined up with the normal to the centre of the screen initially.
3. The distance between the screen and the lux meter should be kept constant.

Procedures

1. The lazy susan was turned by 10° to route the iPad above it by 10°.
2. The reading of the lux meter was recorded.
3. Steps 1 and 2 were repeated until all light intensity at each 10° of viewing angles was recorded.

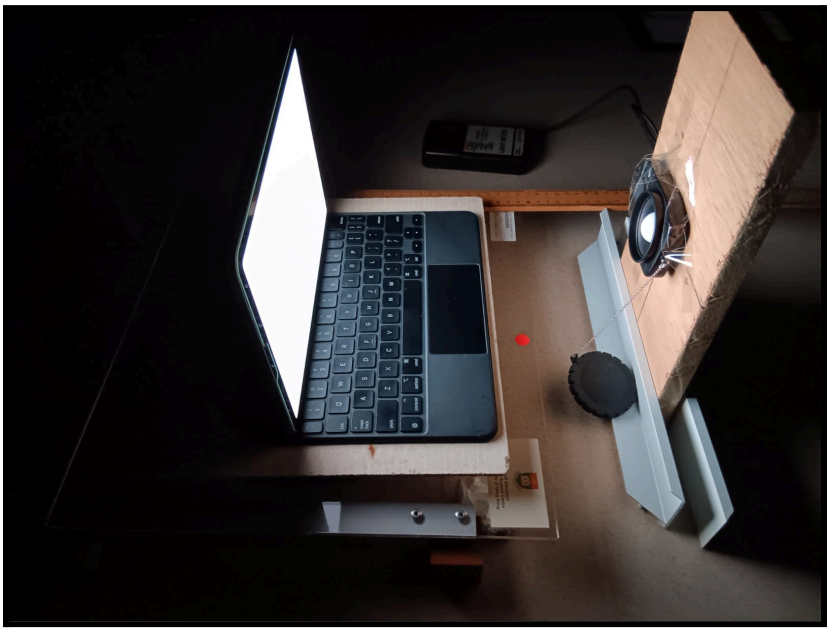


Fig.9a: Photo of the set-up for the verification of the visual angle

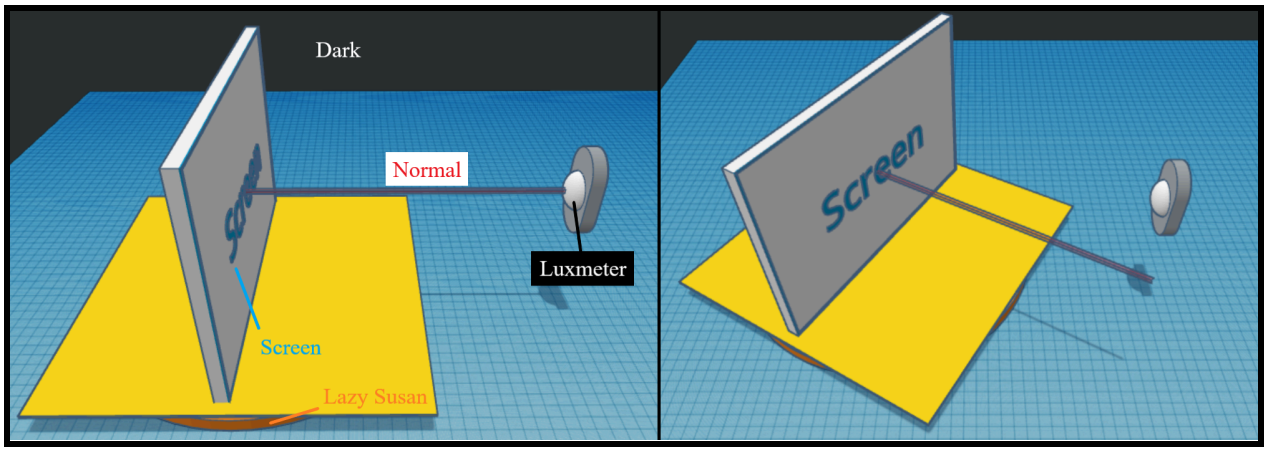


Fig.9b(left): 3D model of the set-up for the verification

Fig.9c(right): 3D model of the set-up after Step 1

Data Analysis

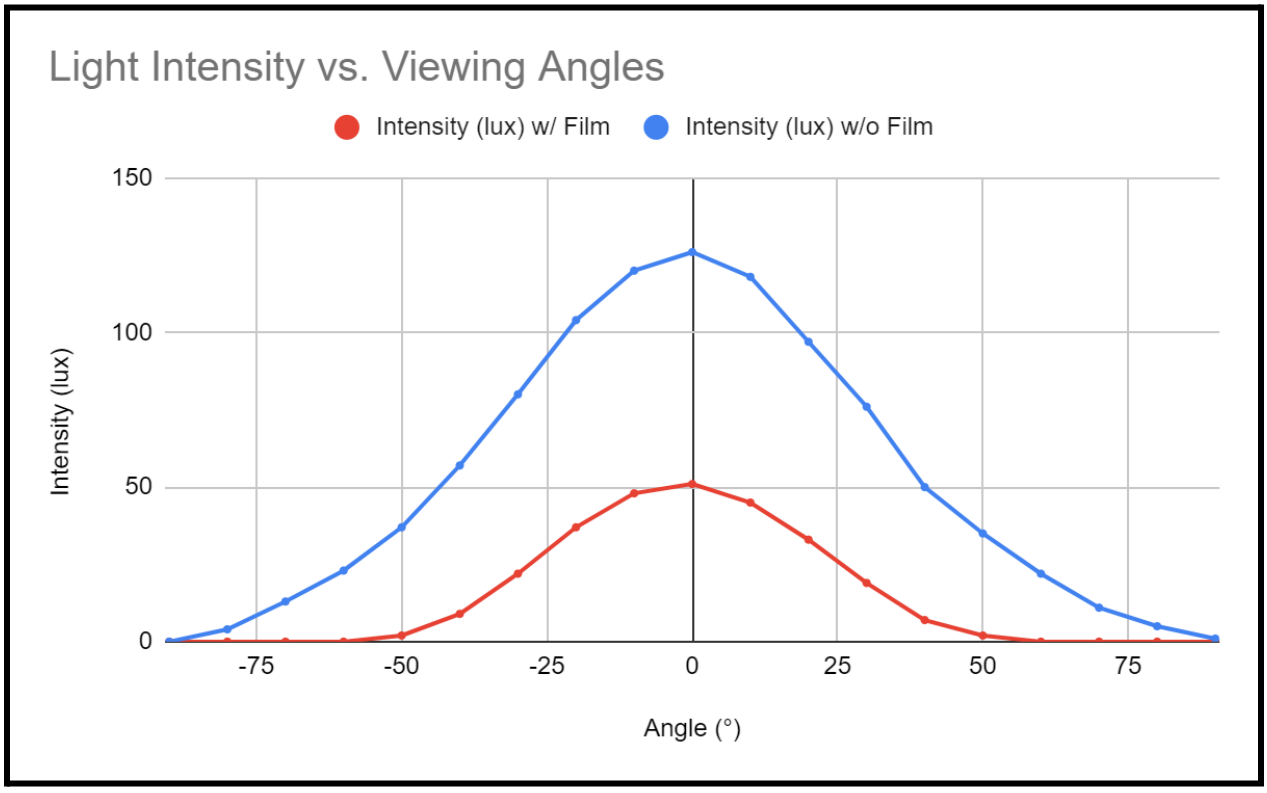


Fig.10: Result of the Verification of the visual angle of the filter

From the result, the light intensity was reduced by the filter to 30% at ±30° viewing angle. The light intensity fell to 0% beyond the 60° viewing angle. The screen privacy filter reduced the light intensity at the viewing angle similar to the calculated and measured values.

4.2 The Device

To achieve the objectives, the privacy film was angulated. A sawtooth-surfaced add-on device was designed to angulate the filter. The sawtooth surface is composed of black upward blinds and downward privacy filters. With the data collected in the case study and the visual angle found above, the angles for the blinds and filters that could achieve the specific objectives were found as 42° and 48° respectively.

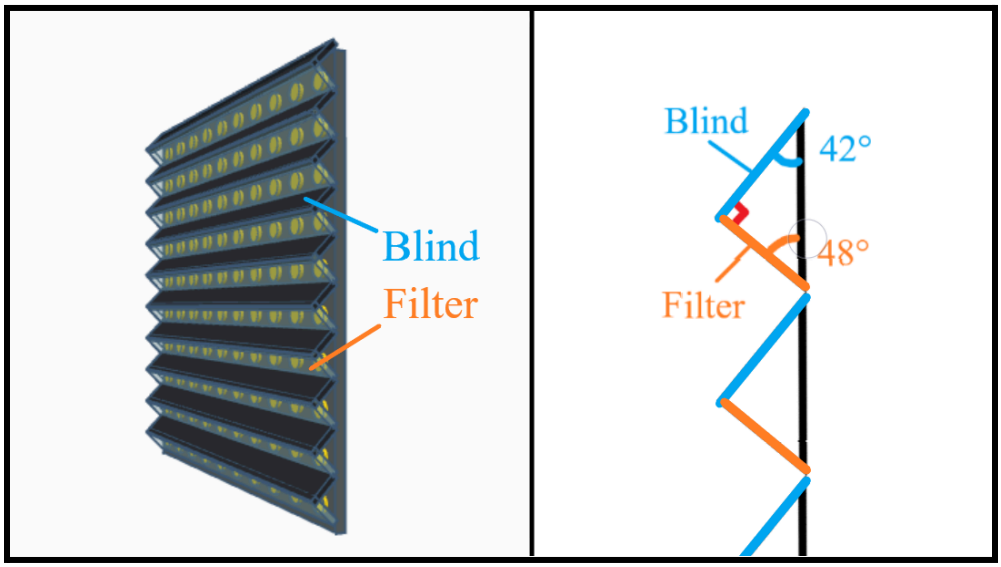


Fig.11a(left): A 3D model of the Device

Fig.11b(right): Diagram of the side view of the device with angles for achieving the objectives in the case study

5. Experiments

5.1 Prototype of the Device

To test the above proposal, a prototype of the Device was built for experiments. However, to simplify the building process, the angles for the upward blinds and downward filters were both chosen as 45° and the prototype was enlarged.

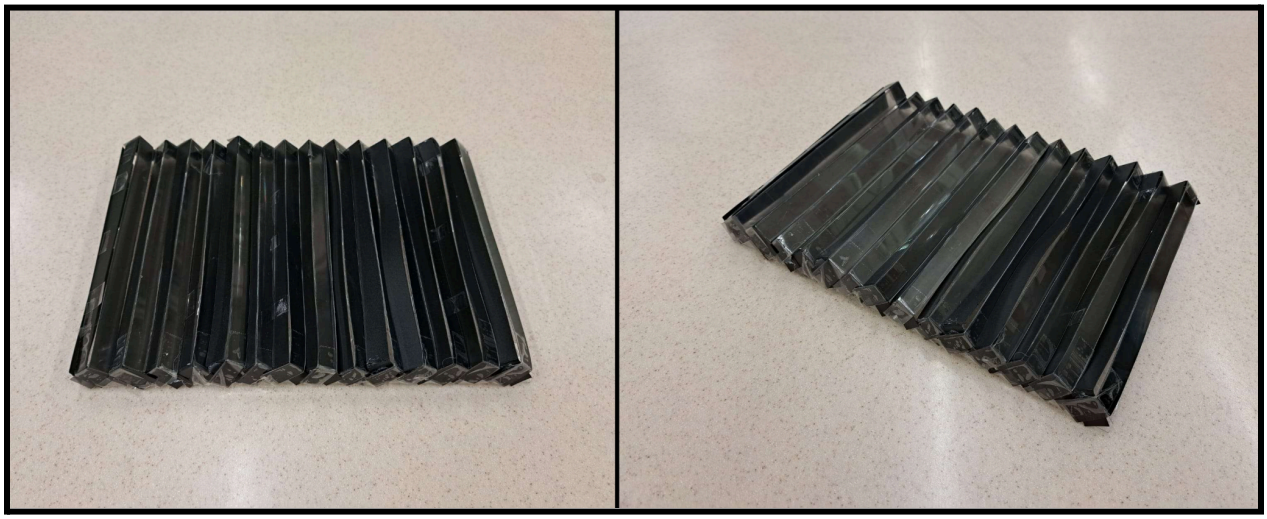


Fig.12a&12b: Photos of the prototype

5.2 Experiment on LCD screen

Fig.13a(left): Photo of the experimental set-up

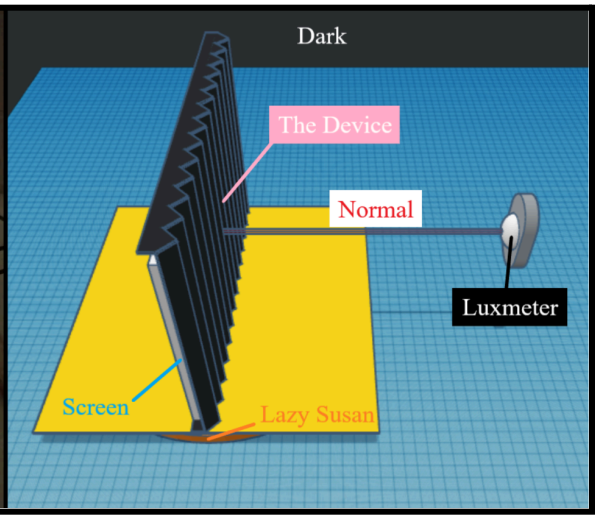


Fig.13b(right): 3D model of the experimental set-up

Instruments

1. A lazy Susan was used to route the screen.
2. A lux meter (Lutron LX-113S) was used to measure light intensity.
3. An iPad Air (5th gen) was used as a screen.

Precautions

1. The verification should be conducted in complete darkness.
2. The lux meter should be lined up with the normal to the centre of the screen initially.
3. The distance between the screen and the lux meter should be kept constant.

Procedures

1. The lazy susan was turned by 10° to route the iPad above it by 10°.
2. The reading of the lux meter was recorded.
3. Steps 1 and 2 were repeated until all light intensity at each 10° of viewing angles was recorded.

All instruments, precautions and procedures were identical to the previous verification of the visual angle of the filter, except the prototype of the Device was tested rather than the filter in the verification.

Data Analysis

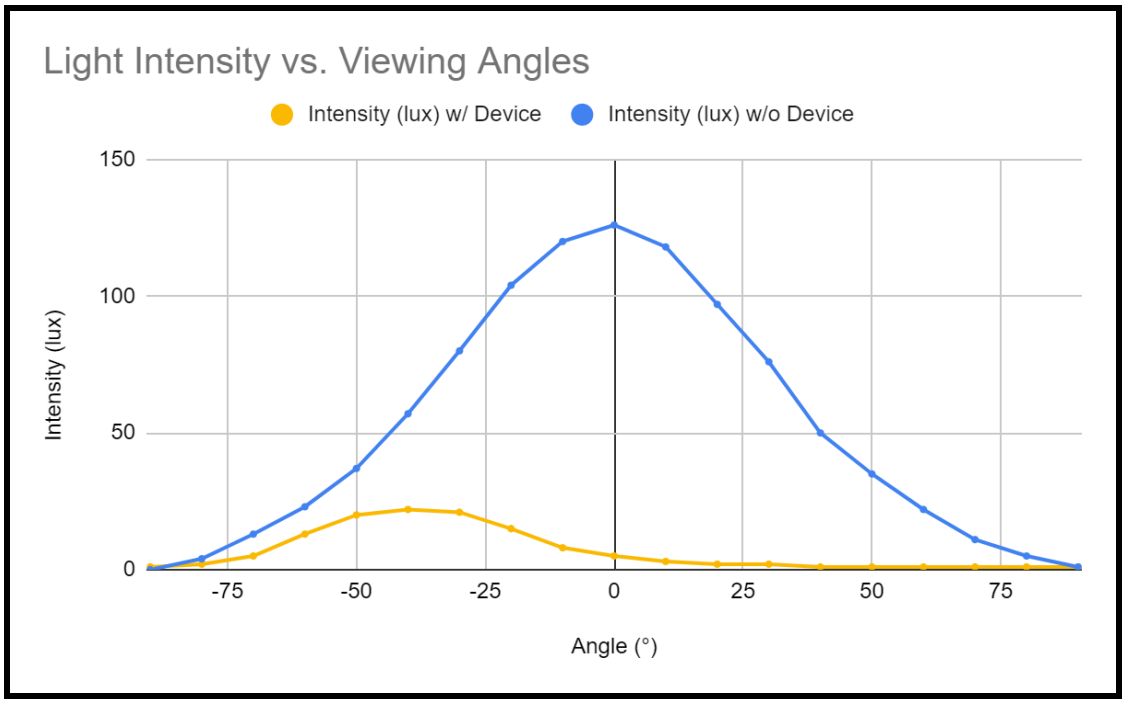


Fig.14a: Result of the experiment on LCD screen

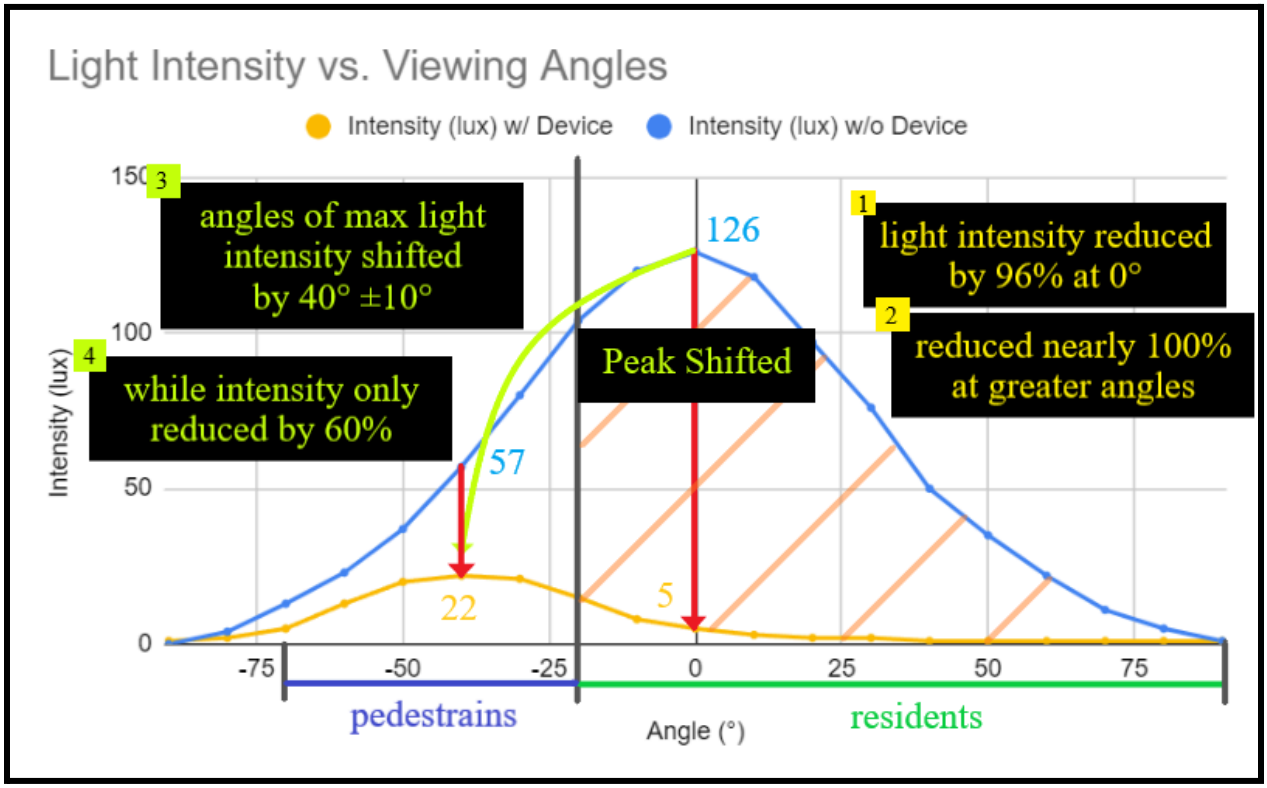


Fig.14b: Data analysis of the result of the experiment on LCD screen

From the result, light intensity was reduced by 96% at 0° and nearly 100% at all angles of elevation, where the angles of disturbing residents (i.e. angle > 0°) were located. The reduced light intensity at these angles could no longer interfere with the nearby residents. The peak of the maximum light intensity was shifted by 40° ±10° away from the normal and the intensity of light was only reduced by 60% when compared with the original peak. The screen was still visible and clear to pedestrians on the street.

6. Conclusion

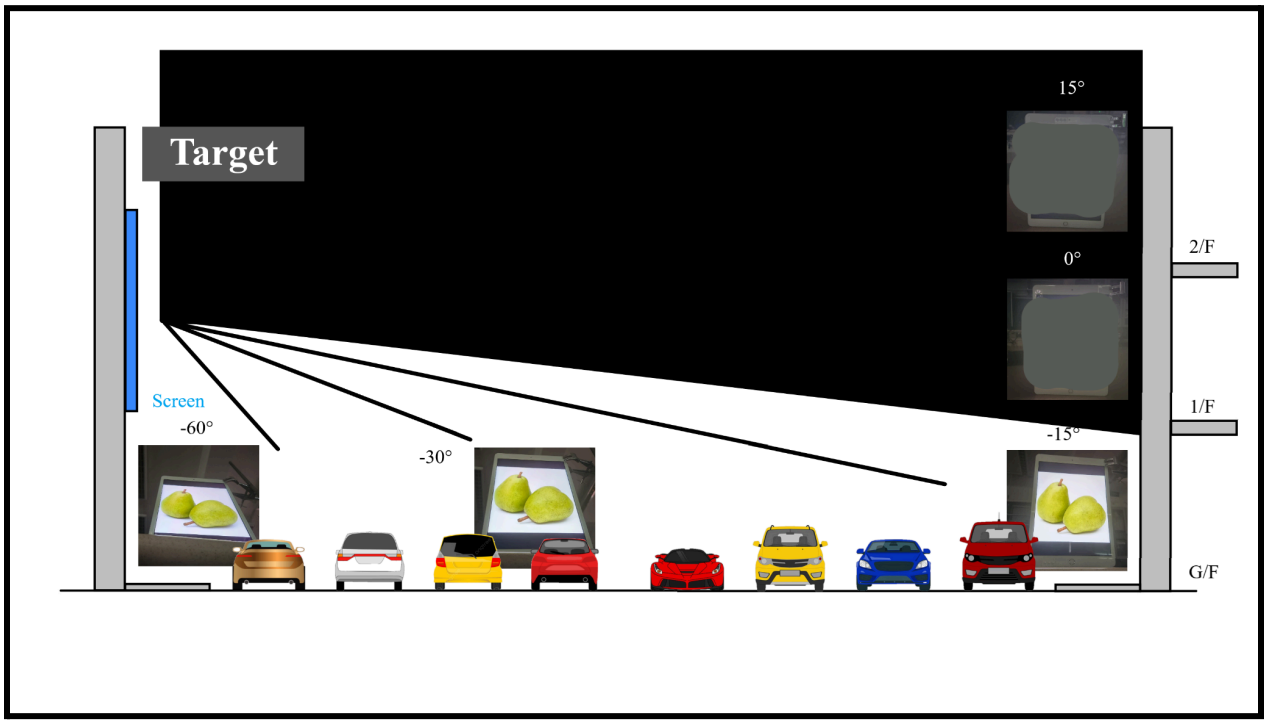


Fig.15a: Re-cap of the side view of the street showing the objectives

Fig.15b: Side view of the street showing the effect of the prototype

From the result of the experiment,

1. The light intensity resulting from the emission of the LED billboard onto the residential area was minimized.
2. The light from the screen to the pedestrians was redirected without having a huge depreciation on the image clarity.

The prototype could achieve the objectives successfully. It reduced screen light pollution with angulated privacy filters.

7. Discussion

7.1 Possible Error

Inadequacy of Hand-crafting: Gaps between the blinds and filters were present in the prototype due to the imperfections of hand-crafting. Some light from the screen could pass through directly from the gap rather than the filters. The reading of the light intensity might be affected by this.

7.2 Limitations

(1) Screen-exclusive: The Device was exclusively designed for screens. Other types of light pollution could not be solved by the Device.
(2) Displayed Colours Affected: Different colours have different wavelengths and would be absorbed differently. The original displayed colour of the screen would be affected due to the extra layer of filter. A colour adjustment of the screen would be required to restore its original colour space.

7.3 Improvement Suggestion

The layers of the screen privacy filter were found dark. As a result, a higher amount of light intensity was absorbed. If transparent layers were used, less light would be absorbed by the filter. A brighter image for advertising could have remained.

7.4 Further Investigations

(1) Filters with different densities of the slits and visual angles could be further studied to learn the relationship between the density of slits, visual angle and resulting light intensity. An optimal ratio could be designed with the relationship to minimize the negative effects of the device on advertising.
(2) In the cross-sectional view of the filter, the slits were found to have “thickness” to limit the angle of view. Different “thickness” of slits could be tested to determine the effect of it on limiting the angle.
(3) Methods of installing the Device on existing screens could be investigated to promote the installation of the Device.

8. Reference

- HKU Light Pollution Research. (n.d.). The Seriousness of Light Pollution in Hong Kong. Retrieved from https://nightsky.physics.hku.hk/en-hk/light-pollution-resources/educational-resources/seriousness-light-pollution-hong-kong

- Lau, S. Y., Ng, K. L., Tsang, H. T., & Vong, Y. C. C. (2014). Light pollution in Hong Kong (Outstanding Academic Papers by Students (OAPS)). Retrieved from City University of Hong Kong, CityU Institutional Repository.

- Hong Kong Free Press. (2022). Hong Kong urged to legislate against light pollution as green group calls voluntary charter a 'toothless tiger'. Retrieved from https://hongkongfp.com/2022/11/28/hong-kong-urged-to-legislate-against-light-pollution-as-green-group-calls-voluntary-charter-a-toothless-tiger/%5C

- Cyberphysics. (n.d.). Diffraction Gratings. Retrieved from https://www.cyberphysics.co.uk/topics/light/A_level/difraction.htm#google_vignette

- Tuttee. (2022). AS/A-level Physics: Diffraction gradient. Retrieved from https://www.tuttee.co/blog/as-a-level-physics-diffraction-gradient

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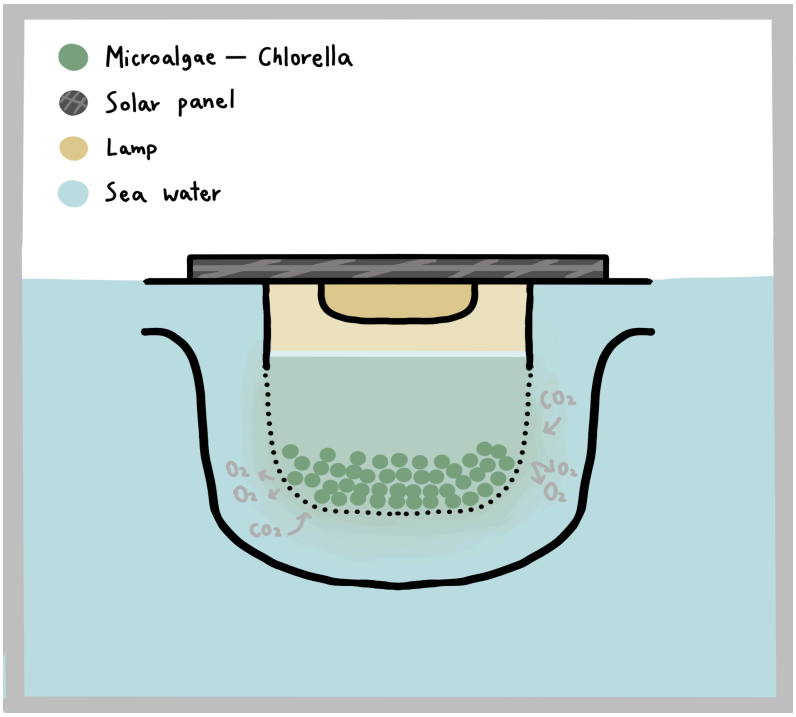
The 17th Hong Kong Budding Scientists Award
2023-2024

SHATIN PUI YING COLLEGE

Topic 1 – Waterfront Algal Lights for CO_2 Absorption



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1. Introduction

In line with the global trend, Hong Kong has been warming up in the last century or so. The number of hot nights is increasing while the number of cold days is decreasing.[1] Apart from rising temperatures, Hong Kong is experiencing more frequent heavy rain than before. The sea level is rising in Victoria Harbour.

According to an article published in 2023, by the World Health Organisation[2], Climate change is impacting health in a myriad of ways, including by leading to death and illness from increasingly frequent extreme weather events, such as heatwaves, storms, and floods, the disruption of food systems, increases in zoonoses and food, water and vector-borne diseases, and mental health issues.

Human activities including burning coal, oil and gases, and deforestation, are increasing the concentration of some greenhouse gases, in particular carbon dioxide, methane, nitrous oxide, and fluoridated gases. CO_2 is the largest contributor to global warming as it absorbs and radiates heat.[3]

Close to climate change, we have planned to design a setup that contains around a hundred *Chlorella*. There is a solar-powered lamp in the setup so the *Chlorella* can do photosynthesis in the daytime and nighttime and it becomes self-sustainable. Besides, we decided to put this setup into several seas and rivers in Hong Kong to see where it can have the highest photosynthetic rate. We measured CO_2 concentration with a CO_2 sensor and by measuring pH value. In addition to this, we planned to test the best combination of the colour of light, light intensity, and minerals.

Our setup is designed to be put into seas and rivers in Hong Kong. Therefore, our experiment was done by using seawater. High levels of CO_2 reduce the ability of an aquatic species' blood to transport oxygen. We can also neutralise the CO_2 content by using the setup. Moreover, the setup can aestheticise the promenade as it gives out green light for lighting the path.

2. Variable of Our Experiment – Colours of Light and Light Intensity

2.1. Background Research

Light intensity is an influencing factor of growth of *Chlorella*. Generally, higher light intensity leads to higher growth rate and photosynthetic rate[4]. However, excessive light may cause photo-inhibition, which damages the photosynthetic component[5] and decreases the photosynthetic rate.

The most suitable range of light intensity for *Chlorella* is 2000-3000 lux[6]. Excessive exposure to light can cause death of plant cells. Therefore, the algae should not be exposed to light for more than 16 hours per day.

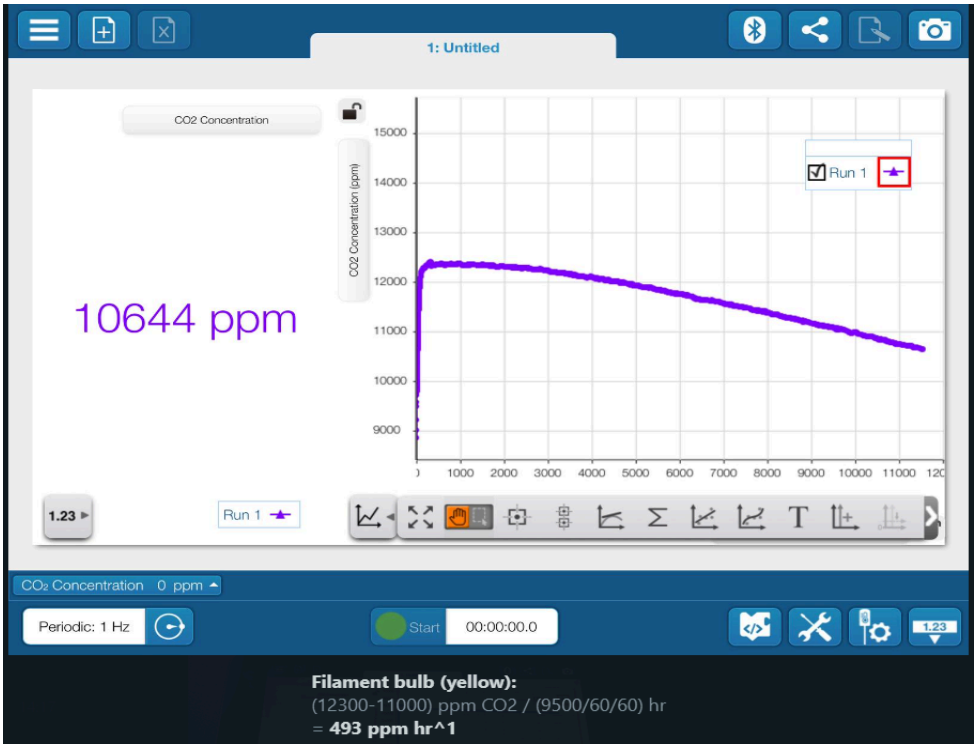
Blue light is believed to be the most effective light colour to improve photosynthesis since blue light can be easily absorbed by chlorophyll.[7]. Studies have shown that blue-white LED lights work best for the growth of photosynthetic pigments. Red lights work best for the production of lipids in microalgae. However, our goal is to increase the photosynthetic rate and reduce dissolved carbon dioxide content in the marine environment and carbon dioxide concentration in the air. Therefore, the combination of blue-white LED light bulbs are the most suitable for our requirements.

2.2. Our Experiment

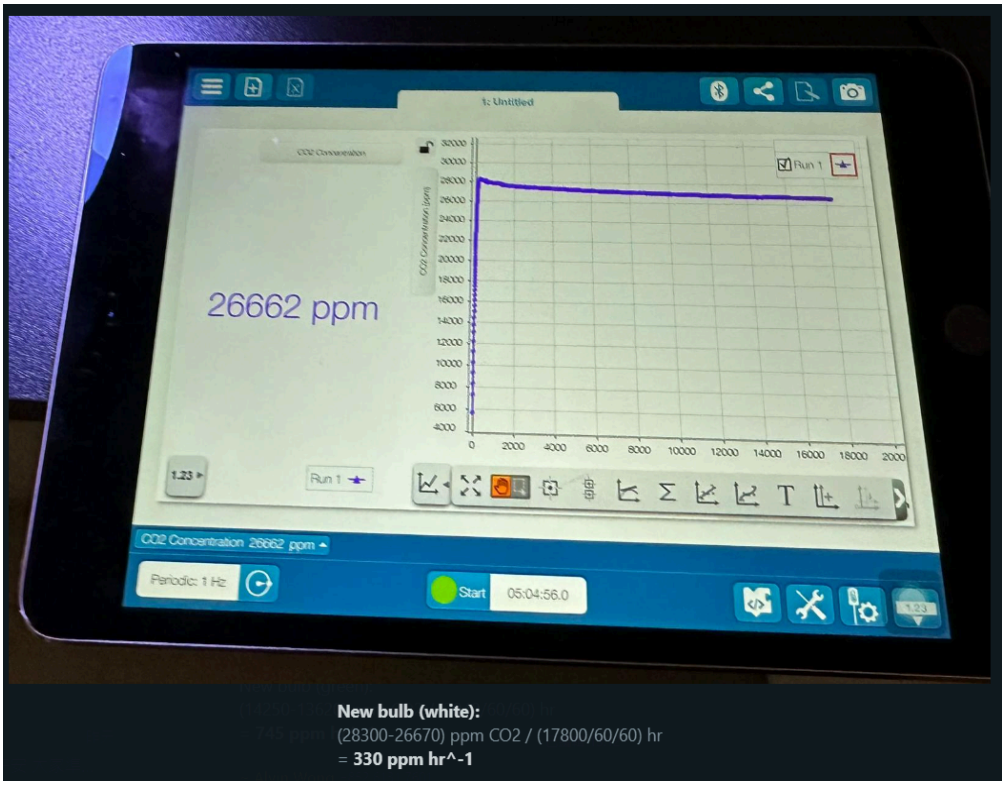
To start with, in order to fulfil our ideal algal lights, we have done the following experiments to test whether the colour of light bulbs, yellow, white and red, will maximise the efficiency of photosynthesis of algae. We have bought *Chlorella* and placed it in our school's lab to feed it regularly. When we need to do the experiment, we use a culture solution to mix with it and use a dropper to make it turn into a ball in a culture solution to make it be a control variable.

2.3. Our Findings

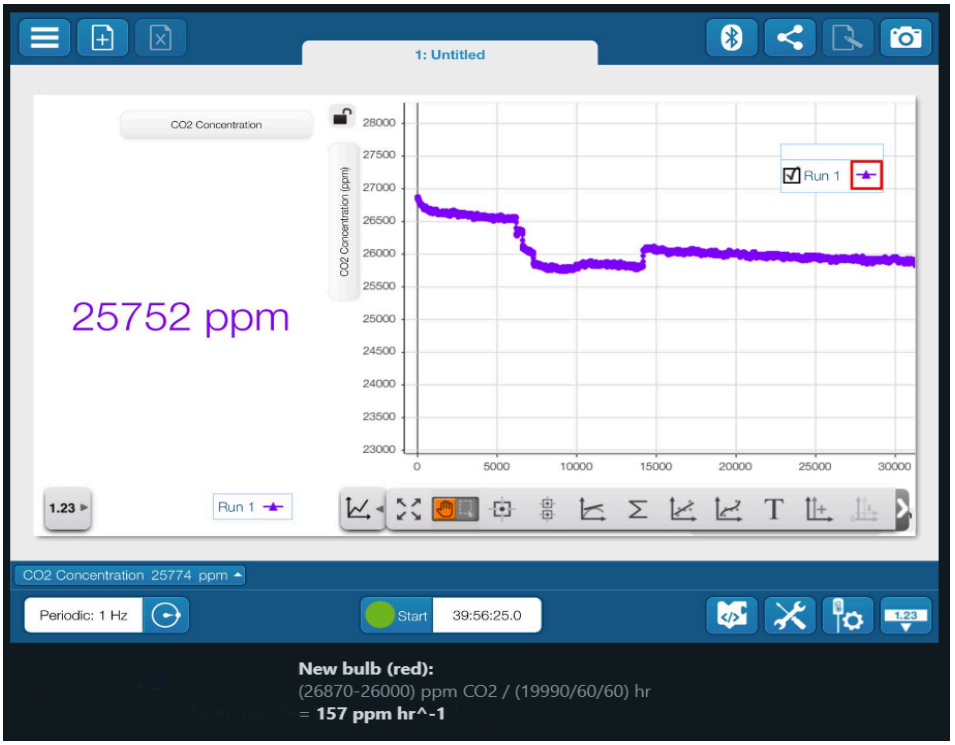
Yellow:



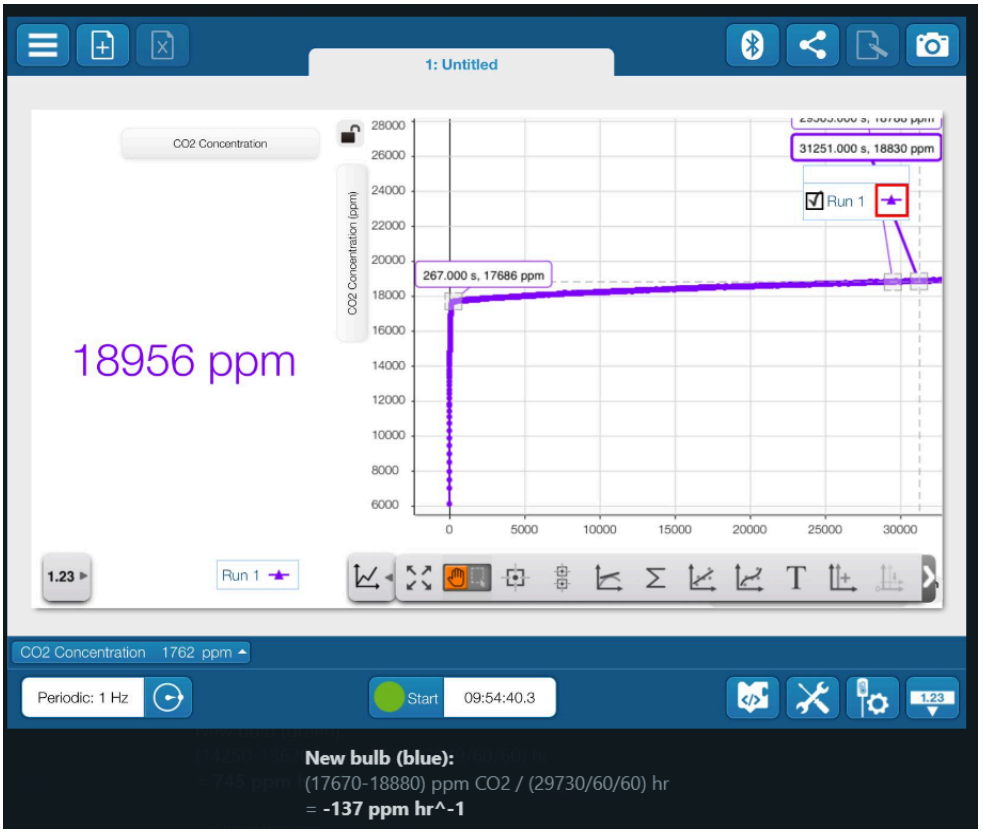
White:



Red:


1: Untitled
CO2 Concentration
25752 ppm
CO2 Concentration (ppm)
Run 1
CO2 Concentration 25774 ppm
Periodic: 1 Hz
Start
39:56:25.0
New bulb (red):
(26870-26000) ppm CO2 / (19990/60/60) hr
= 157 ppm hr^-1

Blue:


1: Untitled
CO2 Concentration
18956 ppm
CO2 Concentration (ppm)
31251.000 s, 18830 ppm
267.000 s, 17686 ppm
Run 1
CO2 Concentration 1762 ppm
Periodic: 1 Hz
Start
09:54:40.3
New bulb (blue):
(17670-18880) ppm CO2 / (29730/60/60) hr
= -137 ppm hr^-1

Green:

We had 4 bottles, one of them was filled with distilled water and 100 algal balls, which is a control set up for the experiment, and the other three had the same amount of algae *Chlorella* as we want to make the whole experiment more controllable and different light. First, we use the yellow light to test the CO_2 concentration, and according to the information from the CO_2 sensor, the CO_2 concentration is (12300-11000) ppm CO_2 / (9500/60/60) hr=493 ppm hr^-1\. Hence, the second photo and the third photo is the result of the white light and red light respectively, which the CO_2 concentration of the white light is about (28300-26670) ppm CO_2 / (17800/60/60) hr= 330 ppm hr^-1 and the CO_2 concentration of the red light is about(26870-26000) ppm CO_2 / (19990/60/60) hr= 157 ppm hr^-1. And the fourth photo and the fifth photo are the data of blue light and green light respectively, according to the data, the CO_2 concentration of the blue light is about (17670-18880) ppm CO2 / (29730/60/60) hr= -137 ppm hr^-1 and the CO_2 concentration of the green light is (14250-13620) ppm CO2 / (3049/60/60) hr= 745 ppm hr^-1.

With reference to the information above, the *Chlorella* under yellow light has the highest photosynthesis rate. Also, as we try to control the whole setup, we have adjusted the distance of the bottle to the light bulbs and the angle of the light shining on the *Chlorella*.

2.4. Limitation and Improvement

At first we added the carbohydrate indicator into the *Chlorella* and tested the photosynthesis rate according to the colour change of pH value of those algae, at first we put 100 algal balls into the bottle fill of hydrogencarbonate indicator the durability of the *Chlorella* to turn the colour of hydrocarbonate indicator was about 45 minutes which took a very long time, later we find out this was not an advisable approach to test for the data, so we buy the CO_2 sensor to test for the rate. Originally we only used filament light, and as we tried to improve the whole experiment, we used the LED light bulb that can change the colour of light to test different colours and hoped if different colours of light can increase the photosynthesis rate of the *Chlorella*. After the failure we tried to look for the other alternatives and we found that the CO_2 sensor can give a clearer information of the photosynthesis rate. We finally purchased and adopted the CO_2 sensor to try to control the whole setup. But after the experiment, we found that the information of green and blue light giving out form the CO_2 sensor was totally different from the research that we were following because blue light was not showing the same photosynthesis data as the research's information. Hence, the first test for the green light is stronger than white light and red light, which is also not matching to the research and the second test for the green light did not show any photosynthesis according to the information of the CO_2 sensor. We estimate that the failed reason is because of the light bulb problem, the concentration of the *Chlorella* is different or the time of the experiment is not enough, so as the improvements, we can buy the alternative light bulbs for green light and blue light, also we can buy more *Chlorella* that is from the same source so that the reliability of the experiment can be improved.

3. Other Possible Variables for Our Experiment

3.1. Temperature

For *Chlorella*, the best temperature range for their growth is about 20°C to 30°C[8], which is the usual range of seawater temperature in Hong Kong. *Chlorella* can live in the temperature of under 5°C[9] and up to 45°C[10]. According to statistics, the lowest ocean water temperature in Hong Kong is about 17°C and the highest is about 30°C[11]. LED lights generally would not emit heat, so that using LED light bulbs would not affect the temperature which damages the microalgae. In terms of temperature, *Chlorella* can definitely survive and optimise its

photosynthetic rate and growth in the marine environment in Hong Kong, and also in our device.

3.2. Mineral Content

Concentration of nitrogen and phosphorus significantly influences the growth of *Chlorella*[12]. Although potassium, magnesium and trace elements such as manganese and zinc, are not as effective as nitrogen and phosphorus individually, they still play important roles in the growth of *Chlorella*. The above elements boost the biomass production of *Chlorella*. For example, glucose. This refers to higher photosynthetic rate as glucose is the product of photosynthesis. The Calvin cycle is the second stage of photosynthesis, which converts carbon dioxide molecules to glucose molecules. This process uses carbon dioxide and lowers the CO_2 concentration.

Moreover, as mentioned above, the minerals increase the growth rate of Chlorella. The more Microalgae, the more photosynthesis occurs. Therefore, more oxygen is produced, improving the oxygen content in the atmosphere.

3.3. Influence to the Local Marine Ecosystem

Our device is believed to bring both positive and negative impacts to the ecosystem. In terms of negative impact, excessive exposure to artificial light may lead to the reduction of reproductive success of fish[13]. In the past decades, plenty of fish species are endangered or near-threatened[14]. For example, according to the statistics by WWF, Napoleon wrasse, leopard coral trout, etc.

On the other hand, in terms of positive influence, our device will reduce the carbon dioxide concentration in both seawater and in the air, which helps lower the pH value in the ocean and the problem of global warming[15]. Acidification of seawater will reduce the mineral content, which are originally used by shrimps, oysters and corals to build up their shells or skeletons. This may damage the biodiversity in the ocean. Also, global warming leads to the rise of water temperature, leading to the bleaching of coral. The problems of decreasing biodiversity and coral bleaching have been highly spotlighted by different green organisations.

Besides, some harmful algae species secrets toxins grow rapidly in the acidic water. They are harmful to human bodies since they will contaminate our water source. Therefore, we believe that the device can improve acidification in the ocean of Hong Kong, reducing different problems brought by high carbon dioxide concentration in the environment.

4. Conclusion

The rise of CO_2 concentration in the atmosphere has been one of the main concerns in the world for decades. However, human activities are worsening the climate. Average concentrations of CO_2 have risen more than 20% in 44 years. Generating energy and manufacturing goods is inevitable in our lives. One of the things we can do is make good use of photosynthesis which is the process that plants use sunlight, CO_2, and water to create oxygen. This is where our setup comes into play, providing an efficient and sustainable way.

After doing various experiments and research, we have found out the best combination in terms of light intensity, the colour of light, minerals, temperature, and effects on the marine environment for the highest photosynthetic rate is using 2000-3000 lux light intensity, blue-white for the colour, the concentration of nitrogen and phosphorus, and 20°C to 35 °C for the seawater temperature.

Despite our setup's benefits, there are still limitations that we hope to overcome in the future. Firstly, we bought the CO_2 sensor too late. Besides, we used filament light instead of LED light to test at the beginning.

In the near future, we will test how the light intensity, minerals, and temperature affect the *Chlorella*, to determine the best combination to maximise photosynthetic efficiency with our CO_2 sensor. We are planning to implement our setup in Shing Mun River in the coming summer holiday for beta testing.

5. References

1. Hong Kong Observatory. Climate Change in Hong Kong - Extreme weather events. Retrieved from: https://www.hko.gov.hk/en/climate_change/obs_hk_extreme_weather.htm#:~:text=Over%20the%20last%20hundred%20years,%E2%84%83%20or%20below)%20has%20decreased
2. World Health Organization. Climate change. Retrieved from: https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health#:~:text=Climate%20change%20affects%20food%20availability,700%20000%20annually%2C%20may%20rise
3. European Commission. Causes of climate change. Retrieved from: https://climate.ec.europa.eu/climate-change/causes-climate-change_en
4. Pan, J. & Guo, B. (2016). Effects of Light Intensity on the Growth, Photosynthetic Characteristics, and Flavonoid Content of Epimedium *pseudowushanense* B.L.Guo. *Molecules*, 21(11): 1475. doi: 10.3390/molecules21111475
5. Ruban, A.V. & Belgio, E. (2014). The relationship between maximum tolerated light intensity and photoprotective energy dissipation in the photosynthetic antenna: chloroplast gains and losses. *Philos Trans R Soc Lond B Biol Sci*, 369(1640): 20130222. doi: 10.1098/rstb.2013.0222
6. Febrieni, V.N., Sedjati, S. & Yudiati, E. (2020). Optimization of light intensity on growth rate and total lipid content of *Chlorella vulgaris*. *IOP Conf. Ser.: Earth Environ. Sci,* 584: 012040. doi: 10.1088/1755-1315/584/1/012040
7. Li, Y., Xin, G. & Liu, Q. *et al*. (2020). Effects of red and blue light on leaf anatomy, CO_2 assimilation and the photosynthetic electron transport capacity of sweet pepper (*Capsicum annuum* L.) seedlings. *BMC Plant Biol*, 20: 318. doi: https://doi.org/10.1186/s12870-020-02523-z
8. Ziganshina, E.E., Bulynina, S.S. & Ziganshin, A.M. (2022). Growth Characteristics of Chlorella *sorokiniana* in a Photobioreactor during the Utilization of Different Forms of Nitrogen at Various Temperatures. *Plants (Basel)*, 11(8): 1086. doi: 10.3390/plants11081086
9. Lindberg, A., Niemi, C. & Takahashi, J. *et al*. (2022). Cold stress stimulates algae to produce value-added compounds. *Biolresour. Technol. Rep.*, 19: 101145. doi: https://doi.org/10.1016/j.biteb.2022.101145

10. Shen, H. & Lee, Y.K. (1997). Thermotolerance induced by heat shock by Chlorella. *J. Appl. Phycol.*, 9: 471-475. doi: https://doi.org/10.1023/A:1007956507345

11. World Sea Temperature. Hong Kong Water Temperature. Retrieved from: https://www.seatemperature.org/asia/hong-kong/hong-kong.htm#:~:text=The%20graph%20below%20shows%20the,historical%20sea%20surface%20temperature%20data.&text=The%20warmest%20water%20temperature%20is,%C2%B0F%20%2F%2018.7%C2%B0C

12. Yaakob, M.A., Mohamed, R.M.S.R., & Al-Gheethi, A. *et al*. (2021). Influence of Nitrogen and Phosphorus on Microalgal Growth, Biomass, Lipid, and Fatty Acid Production: An Overview. *Cells*, 10(2): 393. doi: 10.3390/cells10020393

13. Marangoni, L.F.B., Davies, T. & Smyth, T. *et al*. (2022). Impacts of artificial light at night in marine ecosystems–A review. *Glob Chang Biol.*, 28(18): 5346-5367. doi: 10.1111/gcb.16264

14. Lai, C. (2017). Hong Kong's wet markets selling 17 types of threatened fish, study says. *Hong Kong Free Press*, 8 December 2017. Retrieved from: https://hongkongfp.com/2017/12/08/hong-kongs-wet-markets-selling-17-types-threatened-fish-study-says/

15. Union of Concerned Scientists. (2019). CO_2 and Ocean Acidification: Causes, Impacts, Solutions. *Union of Concerned Scientists*, 30 January 2019. Retrieved from: https://www.ucsusa.org/resources/co2-and-ocean-acidification#:~:text=CO2%20concentrations%20drive%20rising,the%20detriment%20of%20marine%20ecosystems

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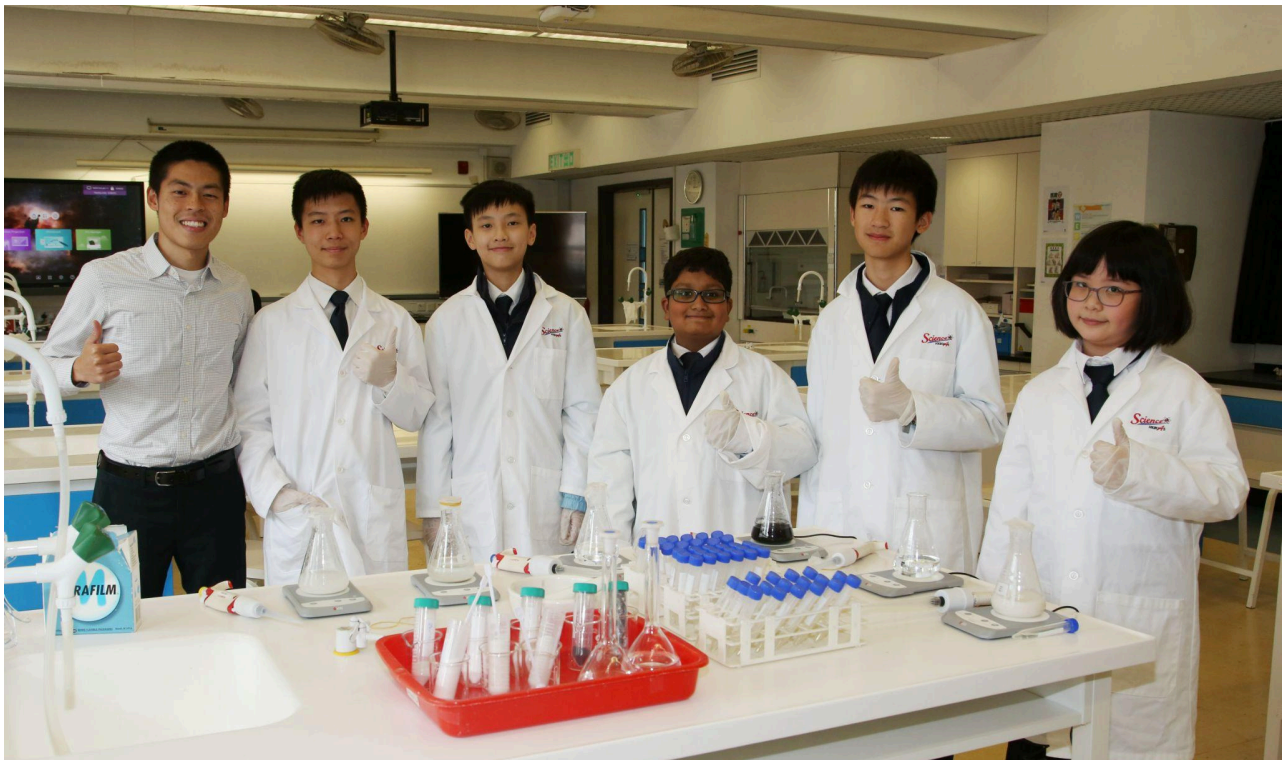

Investigation of different adsorbents to remove mercury metal ions in water

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Content

Abstract

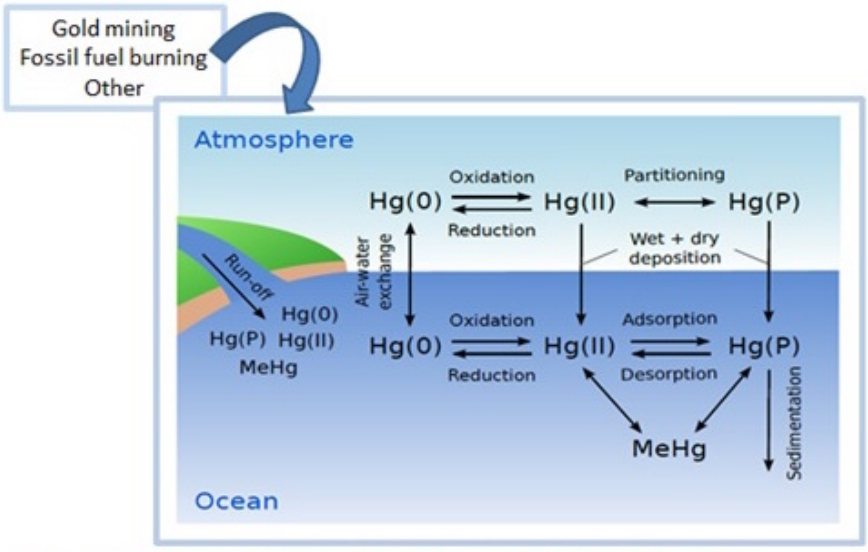
Mercury is considered a serious environmental issue all over the globe. This study aims to investigate the possible solutions to this problem, by implementing various "adsorbents" such as activated carbon, zeolites and clam shells to evaluate how effectively they can adsorb mercury pollutants from sea water, and devise an optimal solution to the current infestation of mercury. Experiments were conducted and records of the respective efficiency of adsorption, difference in mercury concentration of the sample were taken. The study mainly focused on the potential of the adsorbent candidates as the possible solutions to this environmental issue and our future aspirations.

Introduction

Mercury pollution and impact of mercury pollution

Mercury is a heavy metal (with a density of approximately 13 g/cm^3) that travels easily through different environmental compartments around the world. Due to its ability to disperse over long distances through air and water currents, mercury released locally can ultimately affect wildlife around the world, including those in remote locations. This makes mercury pollution global scale. An international action plan was therefore proposed in 2002 in recognition that reducing mercury emissions and legacy pollution requires coordinated international solutions. Mercury is normally deposited as cinnabar, i.e. mercuric sulphide, which has two colours, red (alpha-form) and black (beta-form). The red colour form is more common, and because of its colour, it was historically used as a red pigment, known as vermillion. Mercury occurs naturally in the earth's crust, but human activities, such as mining and fossil fuel combustion, have led to widespread global mercury pollution. Mercury emitted into the air eventually settles into water or onto land where it can be washed into water. Once deposited, certain microorganisms can change it into methylmercury, a highly toxic form that builds up in fish, shellfish and animals that eat fish. Most human exposure to mercury is from eating fish and shellfish contaminated with methylmercury. One major recipient and storage site for mercury in the global environment is the ocean. Modelling estimates indicate that human activities have added approximately 45,000-80,000 metric tons of mercury to marine waters globally. Much of this deposition occurred in shallow coastal and continental shelf waters less than 1000 metres deep. These upper ocean zones are important habitats for many consumable fish and seafood species. Due to bioaccumulation and biomagnification through the food web, mercury poses risks to ocean health on a global scale. Its widespread distribution and accumulation in the ocean ecosystem underscore the need for a united global action to curb and remediate mercury contamination around the world.

(United States Environmental Protection Agency, 2023)



Below are the national standards of People's Republic of China of China Farmland Irrigation Water Quality Standards (1992).

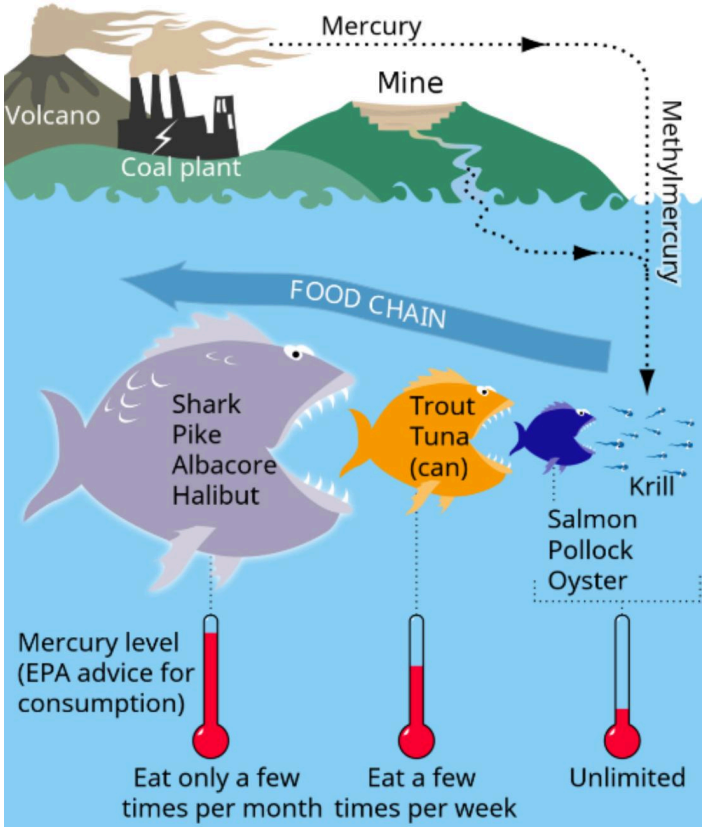
重金屬/病原體項目	土壤參考標準* (mg/kg)	水參考標準# (mg/L)
砷 (As)	55	0.05
鎘 (Cd)	12	0.005
鉻 (Cr)	380	0.1
銅 (Cu)	190	1.0
鎳 (Ni)	210	--
鉛 (Pb)	530	0.1
銻 (Sb)	15	--
硒 (Se)	--	0.02
鋅 (Zn)	720	2.0
汞(Hg)	10	0.001
糞大腸菌群數	--	10000 個/L
蛔蟲卵數	--	2 個/L

*荷蘭土壤品質標準--干預值
中華人民共和國國家標準--- 農田灌溉水質標準

Harms of mercury and risk of mercury intake

Mercury, in the forms of organic mercury and methylmercury, is most commonly found in the environment. It is converted from the respective inorganic form by a biological bacterial process. It bioaccumulates in the environment and is most commonly found in fish. This is how mercury enters into the food chain. Oral ingestion of fish is the most common route of human exposure to mercury. Methylmercury crosses blood/brain and placental barriers, which can damage the central nervous system and causes birth defects, neurological problems and developmental delays. Foetuses are most vulnerable to methylmercury's toxic effects, and several studies have shown that the mercury level in cord blood is twice as concentrated as that in maternal blood. Chronic exposure to methylmercury can cause an impairment in vision, speech, walking and hearing, and a lack of coordination. It can also cause a "pins and needles" sensation. Extreme exposures can lead to death.

(Department of Environmental Conservation, n.d.)



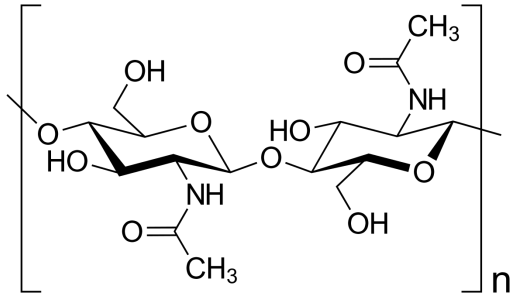
Hypothesis

In light of the known risks that mercury poses to ocean health, we propose a solution aimed at effectively removing mercury ions from seawater. Our approach involves investigating the potential of naturally occurring substances to serve as effective adsorbents for mercury in seawater. If these adsorbents prove successful, their practical application in enhancing the overall quality of seawater can be further explored.

1. **Shells of crustaceans (Scallop shells and clam shells)**

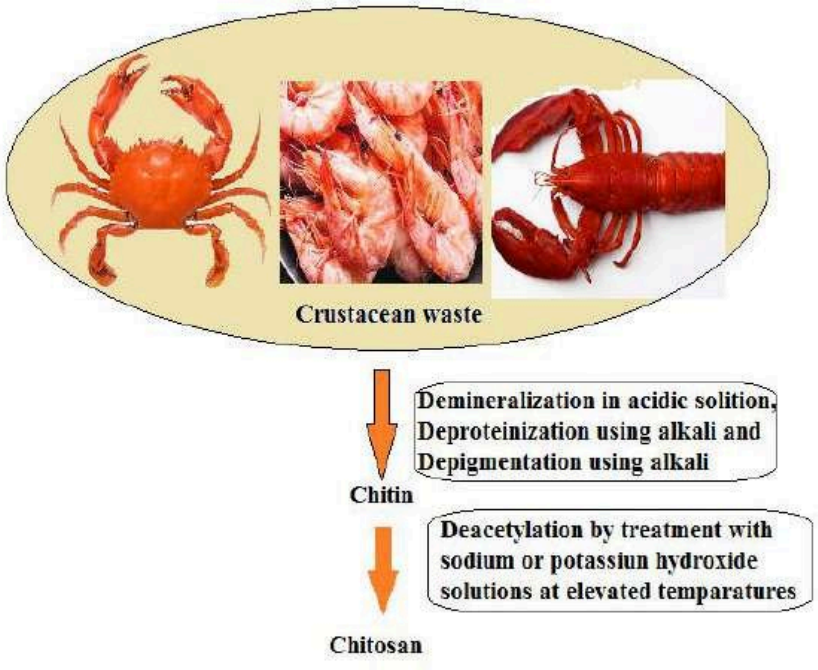
Mechanism

Chitin is a complex polysaccharide that is found in the shells of crustaceans such as crabs, lobsters, and shrimp. Previous study (Morris and Sneddon, 2011) revealed that the chitin in crustacean shells contains various functional groups, such as amino and hydroxyl groups, that have an affinity for heavy metals like mercury. These functional groups can form chemical bonds or interactions with mercury ions, allowing the shells to trap and retain mercury on their surface.



Chemical structure of chitin

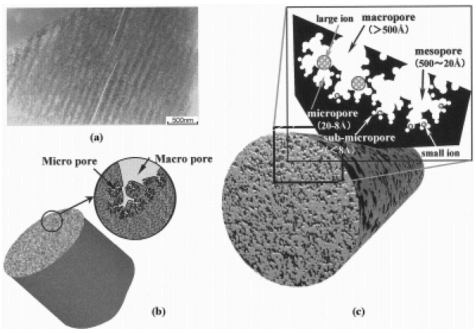
Using waste crustacean shells offers several benefits over synthetic adsorbents for mercury wastewater treatment. Shells are a low-cost, abundantly available natural material that does not require much energy in purification processes. As shells are primarily composed of chitin, a renewable biopolymer, they represent a more environmentally-friendly adsorption alternative compared to conventional activated carbon adsorbents.



How Chitin is extracted from crustacean shells (Renewable biopolymer) - Sussela Lanka

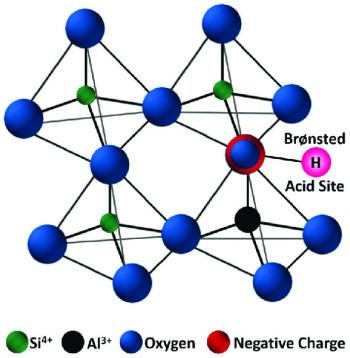
2. Activated carbon

Activated carbon (AC) shows great potential as an adsorbent for mercury removal from seawater. ACs are carbonaceous adsorbents derived from carbon-rich materials such as coconut shells, coal, or wood through physical, chemical, or combined processes. They possess a porous amorphous structure with varying pore sizes, including micropores (0.8-10 nm), mesopores (10-50 nm), and macropores (50-2000 nm). ACs exhibit considerable internal surface areas, typically ranging from 700 to 1800 m^2 g^{-1} (Jeguirim et al., 2018; Manocha, 2003). The large internal surface area in turn provides numerous active binding sites for adsorption. Once loaded with mercury, thermal or chemical treatments allow for adsorbent regeneration and reuse. The activated carbon column could be reused more than three times after simply drying (Zhang and Zuo, 2023). In addition, its surface properties can be tailored through carbonization parameters (Shewchuk & Azargohar, 2016).



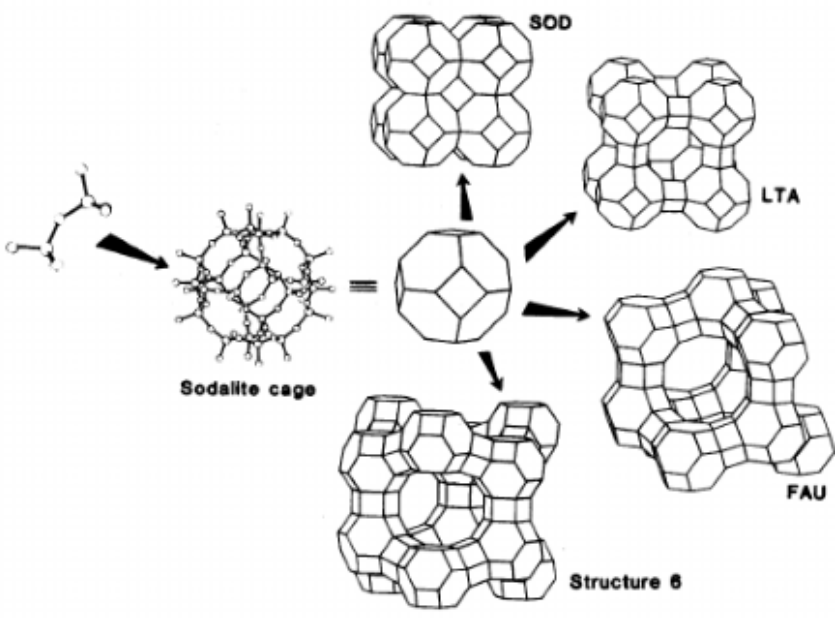
Overall, activated carbon represents a promising, commercially available adsorbent for removing mercury pollutants from seawater in an economically feasible manner, especially when regeneration is applied to extend service life.

3. Zeolites



Zeolites have a unique porous aluminosilicate structure, where silicon and aluminium are tetrahedrally coordinated. Silicon cation and aluminium cations are enclosed by four oxygen anions (O^{2-}). The tetrahedral structure of SiO_4 and AlO_4 forms the building blocks of zeolite enclosing cavities and channels.

Zeolites have small pores serving as channels with dimensions of 0.3 nm to 0.8 nm. This shows characteristic property of zeolite is its open cage-like framework structure that helps zeolite trap water and ions of potassium and calcium, which can be exchanged for other cations like mercury (Kaviani, 2022). Zeolites are thermally and chemically stable under different environmental conditions (Hatmoko et al., 2020), enabling potential regeneration and recycling of the adsorbent.



Cage like structure of different types of zeolites

Experimental Details

Preparation of polluted mercury water

A concentration of 1ng/L of mercury was prepared for the experiment. We received a standard solution of mercury from Dr. Martin Tsui, with a concentration of 1mg/mL. We diluted the solution 3 times by a hundred to achieve a concentration of 1ng/L. We prepared enough polluted mercury water to make all six solutions.

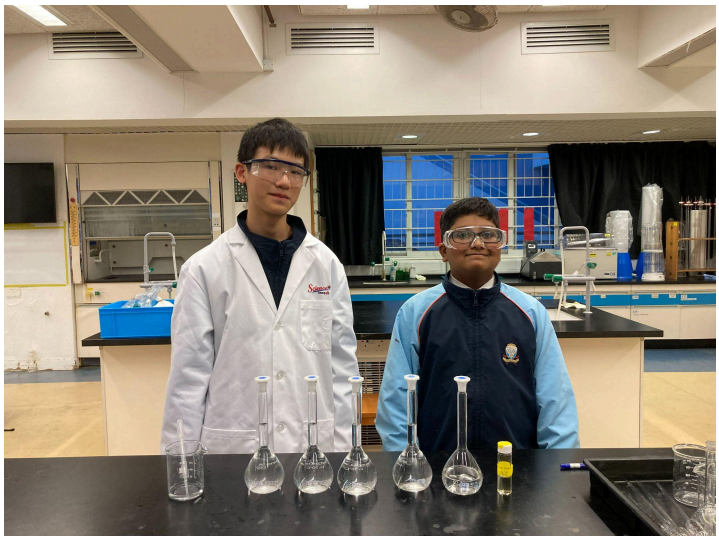
Procedure in preparation of diluted seawater sample

1. Pipette 1 cm^3 of standard 1mg/mL mercury solution into a 100 cm^3 volumetric flask.
2. Add seawater to the graduation mark of the 100 cm^3 volumetric flask. Add seawater, with the aid of filter funnel and dropper, to the graduation mark of the 100 cm^3 volumetric flask. Stopper and swirl the volumetric flask. Now the concentration is 1 mg/L.
3. Pipette 1 cm^3 of diluted seawater from the volumetric flask into another new 100 cm^3 volumetric flask.
4. Add seawater to the graduation mark of the new 100 cm^3 volumetric flask. Add seawater, with the aid of filter funnel and dropper, to the graduation mark of the new 100 cm^3 volumetric flask. Stopper and swirl the volumetric flask. Now the concentration is 1 μg/L.

To prepare a greater volume of diluted seawater for several samples, this diluted seawater is further diluted twice by ten times to have the final concentration of 1ng/L of the seawater sample.

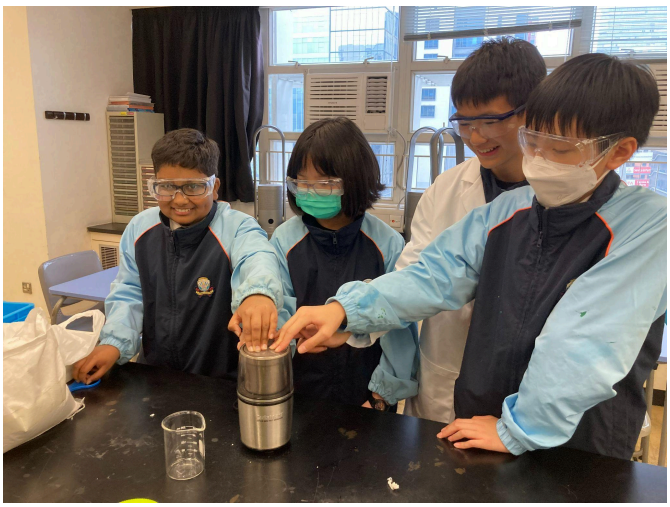
5. Pipette 25 cm^3 of diluted seawater from the volumetric flask into a 250 cm^3 volumetric flask.

6. Add seawater to the graduation mark of the 250 cm^3 volumetric flask. Add seawater, with the aid of filter funnel and dropper, to the graduation mark of the new 100 cm^3 volumetric flask. Stopper and swirl the volumetric flask.
7. Repeat steps 5 and 6 to prepare 4 diluted samples in total. In total, 1000mL of diluted mercury seawater samples are prepared.



Procedure in preparation of adsorbents

8. Place an adsorbent in a clean, dry mortar
9. Crush/pound them using the pestle until lightly powdered
10. Grind it in the grinder until it turns into a fine powder
11. Clean all used apparatus and repeat for the other adsorbents



Grind the adsorbents using mortar and pestle, followed by grinder

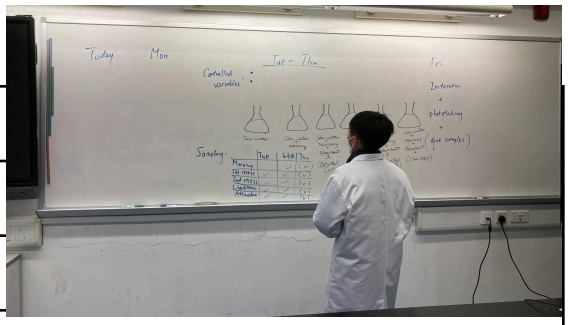
Ground adsorbents, diluted mercury seawater and standard mercury solution provided by Dr Martin Tsui (most left end)

Preparation of adsorption Test

Apparatus

- Magnetic stirrer x6 (They will only be turned on from 7:50 am to 4:20 pm ever the course of the experiment)
- Magnetic stirrer bar x6
- Conical flask x6
- Micropipette x4
- Pipette nozzle x49 (one for each sampling to avoid contamination)
- Syringe x49 (one for each sampling to avoid contamination)
- Filter x49 (one for each sampling to avoid any contamination)
- Parafilm x6 (may need new ones if any is damaged during the experiment)
- Rubber band x6 (to hold the parafilm on the nozzle of the conical flask)

Preparation of solutions



Solution	Description
A1(Control)	Seawater
A2(Control)	Seawater + Mercury
B	Seawater + Mercury + Activated carbon
C	Seawater + Mercury + Zeolites
D	Seawater + Mercury + Scallop shells
E	Seawater + Mercury + Clam shells

A1: Pour in 150 mL of seawater in a conical flask

A2: Pour in 150 mL of polluted mercury seawater in another conical flask

B: Pour in 150 mL of polluted mercury seawater and measure 5 cm^3 of activated carbon using a measuring cylinder and transfer it using a spatula into another conical flask

C: Pour in 150 mL of polluted mercury seawater and measure 5 cm^3 of powdered zeolites using a measuring cylinder and transfer it using a spatula into another conical flask

D: Pour in 150 mL of polluted mercury seawater and measure 5 cm^3 of powdered scallop shells using a measuring cylinder and transfer it using a spatula into another conical flask

E: Pour in 150 mL of polluted mercury seawater and measure 5 cm^3 of powdered clam shells using a measuring cylinder and transfer it using a spatula into another conical flask

Final setup

1. Add a magnetic bar in each conical flask (with the solutions)
2. Place each conical flask on the magnetic stirrers
3. Cover the conical flasks with parafilm and secure it with rubber bands
4. When it is 7:50 am on the 5th of March, turn on all magnetic stirrers

Experiment setup with solutions A1 to E (from left to right)

Sampling

Time of sampling

The samples were taken over the course of three days (5th of March to the 7th of March), to ensure a good amount of time for the adsorption of mercury from the solutions. They were taken in these time periods:

- Lunch time of 5th, 6th and 7th March (around 1:20 pm)
- After school of 5th, 6th and 7th March (around 4:00 pm)
- Morning of 6th and 7th March (around 7:55 am)
- Before the start of the experiment

Sampling procedure

The steps for taking the samples are as follows:

1. Remove the rubber band and parafilm from the conical flask.
2. Use a micropipette to transfer around 5 cm^3 of each solution into different syringes. (pipette nozzles cannot be reused to avoid any unnecessary contamination)
3. Filter the solutions through the syringe and filter into different sampling containers labelled based on the time of taking the sample.
4. Dispose of all used syringes, filters and pipette nozzles after washing to avoid contamination.
5. Repeat this process when taking other samples and use completely different filters, syringes and nozzles.

The transfer of liquid using a micropipette(left) and the filtering of a solution into the sampling container(right)

Results and Analysis

The following are the labels of the 6 set-ups. A1 and A2 are control set-ups. B to E are set-ups containing different adsorbents.

A1: 150 mL of seawater

A2: 150 mL of polluted mercury seawater

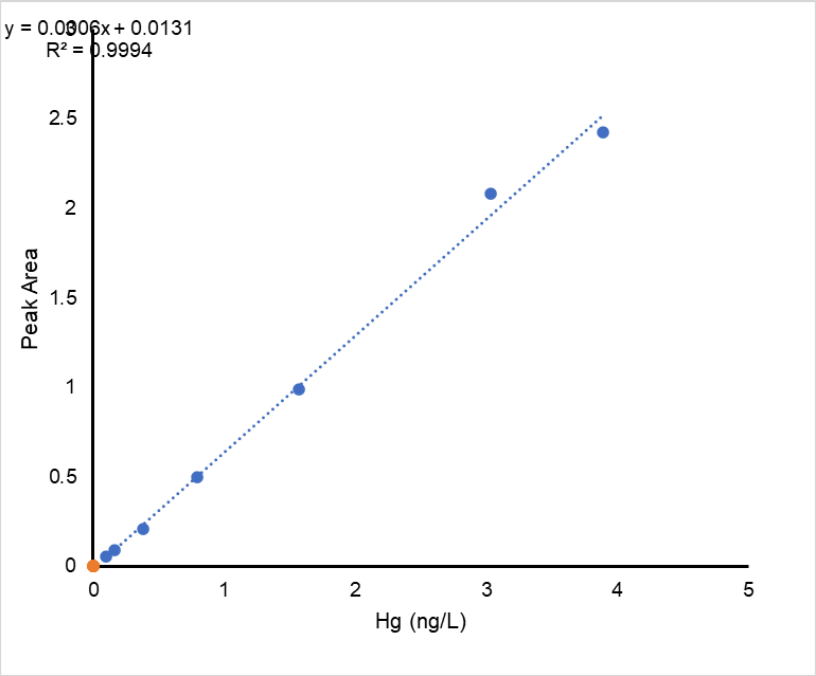
B: 150 mL of polluted mercury seawater with 5 cm^3 of activated carbon

C: 150 mL of polluted mercury seawater with 5 cm^3 of powdered zeolites

D: 150 mL of polluted mercury seawater with 5 cm^3 of powdered scallop shells

E: 150 mL of polluted mercury seawater with 5 cm^3 of powdered clam shells

Samples were collected from each setup and stored under refrigeration before transport to the analytical laboratory of Dr. Martin Tsui for instrumental mercury analysis. Due to time constraints, Dr. Tsui's team was not able to provide a few of the mercury concentration results. The following graph is the calibration curve we used in determination of the concentration of mercury in seawater samples. The horizontal axis is the concentration of mercury (ng/L). The vertical axis is the peak area.



To determine the concentration of mercury, we can match the peak area with the corresponding concentration of mercury

The summary of data from these analyses is shown below:

	Concentration of mercury (ng/L)								
	Before mixing 7:55 am	5th Mar lunchtime 1:20pm	5th Mar afterschool 4:00pm	6th Mar morning 7:55am	6th Mar lunchtime 1:20pm	6th Mar afterschool 4:00pm	7th Mar morning 7:55am	7th Mar lunchtime 1:20pm	7th Mar afterschool 4:00pm
A1	75.3	N.A.	N.A.	N.A.	N.A.	N.A.	62.7	53.7	36.6
A2		N.A.	N.A.	N.A.	N.A.	N.A.	32.9	46.2	44.2
B		N.A.	N.A.	N.A.	N.A.	N.A.	69.5	43.4	36.5
C		N.A.	N.A.	N.A.	N.A.	N.A.	47.1	56.5	45.9
D		N.A.	N.A.	N.A.	N.A.	N.A.	36.8	70.4	28.9
E		N.A.	N.A.	N.A.	N.A.	N.A.	65.9	67.2	69.1

The limited data obtained can only provide a preliminary view of mercury levels after treatment with some of the adsorbent materials. Further replicate analyses are still needed to draw definitive conclusions about the adsorbents' efficacy across all test conditions.

Based on the limited data obtained, some preliminary observations can be made:

- Setup B, containing activated carbon, showed a consistent decrease in mercury concentration over time, with mercury levels generally lower than other setups. This suggests activated carbon was effective at adsorbing mercury from the seawater sample. The mercury content decreased by a whopping 33 ng/L. If this investigation is valid, activated carbon can be concluded to be the most effective adsorbent among the three other adsorbents.
- Setups D and E, using scallop and clam shells respectively, exhibited variable mercury readings that occasionally exceeded other setups. They both spiked in mercury contents in the second sample, indicating that the shells may have initially contained an elevated mercury level that was released back into the water over time. More discussion about

this error will be addressed in the later part. In setup D, the mercury level has decreased in the last sample, and was even lower than the level in the morning on 7/3 and the level before the adsorption test. In setup E, the mercury levels were still continuing to rise. In the end, the mercury levels increased by 3.2 ng/L compared to the morning sample on 7/3. We are however not able to conclude whether or not the clam shells were able to adsorb back the mercury it released because of the lack of data.

- Controls A1 and A2 also showed variability in mercury levels, potentially due to the low concentration (1 ng/L) used due to sample dilution errors. This could have magnified random measurement errors. More discussion about this error will be addressed in the later part.

- In set up 3, it appears that there was a potential increase in mercury contents in sample 2, which could possibly be attributed to the zeolites initially having a higher level of mercury that might have been released back into the water gradually over time. However, in sample 3, there seems to be a decrease in the mercury level. It is uncertain whether the zeolites have adsorbed a certain amount of mercury.

Unfortunately, conclusions regarding the adsorbents' comparative efficacies cannot be drawn from this initial trial due to its limitations, including an incomplete dataset and issues with sample preparation methods. Further replication of the experiment is necessary while addressing identified issues to obtain more meaningful and conclusive results. Modifications to the experimental design will be discussed.

Discussion

Limitations and possible errors

1) Apparatus and Equipment

Pipette and volumetric flask in dilution

Diluting the mercury seawater sample using 1 cm^3 pipettes and 100 cm^3 volumetric flasks for two serial dilutions, followed by 25 cm^3 pipettes and 250 cm^3 volumetric flasks for another two serial dilutions would result in a relatively high percentage error compared to achieving the desired 1,000,000x dilution. This is because with such small volumes at each dilution step, even minor inaccuracies in pipetting or volumetric measurements can lead to significant deviations from the expected concentrations.

Sampling syringe and filter

0.45 micrometre pore-size syringes have been used at the beginning to filter off microorganisms and particulate matter. Because of the lack of 0.45 micrometre syringe filters, starting from day two, set-ups except activated carbon used normal filter paper with pore sizes of (80 - 25 micrometre).

2) Environment

Controlled variables including the atmospheric conditions, temperature and moistness can't be controlled into perfect precision, but the parafilm cover and the measurements of seawater should reduce the possibilities of error. The sampling of the chemical samples has induced the problem of the occasional breakage of the parafilm, which may cause inaccuracies in the recorded data. During the experiment procedure, there have been multiple ruptures of the parafilm as we attempted to obtain the extracts, and had to replace them with new ones. Besides this, the temperature at which the mixtures were being stirred may not be uniform. As the magnetic stirrer runs all day, it induces the heating effect of current. The heating effect raises the temperature of the mixtures differently, causing variations in the controlled variable, temperature of the mixtures.

3) **Mixing of adsorbents**

They would sink to the bottom of the conical flask as sediments and the ratio of adsorbents per volume of water might vary. Therefore, it may also affect the withdrawn samples as it would be difficult to ensure the same surface area of adsorbents. The mass ratio of water sample to adsorbents in the conical flask would also vary every time the sample is withdrawn at every time interval. Because of safety concerns, we were not allowed to stir the samples of the mixture overnight. The adsorption process therefore cannot be run continuously for three days.

Suggestions for improvement

1) **Equipment and apparatus**

More comprehensive recordings and accurate measurements: Instead of using pipette at the set up phase, we could have used burettes and electronic pipettes as alternatives. If resources and time allow, using larger volumetric glassware and having fewer times of dilutions are better approaches to minimise the proportional effect of small volume variations. This would reduce the percentage error to within acceptable limits for accurate quantitative analysis and interpretation of results. Recordings on the samples could have also been taken more frequently to ensure accuracy. Prior mercury adsorption tests should also be conducted to find the optimum amount of adsorbents needed for a certain concentration of mercury solution so that the adsorption efficiency comparison for each adsorbent can be more obvious in this investigation.

2) **Preparation of shells of crustaceans (Scallop shells and clam shells)**

The results obtained for using ground clam shells and ground scallop shells as adsorbents were unsatisfactory and did not show a reduction in mercury levels in seawater as expected.

Upon further analysis, we realised a key mistake in the experimental design - the shells used may have already contained elevated levels of mercury prior to being added to the seawater sample. As crustacean shells are known to naturally adsorb and accumulate

mercury from their environment over time, using shells directly in the experiment likely led to a reverse effect. Instead of adsorbing mercury from the seawater, the shells with higher internal mercury concentrations likely released some of the stored mercury back into the seawater. This might explain the unexpected increase in mercury levels observed.

To address this issue in future experiments, methods need to be explored to recover or regenerate the shells first to remove any mercury already present. Only shells with mercury levels lowered to background levels should be tested as adsorbents, to properly analyse their ability to adsorb mercury from seawater. This will allow for more accurate and meaningful results.

3) Preparation of dilute mercury seawater samples

The results from testing the different adsorbents (activated carbon, zeolites, ground clam shells, ground scallop shells) did not show a significant decrease in mercury levels in seawater as we had expected.

Upon further analysis, we identified a key issue with how the seawater samples were prepared for testing. Specifically, we diluted the mercury concentration in the seawater samples too much, resulting in a very low concentration of mercury in just 1 ng/L. This concentration is much smaller than what is typically found in real-world environments like near industrialised coastal areas or sewage outflows, which can range from 100 ng/L to 10 μg/L. For example, according to the national standards of People's Republic of China of China Farmland Irrigation Water Quality Standards, water samples with mercury concentration higher than 10 μg/L is considered excessive and harmful. Testing at such a low mercury level makes it unlikely that any meaningful adsorption by the materials would be detected.

For future experiments, we need to be more careful in preparing seawater samples that have mercury concentrations more representative of authentic conditions. Using higher concentrations that better simulate real situations will allow us to properly analyse and compare the adsorption effectiveness of the different materials. Addressing this sample

preparation issue should yield more accurate and useful results regarding the adsorbents' abilities to reduce mercury pollution in the environment.

Further Investigations

1) **Aspirations / Significance**

   Discover the effects of organic/ inorganic mercury on the environment of the world such as in wetlands, tropical rainforest and other habitats of living things and organisms. We could also breach biology and investigate the possible medications for mercury poisoning and the symptoms. The relationship between adsorbents and mercury could also be further explored.

2) **Practical Experiments**

   We can test the adsorbents such as the zeolites and activated carbon on real-life environments to sufficiently measure the realistic effects of the adsorbent. Such as the different adsorption rates of adsorbents in different environments and what measures can be taken to maximise the adsorption rates in different environments respectively. In addition, we can also investigate how to incorporate different factors, such as: enhancing the porosity, modifying the chemical composition, applying a coating, which could increase the adsorption rates.

Conclusion

This planned experiment involves testing four different adsorbent materials — activated carbon, zeolite, clam shells and scallop shells — for their effectiveness in removing mercury from seawater samples. While this proposed study aims to evaluate promising low-cost materials for an important application, some aspects of the experimental design and restrictions have limited obtaining definitive, generalizable conclusions. However, identifying suitable adsorbents through systematic laboratory screening has strong potential to provide a practical solution for mercury management challenges. With refinements to broaden test conditions and increase replication to better simulate field complexities, results could help advance development of treatment methods with tangible benefits.

Reference

Department of Environmental Conservation. What do you know about Mercury?. (n.d.). New York State. https://dec.ny.gov/environmental-protection/mercury/what-do-you-know

Hatmoko, D. R., & Ramelan, A. H. (2020, June). The Effectiveness of Zeolite/Claystone/Activated Charcoal Composite in Reducing Levels of Mercury (Hg) in the Waste Resulting from the Activities of Unlicensed Gold Mining (PETI) in Sintang. In *IOP Conference Series: Materials Science and Engineering* (Vol. 858, No. 1, p. 012039). IOP Publishing.

Kaviani, R. (2022). Investigation of the Application of Zeolites in the Adsorption Mechanism. *Journal of Chemistry Letters*, *3*(1), 10-19.

Manocha, S. M. (2003). Porous carbons. *Sadhana*, *28*, 335-348.

Ministry of Ecology and Environment. (1992, October 1) People's Republic of China of China Farmland Irrigation Water Quality Standards. The People's Republic of China. https://english.mee.gov.cn/Resources/standards/water_environment/quality_standard/200710/W020061027512919898588.pdf

Morris, A., & Sneddon, J. (2011). Use of crustacean shells for uptake and removal of metal ions in solution. *Applied Spectroscopy Reviews*, *46*(3), 242-250.

Jeguirim, M., Belhachemi, M., Limousy, L., & Bennici, S. (2018). Adsorption/reduction of nitrogen dioxide on activated carbons: Textural properties versus surface chemistry–A review. *Chemical Engineering Journal*, *347*, 493-504.

Shewchuk, S. R., Azargohar, R., & Dalaia, K. (2016). Elemental mercury capture using activated carbon: A review. *J Environ Anal Toxicol*, *6*(4), 1-10.

United States Environmental Protection Agency. (2023, April 25). Mercury Emissions: The Global Context. The United States of America. https://www.epa.gov/international-cooperation/mercury-emissions-global-context#:~:text=Mercury%20emitted%20into%20the%20air%20eventually%20settles%20into%20water%20or,and%20animals%20that%20eat%20fish

Zhang, T., & Zuo, S. (2023). Drying enables multiple reuses of activated carbon without regeneration. *Environmental Science and Pollution Research*, *30*(15), 45097-45111.

The 17th Hong Kong Budding Scientists Award
2023-2024

SHATIN PUI YING COLLEGE

Interview with a Scientist – Dr. TAM Pui Yuk Tammy

Students:
CHENG Tsun Hei (S.3)
HO Sze Ching (S.3)
HON Chi Kin (S.3)
SHUM Yi Man (S.3)
TONG Chun Yan (S.3)

Teacher:
WONG Kwan Ho

1. Introduction

We are honored to have a chance to do a face-to-face interview with Dr. Tam Pui Yuk on 28th February in the Geology laboratory of the Chinese University of Hong Kong. Dr. Tam has told us a lot of her extraordinary experiences and given us a lot of useful advice. Many of her fun stories inspired us to be passionate and always look for improvements. It is our pleasure to have this opportunity to meet Dr. Tam in person. In this report, we are going to mention the stories of Dr. Tam since her childhood, her current research, and her projects. Also our reflections from participating in this interview, together with the useful advice she gave us.

2. The Stories of Dr. Tam

2.1. Childhood Inspiration - From Visual Arts to Geo-Science

Everyone must have had a dream job once when we were young. Dr. Tam is not an exception, she wished to become an artist when she did not know about the existence of Science. “The Earth is very beautiful.”, this is what she said during the interview and also the reason why she liked drawing so much. Because of this love for drawing, she ditched her lessons and kept those times for drawing when she was a secondary school student. During her drawing times, she discovered that the Earth is way more extraordinary than she thought, expanding her curiosity of wanting to know why the Earth can be so attractive and impressive to her. As she gained more and more knowledge, she knew that the appearance of all the landscapes and rocks could be calculated by using scientific knowledge, this was what she had been curious about. At this moment, she has found out her interest in the Science categories that relate to the structure and composition of the Earth. As a result, Dr. Tam chose to study Geology at the university.

2.2. Undergraduate Studies - First Taste of Geology

When Dr. Tam was studying for the first year at the University of Hong Kong, she had thought about transferring to study architecture, but she found out that she was not studying the things

that she expected to learn. As she had gone on her first field trip, it was so worth it for her to stay in Geology. She thinks that field trips can help her to look through different aspects of the Earth. Through the observations in field trips and using the gained knowledge, she can predict the future and know the past of the place, which could save people, set some targets, and also help people to survive earthquakes or other natural tectonic hazards, which was meaningful to her.

2.3. Postgraduate Studies - The Silver Linings

After studying in the second year of her Master's Degree, her Professor Mr. Zhao Guochun advised her to study for the Doctorate course. However, Dr. Tam did not think she could start the Doctorate course at that time. As an average student, she was not confident in herself. She was always feeling frustrated when she was doing research. Fortunately, Professor Zhao told her not to be afraid to fail in experiments, to keep trying in Science and you get the result, this engaged her a lot. After a lot of studying and researching, she successfully got her Doctorate Degree.

After getting her Doctorate Degree, she chose to be a postdoctoral to deepen her research area and have more experiments and research experience. A period of time later, she was inspired by Dr. Chan Hungsan. Dr. Chan knew she liked communicating with others, so he gave her chances to try to educate students using the knowledge of Geology she had gained so far when she

thought it was tiring to do lots of research continuously instead of studying pure Science. He believed Dr. Tam could know the needs of students and help the students to find a path in Science. And she met his target, as she set this as her teaching philosophy, which is to let students learn what they want to learn, instead of choosing for them.

Because of them, Dr. Tam got a lot more experience to try and research. In these years, she has gone on many field trips to many different countries and cities, such as Taiwan, Cyprus, Japan, and Scotland with the University of Oxford. She said that she would go anywhere in the world that has rocks, to research and to observe it on her own. Sometimes she would go traveling with her family, her family members would like to see the fish and the oceans, but what she would like to see are the rocks and volcanoes. She knows her interests are special and different from others, but this is what she loves.

In one of the field trips she has gone on, she went to the mainland to observe the metamorphic rocks, one of her favorite kinds of rock. A few published papers of hers are about this kind of rock[2] [3]. She thinks metamorphic rocks are special from others, they have a lot of chemicals inside which can be found by optics in different angles. She would always cut it into small pieces and observe it with a patrol graphic microscope, letting her know the record of the metamorphic rock from one kind to another through her observation every time.

2.4. The Future of Geo-Science - Young Power

Apart from the active research in the education of Science, Dr. Tam is dedicated to her current involvement of youngsters to participate in Geology-related activities. Geo-Science Ambassador is a program held by Dr. Tam that allows students to learn everything, the only requirement is that they are interested in those topics. The program welcomes every university student. The participants will tell Dr. Tam and her team a topic in geology that they are interested in, and she will give them the resources and skills to investigate the specific topics. They can also ask her if they face any difficulties during the process, and she will try her best to help them explore. She stressed that her reason for holding this program is that she believes that the biggest motivations for learning are passions and interests. She loves teaching students about what they love. That is

also one of the reasons why she volunteers to do this without credit. She wishes this program could be opened to different students in different universities, she also looks forward to holding similar programs targeting younger students, such as secondary and primary schoolers.

She is currently focusing on teaching, it is due to her belief which suggests young power is very important. She commented that young people are the future of the world, and so it is for Geology. Therefore, she is working hard on how she can make studying Geology easier and more interesting, to heighten the enthusiasm of students in Geology.

Recently, Dr. has published a paper about educating students with VR, AR, and 3D models and print in traditional classes[1]. She said teaching with these new technologies is very different from conventional teaching, in that students start to have reactions in class. Using AR technology, students can see the complicated mineral structures in a fun way, which lets them understand the knowledge more easily. By using VR technology, students can learn using cartoons and some short descriptions. This can help students to memorize and cooperate with books better. Besides, the 3D models and print technology can increase the efficiency of the field trip through the 3D models prepared beforehand. These new technologies can gradually increase the interest of students to learn by themselves. She thinks she is lucky to participate in this project and have this achievement.

3. Our Reflections

3.1. Passion is the Key of Learning

During the interview, not only did Dr. Tam share her interesting teaching experience with us, but she also showed us her personal rocks collection in her office and explained their unique properties, characteristics, and meaningful stories behind them. For example, one of the rocks was given by her teacher, whom she admires a lot and played an important role in her journey of exploring science and her future career. She also told us that we could ask her everything about Geology that we were eager to know, and she would love to share the things she loves with us. We are often taught by different teachers, by Dr. Tam's passion for teaching awakens the parts inside us that are so eager to learn more.

Geo-Science Ambassador is a program held by Dr. Tam that allows students to learn everything, the only requirement is that they are interested in those topics. The program welcomes every university student. The participants will tell Dr. Tam and her team a topic in Geology that they are interested in, and she will give them the resources and skills to investigate the specific topics. They can also ask her if they face any difficulties during the process, and she will try her best to help them explore. She stressed that her reason for holding this program is that believes that the biggest motivations for learning are passions and interests. She loves teaching students about what they love. That is also one of the reasons why she volunteers to do this without credit. She wishes this program could be opened to different students in different universities, she also looks forward to holding similar programs targeting younger students, such as secondary and primary schoolers.

As mentioned above, Dr. Tam is currently working on introducing VR to traditional classrooms for teaching Geology. She explained the reason why she is doing that is because she wants to make the learning more interesting and interactive. so that it is easier for the students to understand the knowledge and they will be eager to learn more themselves, for example, the chemical structure of rocks, which she thinks is difficult to make the students remember just by simply talking about them according to the textbooks. By using VR, students can observe the

molecules in different ways they want. Resulting in an effective learning experience, because a good learning experience should come in two ways.

3.2. ‘Never Settle With the Current Knowledge’

At the end of the interview, Dr. Tam reminded us that critical thinking is very important, it is a crucial value not only for scientists but also for students. People nowadays receive a lot of information from their everyday lives. She teaches us that we cannot just simply believe everything we are taught. We have to consider the authenticity of every single piece of knowledge, even if they are told by our teachers and seniors. We can always discuss the topics politely with our supporting facts. This is the value of scientific discussions and what makes them attractive and fascinating. There is no guarantee to have an absolute right answer in every discussion. Still, we should never give up on finding the truth, the path of scientific discoveries will never end. However, we need to be aware of the sources of the information we find. Find more reasons to support every theory, do not ever jump to conclusions without abundant evidence for support.

3.3. Believe in yourself and seize the opportunities

In the interview, Dr. Tam kept mentioning her teacher, Dr. Zhao. She said that she was so lucky that he saw her potential and gave her so many opportunities. The one she remembers the most is

that after studying for a bachelor's degree for one and a half years, she started to study for a master's degree. When she was studying for a master's degree, she was allowed to study for a PhD before finishing the master's degree. It was a difficult path for someone like her to choose. However, encouraged by her teacher, she decided to trust her ability and gave herself a try. This is one of the reasons why she had such achievements at a young age. If she had never accepted that opportunity, she would not have had that kind of achievement now. Therefore, seize every opportunity, because you will never know what you will achieve.

3.4. ‘The world is gorgeous!’

Dr. Tam's research is mainly related to Metamorphic rock because she thinks they are so beautiful. They have various forms, and she can always discern different minerals in them. She shared something interesting about herself, which is her childhood dream. It was to become a painter. It is due to the reason that She has always thought the world is so beautiful since she was young, her passion is to depict the things she is delighted in. However, as she grew older, she started to discover her passion for science. This changes a lot about her dream job. Then she met Geology, which allowed her to explore this magnificent world she loves. One work that is essential in every field trip is sketching the environment, and this suits her interest in drawing perfectly, being the other reason that she chose Geology. This makes her keep doing the research, to do something she enjoys, her passion.

4. Conclusion

It was our pleasure to have this wonderful opportunity to have an interview with Dr. Tam. We have learned a lot from her. As mentioned before, her passion influenced us, it reminds us to never give up or stop exploring the things that we love. Take Science as an example, the world of science is wonderful, it is endless, infinite numbers of investigations can be carried out and endless possibilities can be discovered. That is the beauty of Science studies.

5. References

1. Tam P.Y., Kwok C.F.E., Chu S.Y. & Wong T.S.D. (2020). Virtual Reality and Augmented Reality Application in Classroom Teaching and Field Study. Poster presentation, EXPO2019/2020.

2. Wu, K.K., Zhao, G.C., Sun, M., Yin, C.Q., He, Y.H. & **Tam, P.Y.** (2012). Metamorphism of the Northern Liaoning Complex: Implications for the tectonic evolution of Neoarchean basement of the Eastern Block, North China Craton. *Geoscience Frontiers*, 4(3): 305-320.

3. Tam, P.Y., Zhao, G.C. & Zhou, X.W., *et al*. (2012). Metamorphic P-T path and implications of high-pressure pelitic granulites from the Jiaobei massif in the Jiao-Liao-Ji Belt, North China Craton. *Gondwana Research*, 22: 104-117.

End

Cheung Sha Wan Catholic Secondary School

Interview with Professor Law Kam Tuen, Vic

Ho Yat Yin

Lai Yat Long

Liang Yat Wai

Li Chung Yin

Tong Pak Yin

"Then you will know the truth, and the truth will set you free." John 8:32

1. Introduction

Our team was honoured to conduct an interview with Professor Law Kam Tuen on the 15th of March in his office at the Department of Physics of the Hong Kong University of Science and Technology.

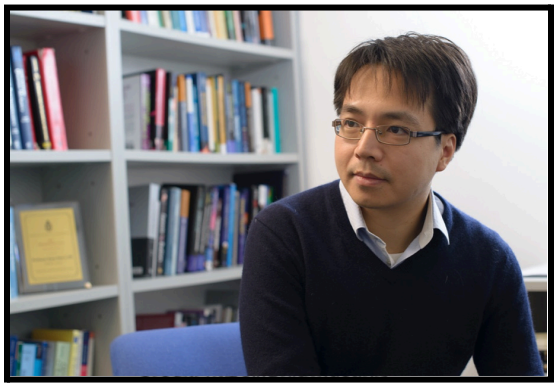
Professor Law shared with us his story, and along with it his valuable experiences and lessons and the way to achieve success. Success, according to Professor Law, stems from pursuing goals that align with both interests and skill sets. Besides, Professor Law also encouraged us to actively seek opportunities from our school to enrich our experiences. His aspirations to contribute to our society and our future greatly inspire us. In turn, we resolve to become influential scientists like him.

2. Brief Background of Professor Law Kam Tuen

Prof. Law Kam Tuen is a local scientist full of passion in physics, especially in quantum mechanics, topological insulators, superconductors and condensed matter theory.

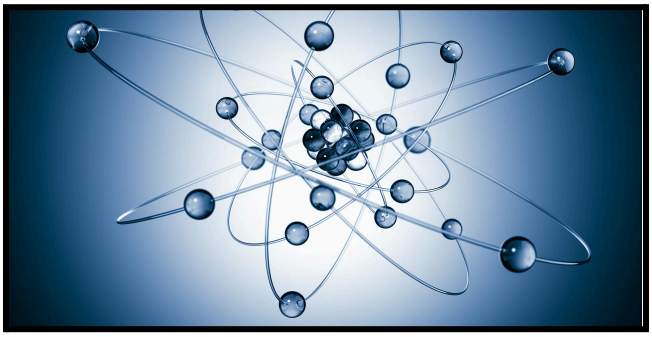
2003	Undergraduate study at Hong Kong University of Science and Technology
2008	Graduate studies at Brown University and received PhD
2008-2009	Joint postdoc fellow of HKUST-IAS and MIT
2009	Croucher Postdoc Fellow
2011	Professor of Hong Kong University of Science and Technology

During the past few years, Prof. Law has achieved several milestones across the globe. He obtained numerous awards in his career. In 2008 he was granted the Anthony Houghton Award for Excellence in Theoretical Physics; in 2014 he obtained the HKUST School of Science Research Award. Professor Law is also one of the founding members and currently serving as the President of the Hong Kong Young Academy of Sciences. He is one of the Associate Dean of Science of Hong Kong University of Science and Technology.



3. Ising Superconductors

Professor Law has always been passionate about different fields of physics. His work involves fractional quantum Hall states, topological insulators and topological superconductors. Within these fields of research, one of his most famous accomplishments is his groundbreaking work on the Ising superconductors.



Superconductivity is a quantum phenomenon in which electrons form pairs and flow with zero resistance. However, strong magnetic fields can break electron pairs and destroy superconductivity. Professor Law led his team and gave an explanation to the complex phenomenon of superconductivity that survives under strong magnetic fields, offering a theoretical answer to an unsolved experimental observation by a group of scientists in the Netherlands.

The scientist from the Netherlands discovered that superconductivity in thin films of MoS_2 could withstand an applied magnetic field as strong as 37 Tesla. In response, Professor Law's team proposed that the lattice structure of MoS_2 thin films allows the moving electrons in the material to experience strong internal magnetic fields of about 100 Tesla. This type of internal magnetic field does not damage superconductivity, and protect the superconducting electron pairs from being destroyed by external magnetic fields. They named this type of superconductors as "Ising superconductors". With this discovery, "we are now closer to the mass production of quantum computers", quote Professor Law.

[1]:https://hkust.edu.hk/news/research-and-innovation/hkust-theoretical-physicists-solve-puzzle-ising-superconductivity

4. From Secondary School to Scholarhood

A. Where the Journey Began

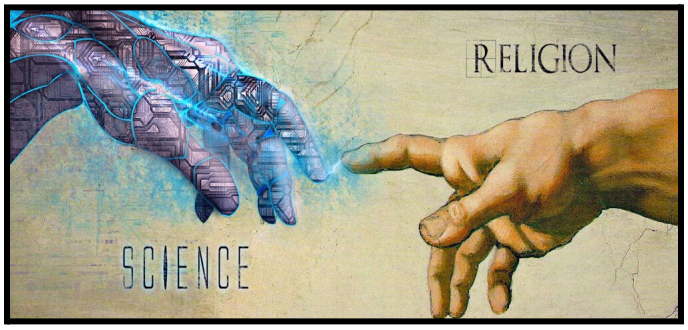
It is all about interest and curiosity that drives a person to dedicate most of his life to physics. Professor Law loved physics and wanted to be a physicist since Form 2. He recalled reading the book ‘God and the New Physics' by Paul Davies, which aroused Professor Law's interest in quantum physics. He said that when he was reading the book, he couldn't fully comprehend the content, but he was just curious about it back in those days.

Also, he emphasised that his secondary school provided him with lots of opportunities to learn and explore his interests. “Experiences of participating in different competitions are important sources of surfing your interests and talents. I found physics interesting because of having a competition.” says Prof. Law.

Prof. Law also gained important companions in his secondary school who have accompanied him on his way of becoming a physicist. “Encouragement between peers is essential for improvements and facing obstacles.” Sometimes, we don't know how to confront challenges ourselves, especially for teenagers nowadays. Prof. Law reminded us to always remember to embrace adversity and communicate with people around; and if problems are seemingly unresolvable, we should not be afraid to ask for help.

[2]Picture credit: https://www.freepik.com/

B. <u>Where the journey is heading: “Religion” vs. “Science”</u>



“When you further explore science, you will discover a miraculous relationship between science and the profound truths in religion, and you will believe in God after years and years of learning.” Prof. Law mentioned the reason he became a Christian. “If any constants in this world have slight adjustments, the world will not exist anymore. Isn’t that thought-provoking? That’s why I became a Christian.” Besides, he shared with us that when he is stressed in his daily life, he will pray to God with faith that He will guide him to success. This motivated him to be a better person day by day.

Also, his faith in God helped him develop gratitude in his life. “When I wake up every day in the morning, I am always thankful for living. This helps me to treasure the time and people around me. It improves my motivation and also improves the interpersonal relationship.’

Most people think scientists do not believe in God because scientists are finding the truth of the world rationally. “It’s common for them to think about that. Scientists have the determination to find the profound truth of the universe, but their determination is unique. Everyone has their own experiences and points of view on life. Therefore, it’s common for scientists to have different beliefs on doing research. The same also applies to religious beliefs.”

[3]Picture credit:
https://wangchu-wang.medium.com/cosmology-study-of-religion-and-science-dc923016c7a0

5. <u>Step-by-Step Guide to Become a Scientist</u>

A. Seeking for Passion, the Initial Step

Passion is the interest in learning new things. With passion, people are willing to invest time and energy in achieving more. It is an important factor to help students learn efficiently and determine their success.

Professor Law used himself as an example of why interest is significant in studying science. When we asked about his enthusiasm in physics, Professor Law highlighted a moment from the past in which his dad cut off the power in their home to stop him from doing maths in the middle of the night and force him to go to bed earlier. Finally Professor Law could only compromise doing maths until midnight. Professor Law finds doing mathematics and physics as entertainment; he never gets bored nor exhausted in them. And that's probably why Professor ended up excelling in physics and maths.

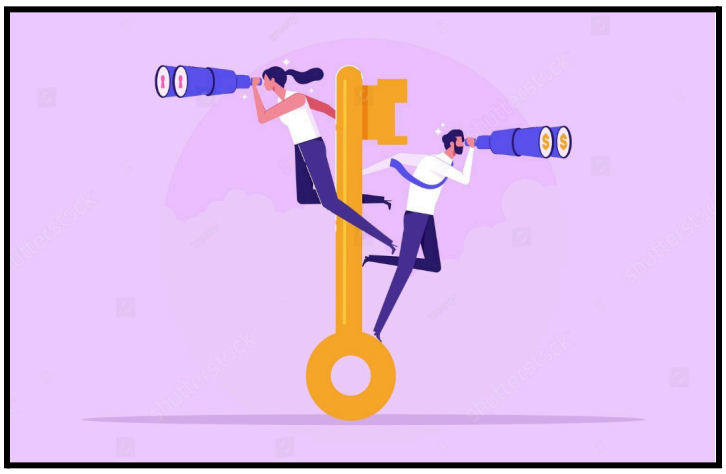
[4]Picture credit:
https://onceuponawrittenword.wordpress.com/2018/02/19/the-metamorphosis-of-passion/

B. <u>Aligning Skills with Passions</u>

“A clear mind knowing our competences and limitations on different areas of our interests gave us an easier path in pursuing science. Our interests and competence may not always match with each other, but they can be adjusted or trained.”

Recalling his memory, Professor Law believed that he lacked potential to be a mathematician despite having decent maths scores. However, Professor Law also pointed out that competences can be improved with the help of enthusiasm. His dedication towards being a physicist motivates him to continuously improve his mathematical ability to meet the requirements of being a physicist.

C. <u>Seize your opportunities</u>



“I was really lucky that I had a favourable learning environment for me to develop my interests. However, it is still necessary to seize your opportunities to achieve success.” Professor Law encouraged us to treasure our school life and participate in as many extracurricular activities as we can. This is needed for finding our interests and talents to prepare for serving our community and achieving your own ‘success’. That’s what Professor Law did in his secondary school life and found that physics is his favourite subject and his life goal.

Picture Credit [4]:
https://www.shutterstock.com/zh/search/seize-opportunity?image_type=vector

6. Artificial Intelligence to a Physicist

AI undeniably speeds up scientific investigation. The finding or generating of results is faster and more convenient. But on the other hand, as AI has developed rapidly in the following years, Professor Law reminded us ‘You will either control the AI perfectly, or be totally controlled by the AI in the future’.

Professor Law told us that he thought AI can help us in performing various types of time-consuming work. When we are doing research and projects, AI would be a convenient tool for us to find the things we need. However, AI can only be our tool and cannot help us to do everything. AI has its limitations when compared with human brains. Professor Law believes that in “no way they are replacing humans.” He explained this with three reasons:

- ➔ Since its energy efficiency in terms of data management compared to our human brain, is specially incomparable.

- ➔ The impact of the human brain in terms of image recognition is much more powerful than the results made by AI.

- ➔ Once an important revolution occurs in human society, humans will manage to restore the labour force into different positions and construct a new societal structure.

AI cannot think by itself, it only does the things we ordered them to do. We should know how to use AI to help us in parts of our work, but not using it to help us complete the entire task. Otherwise, we cannot learn from our work of scientific investigation or research, and may become too reliant on AI to solve problems and become extremely unproductive. We can use AI, but in a wise way.

7. Epilogue

"Then you will know the truth, and the truth will set you free." John 8: 32

Professor Law uses this sentence to be his life motto. "At first, I thought the truth in the Bible quote meant profound knowledge of science. However, after many years of being a scholar, I discovered that 'the truth' is God. Everything is made by God and the world has an incredible balance on everything, everything." Finding the truth is the whole-life-goal for him. He encouraged us to set our goals, and fulfil the three items to achieve the goals: interests, talents and opportunities.

During the amazing interview, we learnt the life philosophy of Professor Law: finding purpose in life. He found that he was interested in physics in form 2, and settled that as his career goal. He emphasised the importance of having a goal because man needs a driving force to improve, and subsequently contribute to society with that accomplishment. The definitive goal of being a physicist during his teenage years is one of the main reasons of his success. Therefore, we need to find the right path of our life and find our own life goal, and to reach our own 'success'.

Professor Law also emphasised the importance of being thankful. "Not to blame God and accuse others but to be grateful for everything." We think that is the main reason why Professor Law has a successful career. His gratitude makes him treasure everything around him. He can make use of all resources near himself and seek help from others. If we have no gratitude, we will start blaming other and be blind to our own shortcomings. Discovering our own weaknesses is the point of self-improvement. Also, appreciating others can develop better relationships between others. Hence, being grateful can guide us on our righteous path to seek our own success.

8. Conclusion

In conclusion, we gained valuable knowledge and insights during the interview. For example, we should first identify our own interests. Moreover, if we want to be successful in an aspect, we have to grasp the chance nearby. Professor Law's point of view of life philosophy inspired us a lot. For instance, he does not only think about things in terms of physics, but also in terms of religion. Once and for all, Dr Law lets us know many things not about academics, but about life and attitude. We all feel thankful to have such a meaningful talk with Professor Law.

9. References

香港科技大學理學院物理系助理教授羅錦團博士簡歷
https://www.hku.hk/f/news/12605/Dr%20LAW%20Kam-tuen%203c.pdf

HKUST Department of Physics website, Personal Home Page
https://physics.ust.hk/eng/people_detail.php?pplcat=1&id=33

HKUST Department of Physics website, Vic KT Law's Condensed Matter Theory Group Home Page
https://phlaw.ust.hk/

HKUST – Theoretical Physicists Solve the Puzzle of Ising Superconductivity
https://hkust.edu.hk/news/research-and-innovation/hkust-theoretical-physicists-solve-puzzle-ising-superconductivity

Hong Kong Budding Scientists Award 2023-2024

An Interview with a World Class Scientist– Professor Chi-Ming Che (支志明教授) Chair Professor, Department of Chemistry, The University of Hong Kong

BSc (HKU); PhD (HKU); FRSC; BBS;
Member of The Chinese Academy of Sciences;
Foreign Associate of Natural Academy of Sciences (USA);
Fellow of World Academy of Sciences for the Advancement of Science in Developing Countries;
Fellow of Federation of Asian Chemical Societies;
Founding Member of The Hong Kong Academy of Sciences

Marymount Secondary School
Trinity Orlanda Loo
Leung Ka Yan, Augusta
Yeung Oi Yin Vanessa
Hung Ka Yi, Lily
Cheng Hiu Yee Celeste

Introduction

We were very honoured to have the opportunity to interview Professor Che, a world class scientist with many achievements and awards. We were delighted to have the opportunity to learn from his experiences. He has given us tricks and tips of becoming a successful scientist, while teaching us to step in his own shoes by telling us the mindset that he has been using over the years, letting us know the power of unleashing our true potentials and unshackling the restraints on our creativity. He even shared with us his previous research, experiences and what to look forward to in the future.

During the interview, Professor Che shared with us that he aims to fulfil his responsibilities of being a chemist, by creating solutions that would solve global problems effectively. While having this long-term goal, he thrives to keep a 'no limits to interests' attitude. Professor Che indeed started his career by washing glassware and chemical bottles in the laboratory, which eventually led him into this scientist position that he is at right now.

Biography

Professor Chi-Ming Che is the Head of Chemistry at University of Hong Kong, a professional scientist and chemist. Born in 1957, Professor Che has developed an interest in Science and Maths. He has proudly won more than twenty awards and honours in his career as a scientist. During 1983 to 1993, he had his first 'golden period' in which he was actively involved in multiple research projects representing Hong Kong and China at a young age. He was almost the youngest professor in Hong Kong when he started his career in 1992.

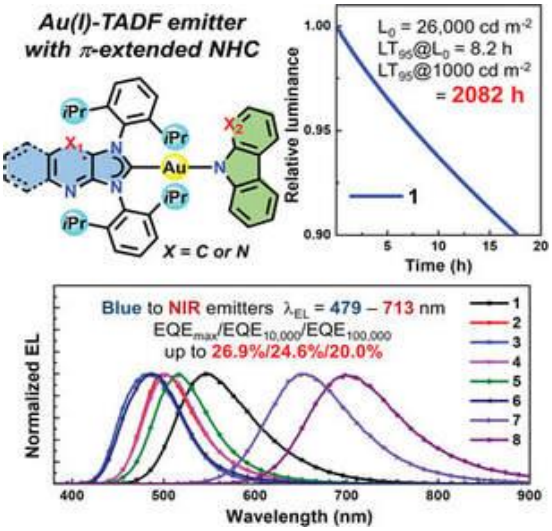
Professor Che has received numerous awards, honours and titles for his outstanding achievements and contributions in the field of natural chemistry over the years. He was elected as a Fellow of the Academy of Sciences for the Developing World (TWAS) and a Foreign Associate (International Member) of National Academy of Sciences, USA in 2013 and served as Davison Lecturer at Massachusetts Institute of Technology. In the same year, he was awarded the Centenary Prize of the Royal Society of Chemistry to recognize his remarkable achievements in research areas in the chemistry discipline and contribution to the innovation and technology community. He also received First Prize of Shenzhen Natural Science Award in 2019 and Luigi Sacconi Medal in 2020. He has contributed a lot in inorganic and organometallic synthesis, and done a lot of bioinorganic chemistry research.

Research Interest

Being one of the most renowned chemists in Hong Kong, continuing his studies in physics and chemistry in his school days, Professor Che's research covers areas from inorganic chemistry in material science to catalysis and medicine. In the early days of his career, he pioneered the development of the Ru-OXO system, opening up massive opportunities for efficient catalytic oxidation processes. He also successfully developed practical tetradentate platinum(II) and gold(III) as well as the chemistry of d8 and d10 metal complexes.

Having had forty years of research, he wishes to develop medicine to treat drug-resistant cancer cells. With that in mind he has set out to develop new targeted drugs that can prolong life and cure patients, leading a group of scientists from the University of Hong Kong to develop the right drug candidates to remove cancer stem cells to prevent its recurrence. Below mentioned are Professor Che's research projects and research areas, all related to material science, photochemistry and biomedical science.

- Inorganic and Organic Syntheses
- Metal Catalysed Organic Transformations
- Organometallic and Inorganic Photochemistry
- Bioinorganic Chemistry
- Organic Oxidations
- Highly Reactive Metal-Ligand Multiple Bonded Complexes
- Chemical Biology of Inorganic Medicine



His Road to Success

How he began his journey

It all began in the summer of 1977, he started participating in chemistry research as a chemistry student. However, the first thing he did when he finally joined the laboratory was cleaning up glassware, preparing experiments, tools and materials for senior students to use. In the final year of university, he decided to take on a graduate research project. From then, he has developed a habit of going to the laboratory seven days a week, rain or shine.

Besides Chemistry, he is also interested in other subjects like Mathematics, Chinese Literature and Arts. He told us his most memorable time was those years around 1983-1993 (his first 'golden period'), where he worked with his students to do what he was interested in and was able to earn reasonably for a living.

The power of habits

"Do what you like, make it a habit, success isn't the main thing to aim at."

Everyone has heard of the saying "fall in love with the process and the results will come", yet never have I seen it in action. Professor Che is the living epitome of this quote. Many people would think that success requires a lot of motivation, expectations, and patience.

Yet what he taught us was aiming for our goals instead of success, turning things like going to work into habits. He mentions how he goes to the lab every single day, regardless of what everyone else thinks.

The point is to have consistency throughout the years so that we can actually make an impact on the world, having sudden spurs of motivation, energy and inspiration isn't fuel in the long run. Little habits can accumulate and grow, conquering what seems impossible into bitesize challenges for everyday life.

The world on his shoulders

“The mindset of not focusing too much on success or failure is what will lead you to it.”

He shared with us different parts of his life, the ‘golden periods’, and even the periods of life that he mentioned were quite slow and lost. Even if we tried our best to minimise the “downs” of our life, it was still bound to happen.

What made these parts of his life so different was how he felt and his mindset. In his early years of his career, he felt free and confident, using all of his creativity and effort, he focused on doing what he loved, marking his first successful years. Yet years after he had become famous, he felt like he was stuck in a rut, he didn’t know what the next breakthrough would be, nor how to shatter down the walls of obstacles. He was racking his brain, not knowing why he was stuck.

“Now!” he said, “it’s my second golden period”, with an exciting tone towards the end of the interview. Perhaps nothing has really changed, his determination, his smartness and his personality are always there. Perhaps he has made up his mind to work on several new research and attempts – be it related to his hobby or the responsibility as a scientist. We can feel the excitement in his shining eyes when he mentioned about doing experiments in the laboratories. Professor Che also invited us to visit his lab some time later and he would able to share his findings with us there.

Fundamental Attributes of an Outstanding Scientist

Curiosity in seeking for the answer

"You need to have the curiosity to follow your hobby."

If knowledge is power, then curiosity is muscle. In order to gain and apply the knowledge, we must first train our curiosity. Just as what Professor Che said, we need to have curiosity to follow our passions and our interests; it might not be something you can achieve, but with curiosity, you can work towards it. Curiosity helps motivate us and ignite our interest to achieve impossibilities. It is one of the most fundamental aspects in becoming a scientist!

Asking ourselves questions about the things we find quirky, for example how a tadpole turns into a frog, may lead to the interpretation of weird and completely irrational explanations for these observations. But it is those kinds of crazy theories that lead to some of the most significant scientific discoveries in history. Curiosity is what fuels scientists to work, they are the basis for making theories and scientific discoveries. Without it, Issac Newton might have never discovered gravity or Alexander Fleming might have never invented penicillin.

Confidence and perseverance are key to success

「不要妄自菲薄」**"Don't belittle yourself."**

Professor Che believes that 'genius' like Einstein exists, so everyone has the potential to become such a genius. "It is just you may not want to be a 'genius', not that you can't." Athletes can win gold medals because they have strong fighting spirit and determination. So why can't scientists? He encourages his students to motivate themselves through setting a goal of 'not being inferior'. He once told his students, they should respect their supervisors but not necessarily follow them blindly because supervisors could make mistakes too and they should have the ability to work independently with confidence. Professor Che wanted to tell us one thing – "You can do something as long as you want to do it. Don't make excuses for yourself."

Nearly every year his students might ask him about whether studying chemistry is promising or not. He replied, "If the future of a chemist is bleak, you wouldn't choose to come here. The question is whether you choose to come here or not, so you have to believe in yourself." It's not certain whether being a researcher or a scientist is their ideal career. Everyone has different interests and hobbies, but if they work hard, they will achieve results.

He said there are three kinds of people, the first kind is a genius with high IQ, the second kind with a relatively low IQ, but very few of both. The third kind, where most people are, is in the middle with similar IQs, but very few can concentrate on doing one or two things very well. Professor Che has been keeping a habit of going to the lab every day whenever he is free since 1977, and he believes this is one of the important keys to accomplish his goal. He believes that as long as you are willing to work conscientiously and keep doing it, you will definitely achieve what you want.

Reflection

After meeting Professor Che, he has changed some of our understanding as a scientist. We used to wonder why scientists could keep staying in labs for so long and continuously do experiments, even when the results weren't certain. Professor Che has greatly inspired us, he taught us how to 'fall in love' with the process, and how to stay by science's side.

We also come to realize that perseverance or wisdom alone couldn't make a scientist succeed by itself. As a scientist, one can easily get extra pressure as people around you might expect you to be smart and the experiment would go as planned, but Professor Che works in his own pace – following either his hobby or responsibility, stays strong, continuing his research. To achieve our goals, we need a perfect mix of perseverance and wisdom. In our reflection, it is just like the product of our project, which needs the correct amount of water and rocks to make the perfect concrete.

One of the takeaways we gained from Professor Che was to never have over expectation on the (experimental) results. As a scientist, it isn't possible to be able to predict the most accurate results and most of the time, things won't always go as planned. Setbacks and failures are inevitable, we often face them, so we have to learn to accept them. If you weren't able to reach your goal or get the results you predicted and considered that as failure, you'll never be able to obtain what you want. Therefore, we should embrace failure and setbacks in the process, and in that way, we will be able to conquer life's ups and downs with ease!

References

1. https://cmche-hku.weebly.com/
2. https://www.scifac.hku.hk/people/che-chi-ming
3. http://www.ashk.org.hk/en/ourMembers/details/34
4. https://hub.hku.hk/cris/rp/rp00670;jsessionid=3EBDC48F63459F3DB5E52CB1CDC4D15D
5. https://pubs.rsc.org/en/content/articlelanding/2011/cs/c0cs00142b/unauth
6. https://pubs.rsc.org/en/content/articlelanding/2015/cs/c5cs00132c/unauth
7. https://www.sciencedirect.com/science/article/abs/pii/S0010854503000651
8. https://cmche-hku.weebly.com/publications.html
9. https://cmche-hku.weebly.com/gallery-photos-news-clips-videos.html

比賽成績

小學組:

冠軍:
聖保羅男女中學附屬小學

亞軍:
優才(楊殷有娣)書院—小學部

季軍:
東華三院鄧肇堅小學

殿軍:
青松侯寶垣小學

優異獎: (排名不分先後)
港九街坊婦女會孫方中小學
油蔴地天主教小學(海泓道)
培基小學

最佳創意方案獎:
聖保羅男女中學附屬小學

最佳匯報獎
港九街坊婦女會孫方中小學

最佳指導教師獎
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科學家報告書獎: (排名不分先後)
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聖保羅男女中學附屬小學
優才(楊殷有娣)書院—小學部

中學組:

冠軍:
拔萃女書院

亞軍:
長沙灣天主教英文中學

季軍:
沙田培英中學

殿軍:
香港浸會大學附屬學校王錦輝中小學

優異獎: (排名不分先後)
瑪利曼中學
觀塘瑪利諾書院

最佳創意方案獎:
長沙灣天主教英文中學

最佳匯報獎
拔萃女書院

最佳指導教師獎
拔萃女書院

科學家報告書獎: (排名不分先後)
沙田培英中學
長沙灣天主教英文中學
瑪利曼中學

合辦團體

教育局課程支援分部資優教育組

香港數理教育學會

比賽評判

(排名不分先後)

小學組

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2023/24

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