2021/22

香港科學青苗獎

Hong Kong Budding Scientists Award

資料匯編

Collection of Students' Proposals

To Future World Problems / Authentic Problems

教育局課程支援分部資優教育組

Gifted Education Section

Curriculum Support Division

Education Bureau

目錄

前言

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

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

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

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

教育局課程支援分部資優教育組

比賽規則

I. 初賽

A. 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；

(因應教育局的停課安排，本屆香港科學青苗獎的決賽取消，獲獎名單根據書面報告的水平而決定。)

比賽題目(未來世界／現實難題)

1. 與食物科學有關的科學探究

識別一個與「食物科學」有關的問題，然後建議一個解難方案，以造福人群。解決方案必須實用、具經濟效益、符合科學原則，並有證據並有科學證據支持，且富創意。請給予所要探究的難題一個探究題目（Title of Investigation）。

2. 香港的海洋污染

新聞不時報導有關本港海洋污染問題，引起市民的關注。香港的天然資源有限，香港特別行政區政府竭力避免海洋環境受到任何污染。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（Title of Investigation）。

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」／重要「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（Title of Investigation）。

Problems of the Heat

(Future World Problems / Authentic Problems):

1. **Scientific Investigations related to food science**

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

2. **Marine Pollution in Hong Kong**

   From time to time news about marine pollution in Hong Kong concern Hong Kong people. The natural resources in Hong Kong are limited and the Hong Kong Government strive to avoid its environment from any marine pollution. Suggest in your proposal how to tackle one kind of marine pollution 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 important real-life problem in which your school team has interest.
   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).

小學組:

冠軍

優才(楊殷有娣)書院 - 小學部

第十五屆香港科學青苗獎

現實難題主題: 食物科學/ 香港的海洋污染

題目： 齊來轉「塑」快、海洋健康曬！

指導老師: 鄧兆華老師

參賽學生: 林嘉晴、蔡致遠、何立行、袁梓嫣、葉澔洋

目錄

一. 引言

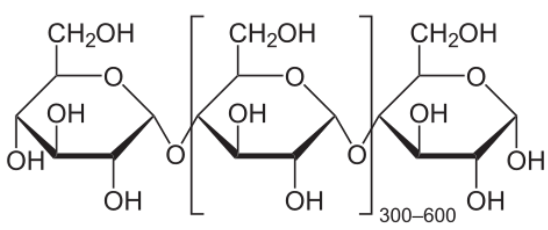
日常生活中使用的塑膠製品，例如膠袋、保鮮紙等，在生產時會消耗大量的化石燃料，加劇全球暖化。廢棄後的塑膠製品會造成塑膠污染，除了需上百年才能天然分解之外，降解的過程中所釋放的物質對土地、海洋以及生物都會造成影響，甚至經由食物鏈危害人類。有見及此，本研究從生物可分解塑膠的概念出發，希望製作出一種生物可降解的塑膠材料取代部份傳統一次性塑膠，從而去解決海洋塑膠污染。

二. 科學原理

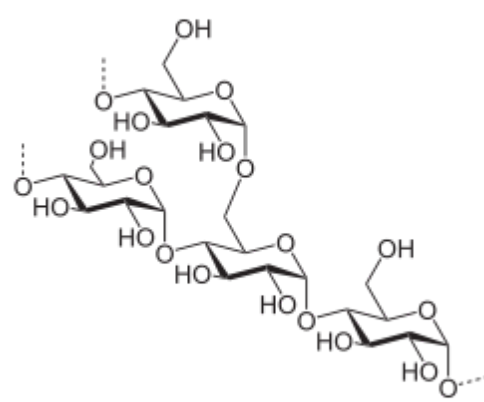
生物可分解塑膠是可以在自然界降解的塑膠材質。在有足夠的濕度、氧氣與適當微生物存在的自然掩埋或堆肥環境中，可被微生物所代謝分解產生水和二氧化碳或甲烷，對環境危害較小。生物可分解塑膠主要的材料是澱粉、聚乳酸及纖維蛋白質等可由微生物所代謝的聚合物。我們將嘗試用澱粉類、海藻酸鈉、果膠及魚膠製作可分解之聚合物。

澱粉

它是一種多糖。分子式為$(C_6H_{10}O_5)n$。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



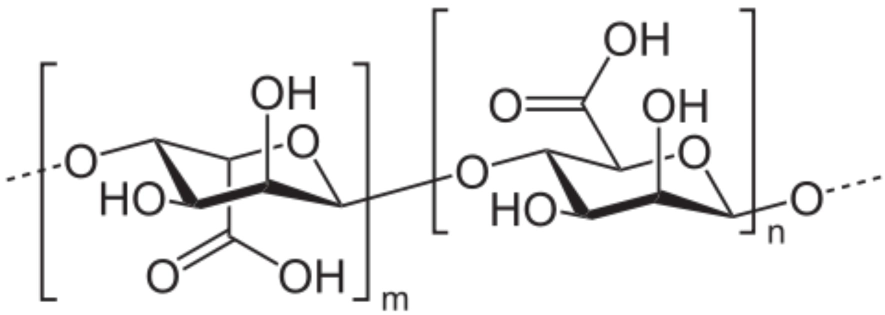
支鏈澱粉

澱粉的糊化作用及膠化作用

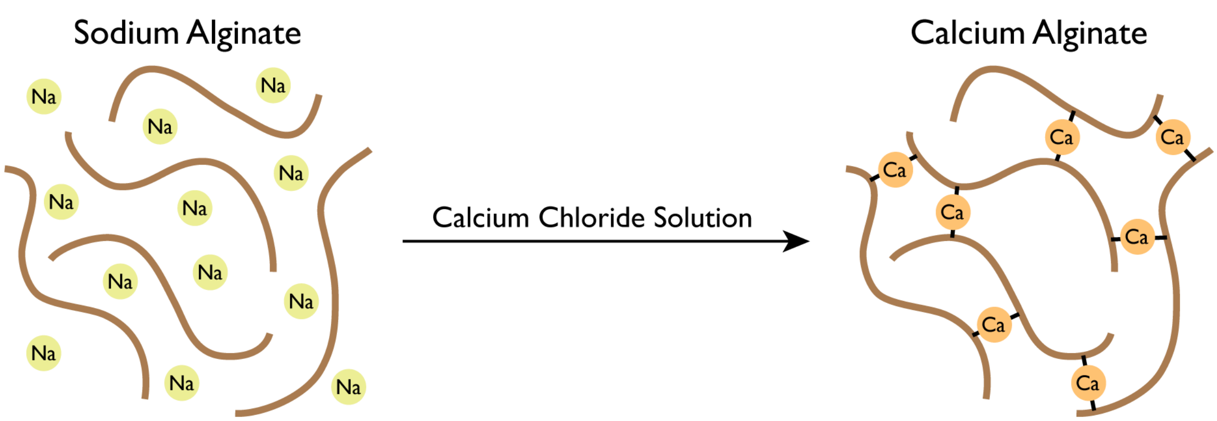
澱粉顆粒受熱吸水膨潤後會產生糊化作用，然後支鏈澱粉的結構能阻止直鏈澱粉緊密整齊的排列，形成類似塑膠的聚合物。而大多數糊化的澱粉在冷卻時使得纏繞現象增加，以及澱粉分子間的氫鍵形成，將許多水分子保留其中，失去其流動性，因而形成凝膠。

海藻酸

海藻酸又稱藻酸、褐藻酸、海藻素，是存在於褐藻細胞壁中的一種天然多糖。海藻酸是由單糖醛酸線性聚合而成的多糖聚合物。

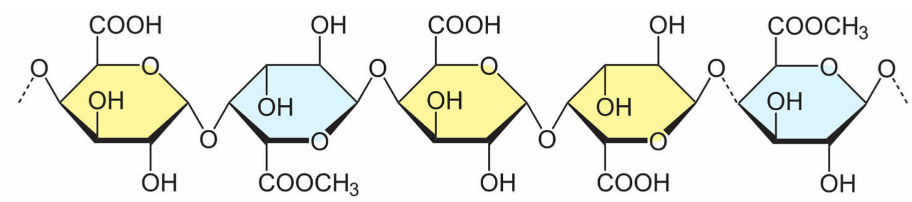


當把海藻酸鈉滴入有氯化鈣的溶液時，海藻酸鈉會立即凝固，因為當海藻酸鈉滴入氯化鈣中，鈣離子會取代納離子的角色，並且抓住海藻酸鈉分子之間的羧酸離子，使得分子間的聯結性更強，此交聯作用使分子更為固定，流動性降低而固化形成膠狀物。



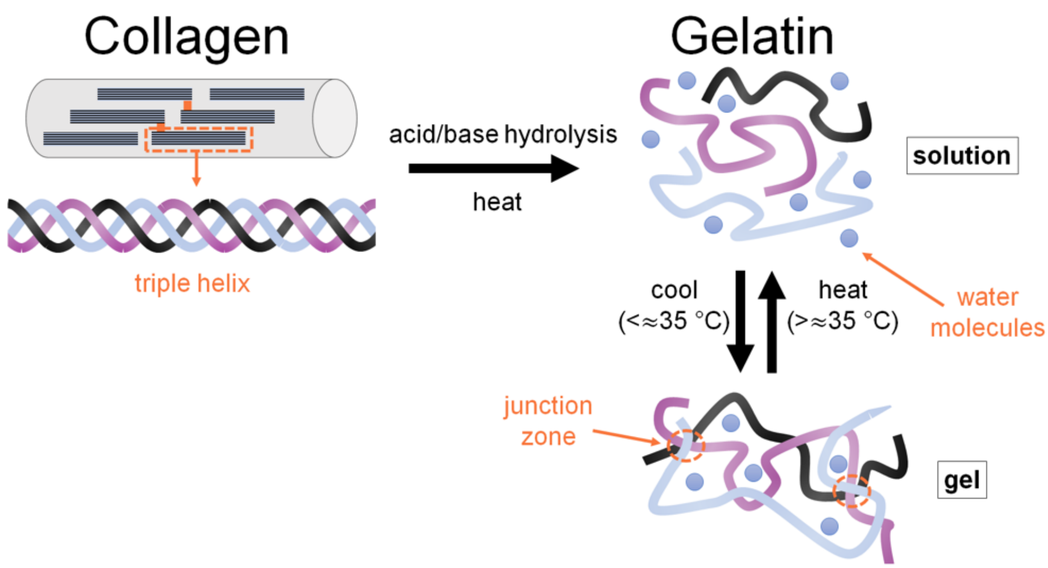
果膠

它是一類天然高分子化合物，具有凝膠、增稠及乳化等作用。果膠也是一種天然的食物添加劑。



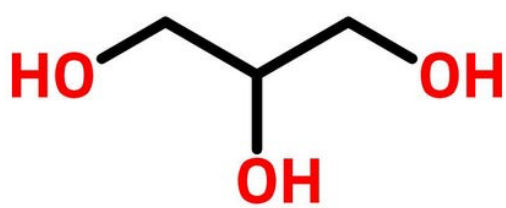
魚膠/明膠

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。



甘油

化學名稱為丙三醇，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，使其形成的生物塑膠更富彈性及柔軟度。



三. 探究目的

一、　利用不同澱粉質、海藻酸鈉、果膠及魚膠製成生物可分解塑膠。

二、　測試生物可分解塑膠的耐熱溫度、強韌度、水溶性、生物可分解性等物理性質。

三、　利用最理想的生物可分解塑膠製作成不同的傳統塑膠替代品。

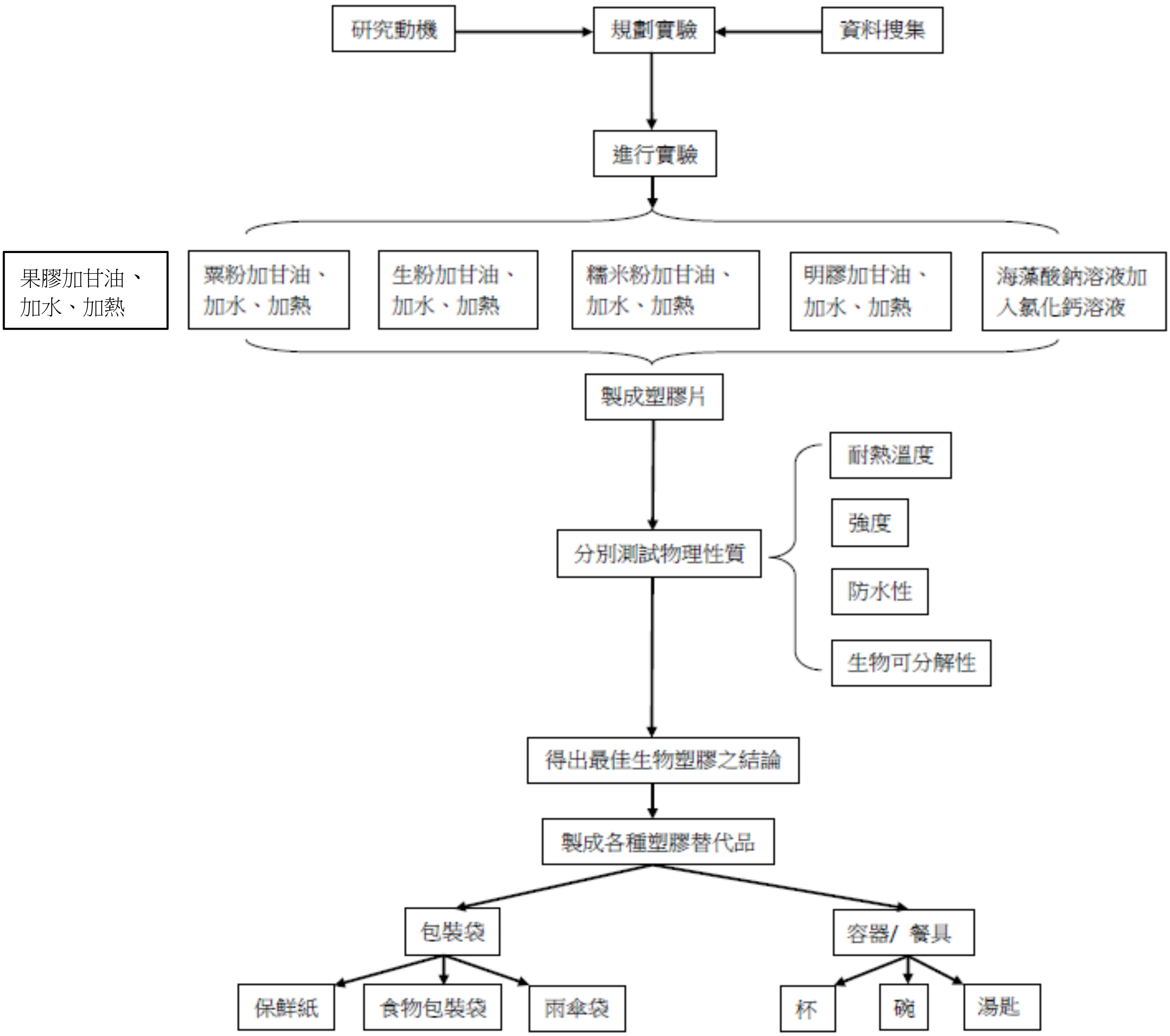
四. 假設

研究假設：「自製的生物可分解塑膠可代替不同的傳統塑膠。」

五. 實驗材料及用具

實驗材料		**實驗用具**	
● 粟粉	● 甘油	● 燒杯	● 煮食鍋
● 生粉	● 醋	● 量筒	● 噴壺
● 糯米粉	● 蒸餾水	● 滴管	● 隔渣網/牛油紙
● 魚膠(明膠)	● 果膠	● 電子秤	● 刮勺
● 海藻酸鈉	● 保解紙（聚氯乙烯）	● 電磁爐	● 鐵架及鐵夾
● 氯化鈣	● A4 透明文件夾（聚丙烯）	● 玻璃棒	● 砝碼
		● 矽膠蛋糕刮勺	● 焗爐
		● 各式模具	● 支架及夾

六. 研究過程及方法



表一: 研究架構流程表

七. 實驗設計及步驟

(A) 製作澱粉生物塑膠片

實驗步驟

（1）用煮食鍋把澱粉加入甘油、米醋及適量蒸餾水，用電磁爐加熱並不停攪拌，直至混合物變得黏稠並化成凝膠狀。

（2）然後把凝膠狀的混合物均勻倒在平底模具上。

（3）放在通風乾爽的地方約 5 日等其水分蒸發後變乾硬化，及後進行各式物理特性測試。

樣本	粟粉	生粉	糯米粉	米醋	甘油	蒸餾水	製成度
粟粉 1	30g	/	/	20mL	0mL	200mL	較差
粟粉 2	30g	/	/	20mL	20mL	200mL	較好
生粉 1	/	30g	/	20mL	0mL	200mL	較差
生粉 2	/	30g	/	20mL	20mL	200mL	較差
糯米粉 1	/	/	30g	20mL	0mL	200mL	較差
糯米粉 2	/	/	30g	20mL	20mL	200mL	較差

表二: 各種澱粉類生物塑膠片之配方

經由多次嘗試製作後，發現粟粉 2 之配方所製成的生物可分解塑膠能夠成形並且不會在取起時大幅度破裂，具一定的柔軟度，因此選為澱粉類生物塑膠片的代表用作後期的物理性質測試品。

(B) 製作海藻酸鈉生物塑膠片

實驗步驟

（1）把海藻酸鈉粉劑加於蒸餾水中，攪拌直至完全溶解。把甘油加至已溶解的海藻酸鈉溶液中，繼續攪拌直至完全混合。把海藻酸鈉溶液倒在容器後並放置在冰箱一晚後待用。

（2）另一方面，把氯化鈣（CaCl2）溶解在蒸餾水中，把少量的氯化鈣溶液噴灑在隔渣網上，再把冷藏過的海藻酸鈉溶液均勻地倒在模具的隔渣網上，

（3） 與製程（A）的步驟 (3) 相同。

樣本	海藻酸鈉	溶解海藻酸鈉的蒸餾水	甘油	氯化鈣（CaCl2）	溶解氯化鈣的蒸餾水	製成度
海藻酸鈉 1	6g	200mL	4g	10g	100mL	較差
海藻酸鈉 2	8g	200mL	4g	10g	100mL	較好

表三: 海藻酸鈉生物塑膠片之配方

經由多次嘗試製作後，發現海藻酸鈉 2 之配方所製成的生物可分解塑膠能成功成形，因此選為用作後期的物理性質測試品。

(C) 製作果膠生物塑膠片

實驗步驟

（1）用煮食鍋把果膠加入甘油和適量蒸餾水，用電磁爐加熱並不停攪拌，直至混合物變得黏稠並化成凝膠狀。

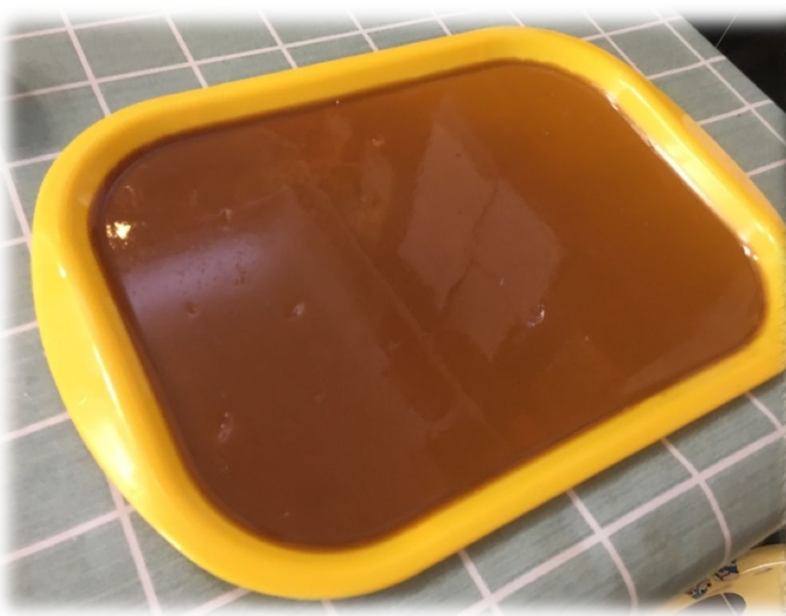
（2）與製程（A）的步驟 (2) 相同。

（3）與製程（A）的步驟 (3) 相同。

樣本	果膠	蒸餾水	甘油	製成度
果膠 1	40g	300mL	4g	較差
果膠 2	60g	300mL	4g	較好

表四: 果膠生物塑膠片之配方

經由多次嘗試製作後，發現果膠 2 之配方所製成的生物可分解塑膠能成功成形，因此選為用作後期的物理性質測試品。



(D) 製作魚膠生物塑膠片

實驗步驟

（1）用煮食鍋把魚膠加入甘油和適量蒸餾水，用電磁爐加熱並不停攪拌，直至混合物變得黏稠並化成凝膠狀。

（2）與製程（A）的步驟 (2) 相同。

（3）與製程（A）的步驟 (3) 相同。

樣本	魚膠	蒸餾水	甘油	製成度
魚膠 1	40g	300mL	4g	較差
魚膠 2	60g	300mL	4g	較好

表五: 魚膠生物塑膠片之配方

經由多次嘗試製作後，發現魚膠 2 之配方所製成的生物可分解塑膠能成功成形，因此選為用作後期的物理性質測試品。

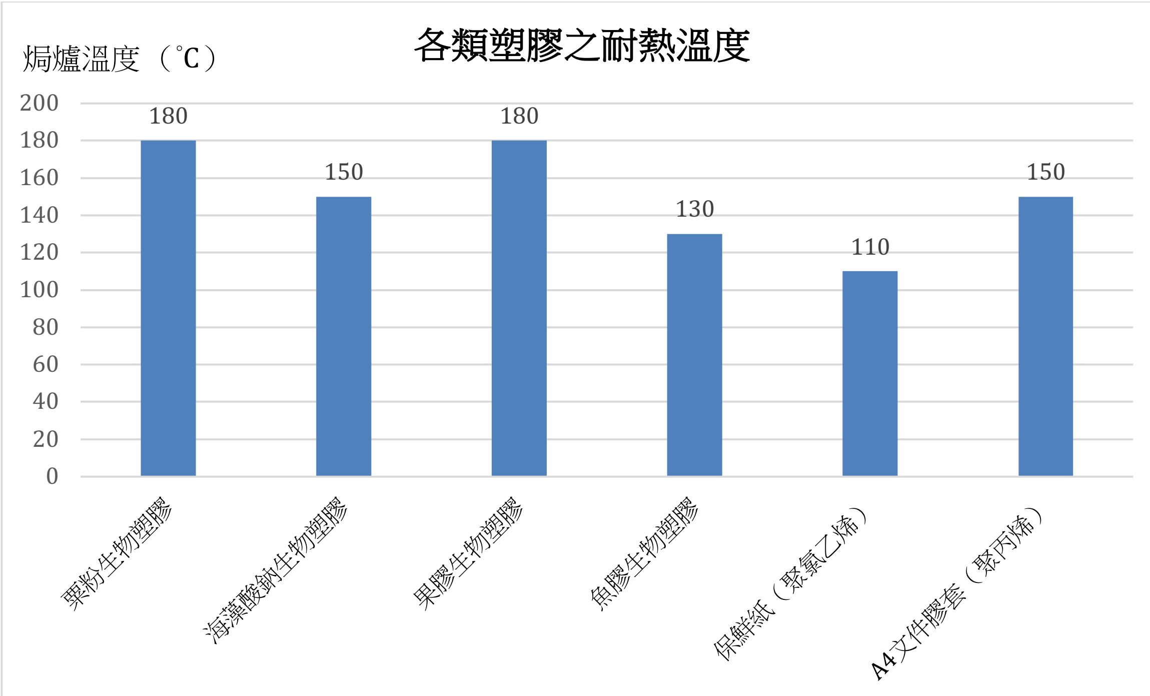
測試物理性質

(I) 生物可分解塑膠耐熱溫度

以焗爐加熱相同面積 （4x4cm）的生物可分解塑膠，觀察其顏色及外觀變化。

溫度、時間	粟粉生物塑膠	海藻酸鈉生物塑膠	果膠生物塑膠	魚膠生物塑膠	保鮮紙（聚氯乙烯）	A4 文件膠套（聚丙烯）
70 度、20 分鐘	顏色不變	顏色不變	顏色不變	顏色不變	顏色不變	顏色不變
90 度、20 分鐘	顏色不變	顏色不變	顏色不變	顏色不變	顏色不變	顏色不變
110 度、20 分鐘	顏色不變	顏色不變	顏色不變	顏色不變	開始卷曲，收縮	顏色不變
130 度、20 分鐘	顏色不變	顏色不變	顏色不變	開始變黃	卷曲成一團，微焦	顏色不變
150 度、20 分鐘	顏色不變	開始變黃	顏色不變	開始變黃	卷曲成一團，焦黑	開始卷曲，收縮
180 度、20 分鐘	開始變黃	顏色加深	顏色少許加深	顏色加深	卷曲成一團，焦黑	卷曲成一團，收縮
200 度、20 分鐘	顏色加深	顏色變啡	顏色少許加深	顏色加深	卷曲成一團，焦黑	卷曲成一團，微焦

表六: 生物可分解塑膠耐熱程度



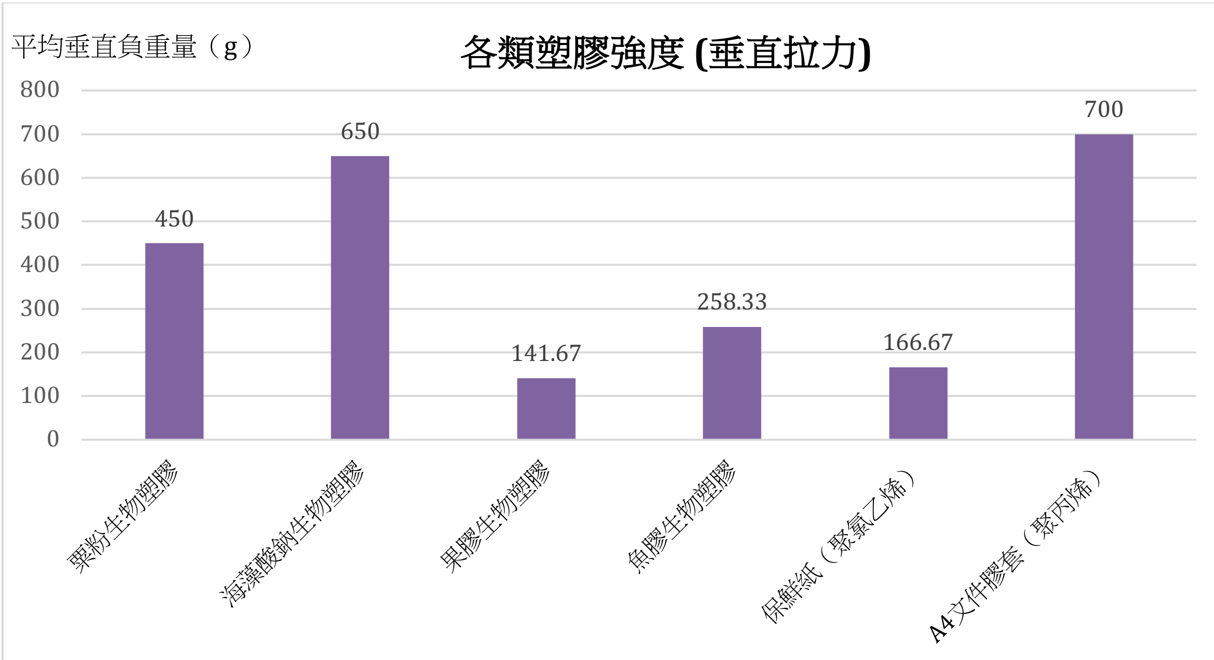
圖一： 各類塑膠耐熱溫度棒形圖

(II) 生物可分解塑膠強度 (垂直拉力)

利用砝碼(每個 50g)測試相同大小(4x4cm)生物可分解塑膠及傳統塑膠的垂直拉力, 直至該塊膠片斷裂而無法承受進一步重量。

項目	次數	粟粉 生物塑膠	海藻酸鈉 生物塑膠	果膠 生物塑膠	魚膠 生物塑膠	保鮮紙 （聚氯乙烯）	A4 文件膠套 （聚丙烯）
垂直拉力(g)	1	400	850	200	350	150	700
	2	350	650	150	250	200	750
	3	450	500	150	250	150	650
	4	450	650	100	350	150	700
	5	550	600	100	200	200	650
	6	500	750	150	250	150	750
	平均值	450	650	141.67	258.33	166.67	700

表七: 生物可分解塑膠垂直拉力強度



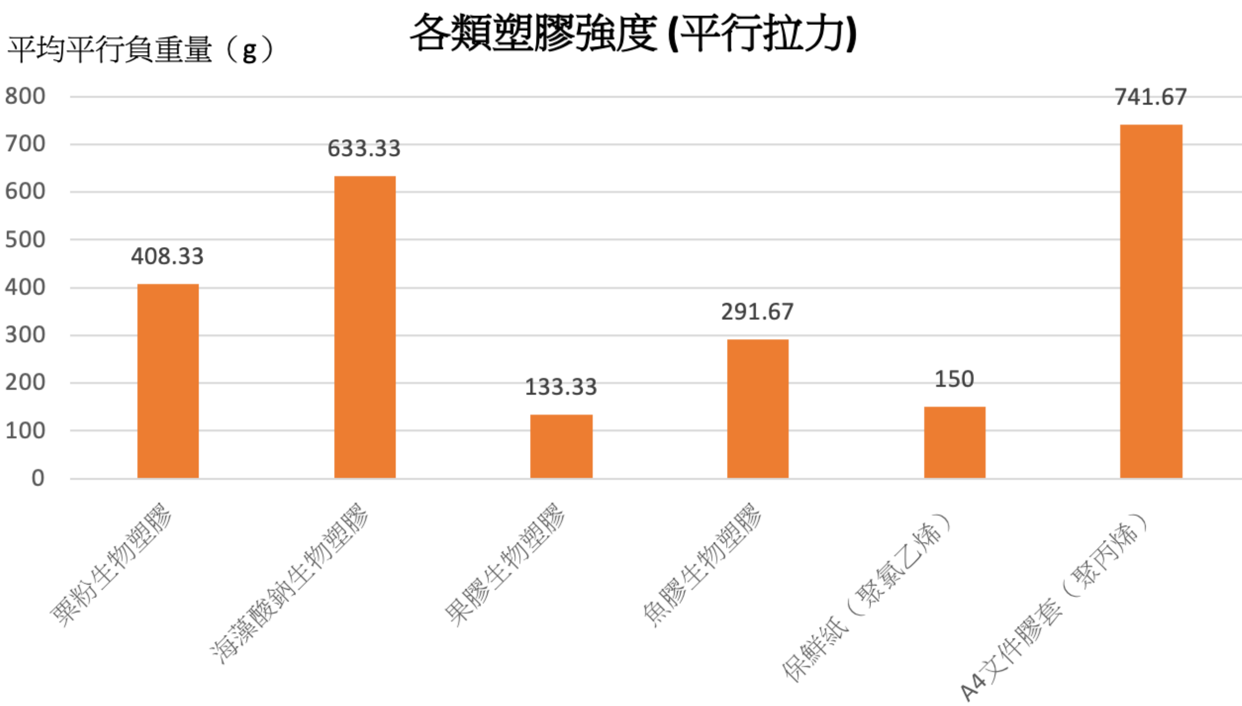
圖二： 各類塑膠垂直拉力棒形圖

(III) 生物可分解塑膠強度 (平行拉力)

利用砝碼(每個 50g)測試相同大小(4x4cm)生物可分解塑膠及傳統塑膠的平行拉力, 直至該塊膠片斷裂而無法承受進一步重量。

項目	次數	粟粉 生物塑膠	海藻酸鈉 生物塑膠	果膠 生物塑膠	魚膠 生物塑膠	保鮮紙 （聚氯乙烯）	A4 文件膠套 （聚丙烯）
平行拉力(g)	1	350	600	100	300	100	800
	2	300	600	100	300	150	750
	3	400	550	150	350	200	750
	4	450	700	150	250	100	650
	5	500	650	200	250	150	700
	6	450	700	100	300	200	800
	平均值	408.33	633.33	133.33	291.67	150	741.67

表七: 生物可分解塑膠平行拉力強度



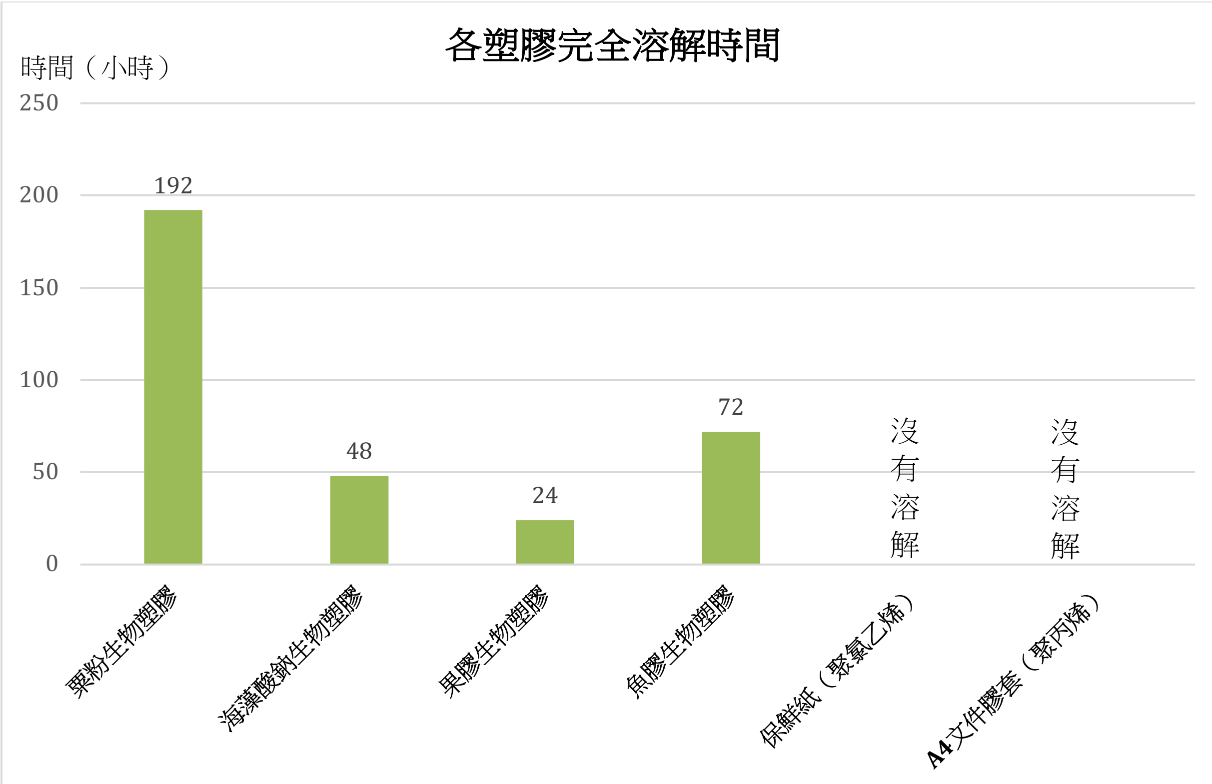
圖三： 各類塑膠平行拉力棒形圖

(IV) 生物可分解塑膠防水性

取片狀(4x4cm)的生物可分解塑膠，秤重後，並加入其重量 10 倍的水，於室溫下加蓋，測試其防水性。

日數	粟粉 生物塑膠 + 30mL 蒸餾水	海藻酸鈉 生物塑膠 + 30mL 蒸餾水	果膠 生物塑膠 + 30mL 蒸餾水	魚膠 生物塑膠 + 30mL 蒸餾水	保鮮紙 + 30mL 蒸餾水	A4 文件 膠套 + 30mL 蒸餾水
1	完整	大面積溶解、殘留有小碎塊	完全溶解、成為棕色黏稠液體	軟化、有碎裂	完整	完整
2	完整	完全溶解、成啫喱狀	完全溶解	碎裂成小片、非常柔軟	完整	完整
3	開始出現碎裂、大致完整	完全溶解	完全溶解	完全溶解	完整	完整
4	大致完整、進一步軟化	完全溶解	完全溶解	完全溶解	完整	完整
5	出現更多小碎片	完全溶解	完全溶解	完全溶解	完整	完整
6	學校假期，未能紀錄。					
7						
8	大部份溶解	完全溶解	完全溶解	完全溶解	完整	完整

表八: 生物可分解塑膠防水性



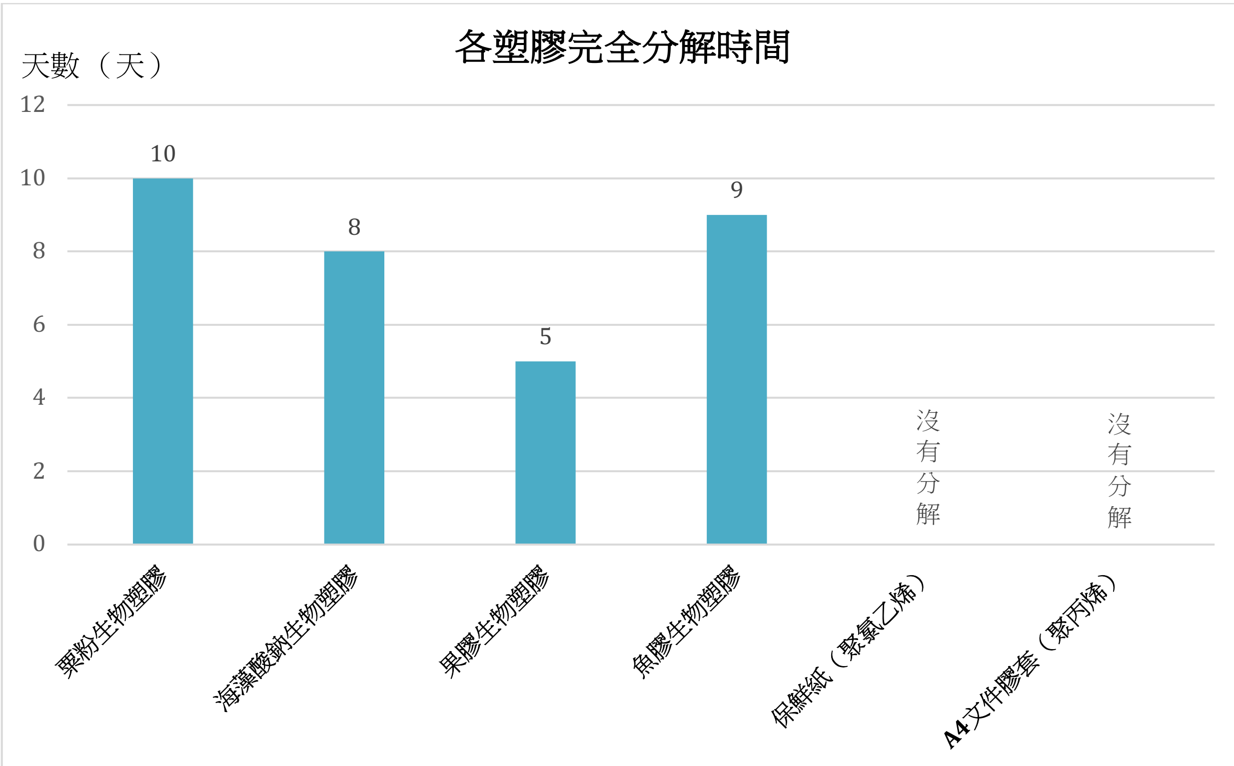
圖四： 各類塑膠水溶性棒形圖

(IV) 生物可分解塑膠生物可分解性

取片狀(4x4cm)的生物可分解塑膠，秤重 5g 後埋入土壤中，鋪上約 10cm 之土壤測試其生物可分解性。

日數	粟粉 生物塑膠	海藻酸鈉 生物塑膠	果膠 生物塑膠	魚膠 生物塑膠	保鮮紙 （聚氯乙烯）	A4 文件膠套 （聚丙烯）
1	完整，但呈捲曲狀	完整，但出現小裂痕、軟化	完整，但普遍軟化	完整，但普遍軟化	完整	完整
2	少許碎裂、軟化	進一步軟化，黏手	大部分分解成小碎片	稍微破碎	完整	完整
3	少許碎裂、軟化	出現小碎塊、軟化	粉末	出現小碎塊、軟化	完整	完整
4	少許碎裂、軟化	出現小碎塊、軟化	粉末	出現小碎塊、軟化	完整	完整
5	少許碎裂、軟化	粉末	分解	粉末	完整	完整
6	學校假期，未能紀錄。					
7						
8	大面積碎裂、軟化	分解	分解	粉末	完整	完整
9	粉末	分解	分解	分解	完整	完整
10	分解	分解	分解	分解	完整	完整

表九: 生物可分解塑膠生物可分解性



圖五： 各類塑膠生物可分解性棒形圖

八. 實驗結果及討論

由以上實驗統整可得：

A. 粟粉生物塑膠特性：可耐熱 180 度，是各生物塑膠中最耐熱；負重能力中等；水中溶解度及生物分解度是各生物塑膠中最低，但仍能於 10 天內分解，生物分解性不俗。

B. 海藻酸鈉生物塑膠特性：可耐熱 150 度，屬中等； 負重能力是各物塑膠中最高，媲美 A 4 文件膠套；其水中溶解度高，4 天後達完全溶解；8 天後可達 100%生物分解，生物分解性優秀。

C. 果膠生物塑膠特性：可耐熱 180 度，是各生物塑膠中最耐熱；可惜負重能力最弱；水中溶解度及生物分解度是各生物塑膠中都屬最高，能於 2 天內完全分解，有著易脆且高度水溶性及高速生物分解性之特點。

D. 魚膠生物塑膠特性：可耐熱 130 度，抗熱力較弱； 負重能力偏弱；唯水中溶解度為各生物塑膠中排第二； 生物分解性優秀，能於 9 天後完全分解。

比較自製生物可分解塑膠及傳統塑膠

	生物可分解塑膠	傳統塑膠
優點	● 其中粟粉及果膠的耐熱程度比傳統塑膠為高，若然作為加熱食物之包裝便更優勝。 ● 4 款自製生物可分解塑膠都具備不同程度的生物可分解性，但它們的分解性都非常優異，不出 10 日都能 100%在泥土中分解, 若能加以應用，能減輕海洋及土地污染問題。	● 低水溶性，常時間浸泡於中水不會軟化及變形，防水力高，不易受空氣濕度影響並透水性及硬度，適宜作盛載液體的容器。 ● 極低生物可分解性，不易發霉，適合作儲存器皿及物品包裝用途。 ● 生產價格低廉。
缺點	● 水溶性偏高，4 款自製生物可分解塑膠中有 3 款都在 3 天內完全溶解於水中。而水溶性最低的粟粉生物塑膠在水中即使沒有快速溶解，但	● 極低水溶性及生物可分解性，在大自然中難以自然分解，容易造成海洋及土地污染，危害食物鏈。

	都會變軟及黏手。因此以上所有自製的生物可分解塑膠都不能作為盛載液體的容器。 ● 由於生物可分解性及水溶性非常優秀，若然天氣潮濕時，這些生物可分解塑膠都會很容易發生發霉的問題，影響衞生。因此難以長時間去保存東西，特別是食物。 ● 使用生物可分解塑膠，需要許多耕地與糧食作原材料。 ● 生產價格較高昂。	● 傳統塑膠的原材料時為石油，在開發時會產生大量空氣污染物，並造成空氣污染。 ● 傳統塑膠的原材料時為石油，為不可再生能源，終有一日會用盡。

九. 應用 - 製成各種傳統塑膠替代品

➢ **隔熱物料**

自製生物塑膠的耐熱度普遍較高，最高可承受 180 攝氏度，比普通傳統塑膠耐熱能力更高。因此可應用在一些需要阻隔高溫的場合，例如隔熱煲墊、一次性熱飲杯邊的隔熱層及其他隔熱物料等。

➢ **一次性的包裝膜/ 食物盒的上層包裝膜**

自製生物塑膠的負重能力相當優秀，特別是海藻酸鈉生物塑膠和粟粉生物塑膠，4x4cm 的大小已可承受最高達 650g 的重量。這優秀的負重力及物理強度足以製成物流快遞運輸與投遞用包裝塑膠膜、袋，又或是禮物包裝紙。另外亦可用於一次性食物盒的上層包裝膜，例如飛機餐中的甜品及水果的餐盒蓋/ 膜。如果日後防水性能能提升的話，可嘗試製作成一次性食物盒、餐具、杯又或是雨傘袋等。

➢ **防疫用具**

自製生物塑膠的負重及物理強度高，也非常適合用於製作防飛沫擋板、面罩、眼罩等防疫用具，使用這些防疫用具時普遍都會避開和液體的接觸，不需過於擔心水溶性的問題。而且這些用品需時不時更換，所以自製生物塑膠亦能應用於此。

十. 限制及改善

1. 生物可分解塑膠在風乾的過程時很受空氣濕度的影響，在制作時經常因回南天潮濕的因素導致未能完全乾硬化，等待天數亦因此延長。最後更經常因此而發生發霉的情況，導致實驗測試品作廢。建議日後如需風乾時，能有烘箱等專業器材加快蒸發生物可分解塑膠的水份，達至理想狀態。

2. 由於疫情斷斷續續令實驗過程中斷，初時所制作的實驗測試品未能及時進行物理測試而導致浪費。建議日後疫情退散後，所有實驗測試品應及時帶回校，與其他實驗組進行公平測試。

十一. 總結

在是次的探究中，不能否認的是現時由同學自製的生物可分解塑膠的多項特性不能取代真正的塑膠。但我們發現由粟粉、海藻酸鈉、果膠及魚膠所製作的生物可分解塑膠不但有很優秀的生物可分解能力，還有一定程度的耐熱性、負重能力、拉力，甚至個別具不俗的防水性。因此它們都非常具備潛質去加以研究，以及升級成為一些傳統塑膠的替代品，例如： 隔熱物料、一次性的郵件/食物包裝膜、防疫用具等。我們期待有高水溶性及生物降解度的生物塑膠能逐步應用到生活當中，進一步減輕由傳統塑膠製造的環境問題，做到人人「齊來轉「塑」快，令個海洋健康曬！」

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亞軍

第十五屆香港科學青苗獎

室温蔬菜保鮮法

聖保羅男女中學附屬小學

參賽學生：陳宥臻　郭溱　梁峰　嚴海亮　陳皆攸

指導老師：王紀人　陳穗雯

一、引言

現時香港約有 22 萬人居住在劏房[1]，由於環境狹小加上電費壓力，不少家庭無法放置雪櫃來冷藏食物，影響食物的儲存期限。就綠葉蔬菜而言，在 0-4ºC 環境下能保鮮達一星期[2]，但在室溫只能保存 1-2 日。另一方面，購買蔬菜時，通常買得越多平均的價錢越便宜，但買得多又不能保鮮只會造成浪費，因此可以推想沒有雪櫃的家庭會避免購買綠葉蔬菜。

可是，綠色蔬菜的好處相當多[3]。除了能提供豐富的鈣、鉀、鎂元素和維生素 K、B2、C，當中的葉酸減低嬰兒畸形風險；含有大量的胡蘿蔔素和葉黃素，促進眼睛健康。而流行病學研究表明，蔬菜的攝取量增加，罹患癌症、冠心病、糖尿病的風險也會顯著下降。

因此我們希望探究**在不用雪櫃的情況下最能延長蔬菜食用期限的保鮮方法**。

二、綠葉蔬菜變壞的原因

1. 當蔬菜暴露在空氣中，水份會因蒸發而流失，過度流失會令食物脱水，影響食物的外觀和質感。[4]

2. 自然腐爛和受微生物污染。[4]

3. 蔬菜含有大量酶，當植物被收割或受損後，植物內部接觸到氧，便會活化這些酶的作用，使蔬菜加速老化。而酶亦會受溫度影響，一般環境下，溫度越高，酶的活性越高。[5]

三、市場產品調查

我們發現市面上有些蔬菜保鮮產品聲稱能提升保鮮蔬菜的效能[7]。根據他們的產品説明，這種蔬菜保鮮袋的成份中有米糠，當中含有的阿魏酸（Ferulic Acid）是一種存在於植物細胞壁的抗氧化物。而根據科學期刊研究，原來麥糠中的阿魏酸成份比其他穀物更多[8]。

四、我們希望測試使用不同的處理方法，減少不同因素對蔬菜的影響，繼而延長蔬菜保鮮期限。針對以上各點，以下是我們初步的設計方向：

1. 選菜的過程中，盡量將蔬菜損毀的部分先除去，避免受感染的部分擴散。

2. 儲存蔬菜時會有遮掩。

3. 針對酶和微生物這兩因素，我們發現有人使用快灼(quick blanch)的方式處理蔬菜，即是短暫地讓蔬菜接觸熱水，目的是停止菜內的酶的作用，同時亦清除表面污泥和殺死微生物。[6]

4. 測試加入麥糠對保存蔬菜的成效。

五、測試指標

1. 觀察蔬菜外表（堅挺/萎縮、完整/腐爛、發霉、發黃/黑)
2. 量度蔬菜重量流失
3. 在後期進行維生素 C 測試

維生素 C 測試原理

維生素 C 具有還原作用，能將碘還原為碘離子（無色溶液）；另一方面碘會與澱粉溶液反應形成藍黑色液體。如果蔬菜汁液（菜汁）中存在維生素 C，會將碘溶液的褐色將變為無色。因此我們將澱粉溶液加入菜汁，然後逐少加入碘溶液，量度令蔬菜-澱粉溶液變成藍黑色所需的碘溶液分量，加入的碘溶液越多，表示維生素 C 含量越高。[9]

方法：

 1.將菜用攪拌機打碎	 2.加入 50mL 水研磨出菜汁

 3.量度出 5g 的菜汁後，加入約 3-4 滴的澱粉溶液。	 4.在蔬菜-澱粉溶液中加入碘液，觀察顏色的變化。
 5.記錄溶液開始變色時的重量，繼續加入碘液至顏色不再改變。	 左：測試前菜汁的顏色 中、右：測試後菜汁的顏色

六、實驗

<u>實驗一</u>

假設：麥糠中的阿魏酸在一般環境中能自然釋出，繼而減慢蔬菜氧化情況

目的：測試加入麥糠能否有效為蔬菜保鮮

方法：將綠葉蔬菜放在有麥糠和沒有麥糠的塑膠容器中，觀察外表和量度重量

測試材料：兩款約 40 克蔬菜（白菜及芥蘭）、膠盒、麥糠

實驗方法及結果：

	包裝方法及環境	第一日起始重量(g) (18/3)	第七日完結重量(g) (24/3)	重量減少比率	萎縮	腐爛	發霉	發黃/黑
1	透明膠盒,陰涼處	 42g	 39g	7.14%	×	✓	✓	✓
2	透明膠盒,內放 40g 麥糠,陰涼處	 40g	 23g	42.50%	✓	✓	✓	✓
3	透明膠盒,放入雪櫃(攝氏 0-4 度)	 43g	 40g	6.98%	×	×	×	✓
4	透明膠盒,內放 40g 麥糠,放入雪櫃(攝氏 0-4 度)	 44g	 33g	25.00%	✓	×	×	✓
5	對照實驗：暴露室內環境	 44g	 11g	75.00%	✓	×	×	✓

註：白菜的實驗結果參考附件

分析：

1. 加入麥糠並沒有顯著提升保鮮效果，可能由於麥糠中有效成分未能釋出，加上麥糠沒有經過特別處理，本身亦可能有微生物，所以沒有麥糠的膠盒中的蔬菜反而更少感染。由於我們希望推廣簡單的保鮮方法，因此不再研究如何進一步處理麥糠。

2. 膠盒內困着的濕氣會令霉菌滋生。

實驗二

假設：1.減低環境的濕度，能減少真菌滋生。

2.空氣會使霉菌容易滋生，以及使蔬菜氧化。

3.高溫(沸水)能停止或減慢酶的作用，並殺死蔬菜表面的微生物和蟲卵。

4.鹽水能沖走蔬菜表面的微生物和蟲卵。

目的：將菜先以不同方法處理，再利用不同的包裹方法，測試能否有效為蔬菜保鮮

方法：

- 在膠蓋上開透氣洞，增加空氣流動；
- 利用廚房紙包裹，吸收水氣；
- 將蔬菜放入密實袋中，並利用水壓將袋內大部分空氣排出(水壓法)；
- 利用快灼的方法，將蔬菜放入沸水中 5 秒；
- 利用鹽水沖洗的方法，將蔬菜放入鹽水(2 升水:5 克鹽)沖洗 10 秒。

材料：每組約 40 克菜心、透明膠盒及開孔蓋、密實袋、廚房紙、鹽水

上圖：以水壓法將密實袋內大部分空氣排出

實驗方法及結果：

	包裝方法及環境	菜的處理	第一日起始重量(g)(29/4)	第五日完結重量(g)(3/5)	重量減少比率	萎縮	腐爛	發霉	發黃/黑
1	膠盒+開孔蓋 +廚房紙將每顆菜包裹	快灼	 42.05	 35.05	16.65%	✓	✓	✓	×
2	密實袋+廚房紙將每顆菜包裹	快灼	 41.65	 36.61	12.10%	✓	✓	×	×
3	膠盒+開孔蓋	快灼	 41.69	 40.29	3.36%	✓	✓	✓	×
4	密實袋(水壓法)	快灼	 43.21	 40.83	5.51%	✓	✓	✓	×
5	膠盒+開孔蓋+廚房紙將每顆菜包裹	鹽水沖洗	 42.20	 37.70	10.66%	×	×	×	✓
6	密實袋+廚房紙將每顆菜包裹	鹽水沖洗	 42.04	 40.42	3.85%	×	×	×	✓

7	膠盒+開孔蓋	鹽水沖洗	 43.36	 36.95	14.78%	×	×	×	✓
8	密實袋(水壓法)	鹽水沖洗	 42.74	 40.17	6.01%	×	×	×	✓
9	膠盒+開孔蓋+廚房紙將每顆菜包裹	/	 43.31	 33.84	21.87%	×	×	×	✓
10	密實袋+廚房紙將每顆菜包裹	/	 41.20	 36.68	10.97%	×	×	×	✓
11	膠盒+開孔蓋	/	 41.84	 34.45	17.66%	×	×	×	✓
12	密實袋(水壓法)	/	 41.13	 39.70	3.48%	×	×	×	×
13	膠盒+開孔蓋+廚房紙將每顆菜包裹 (放在雪櫃)	/	 42.21	 37.71	10.66%	×	×	×	×
14	密實袋+廚房紙將每顆菜包裹(放在雪櫃)	/	 42.31	 38.46	9.10%	×	×	×	×

15	膠盒+開孔蓋(雪櫃)		 43.22	 39.61	8.35%	×	×	×	×
16	密實袋(水壓法)(雪櫃)	/	 41.64	 41.6	0.10%	×	×	×	×
17	對照實驗： 暴露室內環境中	/	 42.91	 16.13	62.41%	✓	×	×	✓

分析：

從外表觀察，放在雪櫃的蔬菜(第 13-16 組)保持嫩綠，經過鹽水處理的蔬菜(第 5-8 組)的小面積葉面變黃，相比下未經特別處理的蔬菜(第 9-11 組)的葉面較黃，只有放在密實袋兼用了水壓法的第 12 組葉面沒有變黃，由此，下一階段會測試使用鹽水，和利用密實袋兼水壓法能否提升保鮮成效。

實驗三

假設：1.利用鹽水沖洗的方法比只用清水沖洗或不沖洗更能令蔬菜保鮮；2.排走密實袋中的空氣能有效保鮮

目的：測試利用鹽水沖洗蔬菜然後放入密實袋，並以水壓法排走空氣能有效保鮮。

方法：1.將蔬菜放入鹽水(2 升水:5 克鹽)、清水沖洗 10 秒或不作任何處理。2.將蔬菜放入密實袋中，不經特別方法或利用水壓將袋內大部分空氣排出(水壓法)。3.於實驗第一天先測試一組約 40 克菜心的維生素 C 含量，並在第六天測試蔬菜的維生素 C 含量與其對照。

材料：每組約 40 克菜心、密實袋、鹽水、清水

實驗方法及結果：

	包裝方法及環境	菜的處理	第一日起始重量 (6/5) (g)	第六日完結重量 (11/5) (g)	重量減少比率	萎縮	腐爛	發霉	發黃/黑
1	密實袋(水壓法)	鹽水	 43.29	 43.15	0.32%	×	×	×	變為淺綠
2	密實袋(水壓法)	清水	 44.62	 44.56	0.13%	×	×	×	變為淺綠
3	密實袋(水壓法)	/	 43.52	 43.99	-1.08%	×	×	✓	變為淺綠

4	密實袋	鹽水	 42.68	 43.26	-1.36%	✗	✗	✓	✓
5	密實袋	清水	 42.21	 43.48	-3.01%	✗	✗	✓	✓
6	密實袋	/	 43.06	 43.65	-1.37%	✗	✓	✓	✓
7	對照組 暴露室內環境中	/	 42.59	 12.95	69.59%	✓	✓	✗	✓

維他命 C 含量比較

	測試菜汁重量(g)	加入的澱粉溶液(g)	加入的碘液(g)
實驗前的對照組(43.75g)	5.06	0.17	3.46
五天後的第 1 組	5.06	0.19	2.45
五天後的第 2 組	5.06	0.15	2.81
五天後的第 3 組	5.06	0.16	2.18
五天後的第 4-6 組	由於第 4-6 組的菜心發霉情況嚴重，並不適宜食用，因此沒有進行維生素 C 測試。		
五天後的第 7 組(對照組)	5.07	0.14	1.88

分析：

1. 第 1-2 組葉表顏色最深色，可見水壓法減少密實袋空氣，加上利用清水和鹽水沖洗蔬菜有效減少霉菌滋生；
2. 由於第 1,2 組的效果分別不大，因此之後會以最簡易原則進行實驗，即使用清水用代替鹽水；
3. 第 4-6 組發霉情況嚴重，第 3 組花的部分亦有發霉，這引致第 3-6 組重量有增長。從觀察得知蔬菜上的花及芽滋生霉菌，所以應在實驗前除掉；
4. 維生素 C 測試中，以密實袋保鮮（第 1-3 組）的菜的維生素 C 含量儘管較第一天下降，但仍比對照組高；
5. 六天的保存期太長，葉面顏色偏淺，下一次實驗縮短日子。

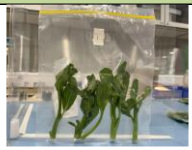
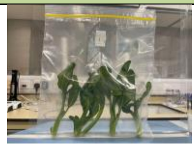
<u>實驗四</u>

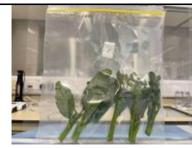
目的：承接實驗三的結論，去除蔬菜的花芽，利用清水沖洗然後放入密實袋，並以水壓法減少空氣，測試 5 天能否有效保鮮。

方法：1.將蔬菜放入清水沖洗 10 秒。2.將蔬菜放入密實袋中，不經特別方法或利用水壓將袋內大部分空氣排出(水壓法)。3.於實驗第一天先測試一組約 40 克菜心的維生素 C 量，並在第五天測試蔬菜的維生素 C 含量與其對照。

材料：約 40 克及約 80 克菜心、密實袋、清水

實驗方法及結果：

	包裝方法及環境	第一日 起始重量(g)(16/5)	第二日	第三日	第四日	第五日 完結重量(g)(20/5)	重量減少比率	萎縮	腐爛	發霉	發黃/黑
1	清水洗放入密實袋放在室內	 43.42				 41.78	3.78	×	×	×	×
2	清水洗放入密實袋放在室內	 83.94				 8.62	-5.6%	×	×	×	×

3	清水洗放入密實袋放在雪櫃	 43.25				 44.98	-4%	×	×	×	×
4	清水洗放入密實袋放在雪櫃	 82.87				 84.99	-2.6%	×	×	×	×
5	對照暴露室內環境中	 42.29				 13.7	67.6%	✓	×	×	✓
6	對照暴露室內環境中	 82.66				 39.57	52.1%	✓	×	×	✓


(圖一)


(圖二)

第 1-4 實驗的蔬菜只稍變為淺綠色，而且沒有萎縮和發霉情況，但葉面卻出現一條條線(紅圈)，線之間有一點點黃白色的昆蟲(藍圈)。經過資料搜集，我們懷疑是類似潛葉蟲的幼蟲在葉面孵化並入侵葉肉[10]。由於蔬菜受蟲害，不適宜食用，因此沒有進一步進行維他命C測試。

實驗五

為了達到更好保鮮的效果，減少蟲害對蔬菜的損害，我們延長沖洗時間，並縮短保存期限至四天。

假設：將蔬菜放在清水中清洗 30 分鐘有助沖洗葉面的蟲卵和蟲

目的：測試把蔬菜清洗後放入密實袋並排走空氣能否有效保鮮 4 天。

方法：1.將蔬菜放入清水沖洗 30 分鐘。2.將蔬菜放入密實袋中，利用水壓將袋內大部分空氣排出(水壓法)。3.於實驗第一天先測試一組約 40 克菜心的維生素 C 含量，並在第四天測試蔬菜的維生素 C 含量與其對照。

材料：約 40 克及約 80 克菜心、密實袋、清水

實驗方法及結果：

	包裝方法及環境	第一日起始重量(g) 25/5	第二日	第三日	第四日完結重量(g) 28/5	重量減少比率	萎縮	腐爛	發霉	發黃/黑
1	清水洗 放入密實袋 放在室內	 42.15			 41.6	1.30%	×	×	×	×
2	清水洗 放入密實袋 放在室內	 84.70			 84.06	0.76%	×	×	×	×
3	清水洗 放入密實袋 放在雪櫃	 41.9			 41.53	0.88%	×	×	×	×

4	清水洗 放入密實袋 放在雪櫃	 84.13			 85.42	-1.53%	×	×	×	×
5	對照 暴露室內環境中	 43.1			 25.83	40.07%	✓	✓	×	✓
6	對照 暴露室內環境中	 82.59			 59.47	27.99%	✓	×	×	✓

維他命 C 含量比較

	測試菜汁重量(g)	加入的澱粉溶液(g)	加入的碘液(g)
實驗前的對照組(41.86g)	5.06	0.19	2.71
五天後的第 1 組,清水洗,放在室內	5.07	0.17	1.86
五天後的第 3 組,清水洗,放在雪櫃	5.06	0.17	1.93
五天後的第 5 組(對照組)	5.05	0.18	1.46

分析：第 1-4 組菜心仍保持嫩綠，表面沒有蟲害侵蝕，亦沒有發霉，放在室溫的蔬菜(第 1 組)維他命Ｃ含量與放在雪櫃的蔬菜(第 3 組)差異不大，都比對照組高。可見，30 分鐘清洗蔬菜，配合密實袋和水壓法，能有助蔬菜保鮮四天。另外，約 80 克的蔬菜量的保鮮效果與約 40 克的相差不大。

七、總結

1. 沒經特別處理的麥糠無法為蔬菜保鮮
2. 困着水氣的膠盒會滋生霉菌
3. 利用水壓法將空氣排走的密實袋能避免滋生霉菌
4. 菜的花和芽容易滋生霉菌
5. 將菜心清洗 30 分鐘可沖走葉面蟲卵，減少蟲害
6. 40-80 克的蔬菜都能使用這個保鮮法

八、建議

預先將菜心清洗 30 分鐘，抹走表面的水份，去除菜的花和芽後放入密實袋，並以水壓法將袋內空氣排出，能有助減少菜心受蟲害、微生物感染和水份流失至少四天。

九、限制

1. 購買蔬菜時，我們盡量選揀新鮮而未經雪藏的蔬菜，但由於無法得知蔬菜採摘和運輸了幾多天，因此只能從外表判斷蔬菜的新鮮程度，如果我們能購買本地的剛新鮮採摘的蔬菜，可能保鮮期可更長。

2. 蔬菜含有豐富營養，受限於實驗室的資源只利用維生素 C 作本實驗的指標。

3. 除了實驗一之外，其餘的實驗均在實驗室環境進行，溫度約是 25 度，濕度亦保持在 60-70%，因此建議使用我們的保鮮方法時，要留意實際天氣和環境狀況，並每天觀察蔬菜的外表來決定食用期限。

4.我們的實驗暫時最多只測試約 80 克菜，如增加蔬菜量，可能會影響水壓法的效果，要留待進一步進行實驗才能確認成效。

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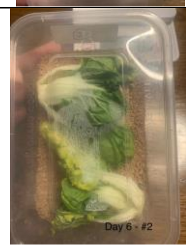
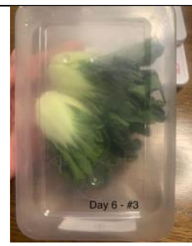
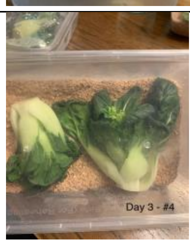
附件：(實驗一：白菜)

設置	包裝方法及環境	重量 Day1 9/3	照片(Day 1)	描述	照片(Day 2)	描述	照片(Day 3)	描述	照片(Day 4)	描述
1	透明膠盒,陰涼處	40g		葉子深綠色，葉莖堅挺， 表面完整，底部充滿水分。		葉子深綠色，葉莖堅挺， 表面完整，底部濕潤。		底部稍微變黃。葉莖堅挺，葉子仍然是深綠色		底部稍微變黃。葉莖開始有皺紋，葉子仍然是深綠色
2	透明膠盒,內放40g麥糠,陰涼處	40g		葉子深綠色，葉莖堅挺， 表面完整，底部充滿水分。		葉子深綠色，葉莖堅挺， 表面完整，底部充滿水分。		底部變乾，莖有皺紋， 葉子仍然是深綠色		底部有黑點，莖有皺紋
3	透明膠盒,放入雪櫃(攝氏0-4度)	40g		葉子深綠色，葉莖堅挺， 表面完整，底部充滿水分。		葉子深綠色，葉莖堅挺， 表面完整，底部充滿水分。		底部濕潤，葉莖堅挺， 葉子仍然是深綠色		底部稍微變乾，莖堅挺，沒有皺紋
4	透明膠盒,內放40g麥糠,放入雪櫃(攝氏0-4度)	40g		葉子深綠色，葉莖堅挺， 表面完整，底部充滿水分。		葉子深綠色，葉莖堅挺， 表面完整，底部充滿水分。		底部稍微變乾，莖有少許皺紋， 葉子仍然是深綠色。		底部稍微變乾，莖有少許皺紋， 葉子稍微捲起。
5	對照實驗：暴露室內環境	40g		葉子深綠色，葉莖堅挺， 表面完整，底部充滿水分。		葉子深綠色，莖有少許皺紋， 表面完整，底部充滿水分。		底部變乾變黃，莖有比較多皺紋， 葉子捲起。		葉子變深，變乾，捲起。莖有較多皺紋。

照片(Day 5)	描述	照片(Day 6)	描述	重量 Day7 25/3	照片(Day 7)	描述
	底部變黃，有皺紋。		底部變乾和稍微變黃，莖有少許皺紋， 葉子捲起少許變黃。	38g		底部稍微變乾和變黃，莖有少許皺紋， 葉子變黃和稍微捲起。
	葉子變黃，有黑點，莖有較多皺紋，底部變黃和變乾。		底部變乾和變黃，有黑點，莖有較多皺紋，葉子捲起和變黃，表面少許萎縮。	29g		底部變乾和變黃，有黑點，莖有較多皺紋，葉子捲起和變黃，表面少許萎縮。有發霉
	底部變乾，莖堅挺，沒有皺紋。		底部變乾，莖堅挺，沒有皺紋。	39g		底部變乾，有微量綠紋， 葉子稍微捲起。菜的表面有水分。
	底部變乾，莖有少許皺紋， 葉子捲起。		底部變乾和稍微變黃，莖有少許皺紋， 葉子捲起。	33g		底部變乾和稍微變黃，有黑點，莖有少許皺紋，葉子捲起。
	底部變乾和變黃，莖有較多皺紋， 葉子稍微捲起。表面萎縮。		底部變乾和變黃，有黑點，莖有較多皺紋，葉子捲起和變黃，表面萎縮。	19g		底部變乾和變黃，有黑點，莖有較多皺紋，葉子捲起和變黃，表面萎縮。

第十五屆

香港科學青苗獎 21/22

季軍

現實難題：探究一次性濕紙巾的回收可能性

研究題目：測試回收濕紙巾的效能和耐用性

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設計理念

濕紙巾是不少人，在生活中不可或缺的必需品。濕紙巾既能用完即棄，價格又便宜，是不少家長照顧嬰兒和清潔家居時的必備法寶，所以濫用濕紙巾的情況愈來愈普遍。可是，很多市民對濕紙巾的成份存着誤解，誤以為濕紙巾是紙或棉，能夠容易被生物降解，甚至有些人以為濕紙巾和普通紙巾一樣，能夠被投進廁格，輕易沖走，最終導致污水渠淤塞。

事實上，市場上常見的濕紙巾都是「不織布材質」，大部分由棉織物及聚酯纖維或聚丙烯等塑料樹脂製成，即是塑膠，其成分複雜，大多含人工香精、殺菌劑、保濕劑和防腐劑等化學物，難以被大自然分解。如胡亂丟棄濕紙巾，便會造成嚴重的環境污染。

因此，為了減少濕紙巾造成的環境污染，我們嘗試回收使用過的濕紙巾來進行實驗。我們首先會把使用過的濕紙巾徹底清洗，接着透過進行實驗，比較未被使用的濕紙巾與使用後的濕紙巾的特性和效能，探究重用及回收濕紙巾的可能性。

我們希望透過這份報告，提出一個既簡單，又環保的方案，把回收的濕紙巾剪碎後放入湯袋，吸收水上油污，除能物盡其用，減少浪費外，還能解決廢物污染及海洋污染問題，為保護環境出一分力。

設計特點

我們把市場上發售的濕紙巾主要分成三類:一般「不織布材質」含塑膠濕紙巾、「生物可分解」濕紙巾、「廁所可沖掉」濕紙巾。我們進行不同實驗，以測試回收濕紙巾的效能和耐用性。

科學原理

吸水性和吸油性

濕紙巾被使用後，它的分子結構可能會有改變，導致它的吸水和吸油效能減低。

重力

把砝碼夾在濕紙巾上來測試濕紙巾的韌性，能承受愈多的砝碼，就表示濕紙巾愈堅韌。

表面面積

回收的濕紙巾剪碎後能增加接觸油污的表面面積，更能有效地吸收水上油污。

實驗前所需材料及用具

抹布、全新的濕紙巾、使用過的濕紙巾、消毒酒精、洗潔精、油、手套、大水盤、砝碼

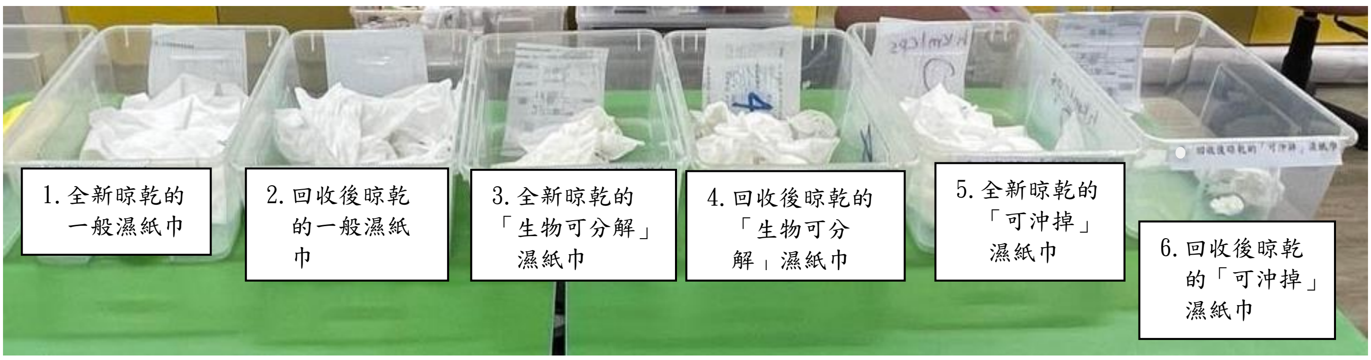
實驗前預備工作的步驟：

1. 把使用過的濕紙巾放入大水盤，然後加入清水和洗潔精。(圖片 1)
2. 用手搓洗濕紙巾後，用清水沖走污垢。(圖片 2 及 3)
3. 擰乾濕紙巾，然後加入消毒酒精，浸泡 5 分鐘。(圖片 4、5 及 6)
4. 把消毒酒精倒掉，然後用清水簡單沖洗濕紙巾，再把它們擰乾。(圖片 7)
5. 把已清洗的濕紙巾和全新的濕紙巾暴露在空氣中晾乾。

實驗設計和步驟

我們將會為濕紙巾進行吸水、吸油、韌性和耐用性 4 個測試，每組進行實驗 5 次。然後挑選出「最佳」回收濕紙巾後，把它們以片狀和粒狀放進湯袋中，再進行模擬實際環境(海水)吸油測試，每組進行實驗 3 次。。我們有 6 組實驗樣本(見下表):

實驗組	
1. 全新晾乾的一般濕紙巾	5. 全新晾乾的「可沖掉」濕紙巾
2. 回收後晾乾的一般濕紙巾	6. 回收後晾乾的「可沖掉」濕紙巾
3. 全新晾乾的「生物可分解」濕紙巾	
4. 回收後晾乾的「生物可分解」濕紙巾	



實驗結果

1. 吸水測試

實驗組		原先重量(g1)	吸水後重量(g2)	重量增加:g3=g2-g1	平均重量增加
1. 全新晾乾的一般濕紙巾	1.	2g	20g	18g	18g
	2.	2g	20g	18g	
	3.	2g	19g	17g	
	4.	2g	21g	19g	
	5.	2g	20g	18g	
2. 回收後晾乾的一般濕紙巾	1.	1g	19g	18g	17g
	2.	2g	18g	16g	
	3.	2g	19g	17g	
	4.	1g	18g	17g	
	5.	2g	19g	17g	
3. 全新晾乾的「生物可分解」濕紙巾	1.	2g	18g	16g	17.4g
	2.	2g	20g	18g	
	3.	2g	19g	17g	
	4.	2g	20g	18g	
	5.	2g	20g	18g	
4. 回收後晾乾的「生物可分解」濕紙巾	1.	2g	27g	25g	22.8g
	2.	2g	25g	23g	
	3.	2g	23g	21g	
	4.	2g	25g	23g	
	5.	2g	24g	22g	
5. 全新晾乾的「可沖掉」濕紙巾	1.	2g	17g	15g	15.8g
	2.	2g	19g	17g	
	3.	2g	18g	16g	
	4.	2g	17g	15g	
	5.	2g	18g	16g	
6. 回收後晾乾的「可沖掉」濕紙巾	1.	2g	17g	15g	15.4g
	2.	2g	18g	16g	
	3.	2g	17g	15g	
	4.	2g	18g	16g	
	5.	2g	17g	15g	

發現：

回收後和全新的濕紙巾在吸水效能上沒有太大的分別，唯獨回收後的「生物可分解」濕紙巾比全新的吸水效能高。

2. 吸油測試

實驗組		原先重量(g1)	吸油後重量(g2)	重量增加(g3=g2-g1)	平均重量增加
1. 全新晾乾的一般濕紙巾	1.	2g	30g	28g	26.8g
	2.	2g	33g	31g	
	3.	2g	31g	29g	
	4.	2g	25g	23g	
	5.	2g	25g	23g	
2. 回收後晾乾的一般濕紙巾	1.	3g	42g	39g	**34.2g**
	2.	3g	31g	28g	
	3.	4g	33g	29g	
	4.	3g	40g	37g	
	5.	5g	43g	38g	
3. 全新晾乾的「生物可分解」濕紙巾	1.	2g	18g	16g	20g
	2.	4g	28g	24g	
	3.	2g	22g	20g	
	4.	2g	24g	22g	
	5.	2g	20g	18g	
4. 回收後晾乾的「生物可分解」濕紙巾	1.	3g	40g	37g	**37.4g**
	2.	3g	42g	39g	
	3.	2g	39g	37g	
	4.	2g	38g	36g	
	5.	2g	40g	38g	
5. 全新晾乾的「可沖掉」濕紙巾	1.	2g	22g	20g	17.2g
	2.	2g	18g	16g	
	3.	3g	18g	15g	
	4.	3g	20g	17g	
	5.	4g	22g	18g	
6. 回收後晾乾的「可沖掉」濕紙巾	1.	2g	8g	6g	8.4g
	2.	2g	12g	10g	
	3.	2g	10g	8g	
	4.	2g	9g	7g	
	5.	2g	13g	11g	

發現：

除「可沖掉」濕紙巾外，回收後的濕紙巾的吸油效果都較全新的濕紙巾高。

3. 韌性測試(負重)

實驗組		負重重量(g)	破損程度	平均負重重量
1. 全新晾乾的一般濕紙巾	1.	1200g	分成兩半	>1560g
	2.	1200g	分成兩半	
	3.	2400g	沒有破損	
	4.	1400g	分成兩半	
	5.	1600g	分成兩半	
2. 回收後晾乾的一般濕紙巾	1.	2400g	沒有破損	>2280g
	2.	2400g	沒有破損	
	3.	2400g	沒有破損	
	4.	1800g	分成兩半	
	5.	2400g	沒有破損	
3. 全新晾乾的「生物可分解」濕紙巾	1.	2400g	沒有破損	>2400g
	2.	2400g	沒有破損	
	3.	2400g	沒有破損	
	4.	2400g	沒有破損	
	5.	2400g	沒有破損	
4. 回收後晾乾的「生物可分解」濕紙巾	1.	2400g	沒有破損	>2400g
	2.	2400g	沒有破損	
	3.	2400g	沒有破損	
	4.	2400g	沒有破損	
	5.	2400g	沒有破損	
5. 全新晾乾的「可沖掉」濕紙巾	1.	1200g	分成兩半	1200g
	2.	1100g	分成兩半	
	3.	1200g	分成兩半	
	4.	1300g	分成兩半	
	5.	1200g	分成兩半	
6. 回收後晾乾的「可沖掉」濕紙巾	回收後已破損，並成團塊。			

發現：

除「可沖掉」濕紙巾外，回收後的濕紙巾的韌性都有不俗的表現，甚至回收後的一般濕紙巾更比全新的較能負重。

4. 耐用性測試

實驗組		吸水和擰乾直至破損次數	破損程度	平均破損次數
1. 全新晾乾的一般濕紙巾	1.	31	中間破洞	29.2
	2.	30	中間破洞	
	3.	26	中間破洞	
	4.	30	中間破洞	
	5.	29	中間破洞	
2. 回收後晾乾的一般濕紙巾	1.	32	中間破洞	30.2
	2.	28	中間破洞	
	3.	30	中間破洞	
	4.	31	中間破洞	
	5.	30	中間破洞	
3. 全新晾乾的「生物可分解」濕紙巾	1.	33	中間破洞	33.4
	2.	31	中間破洞	
	3.	29	中間破洞	
	4.	40	中間破洞	
	5.	34	中間破洞	
4. 回收後晾乾的「生物可分解」濕紙巾	1.	38	中間破洞	33.2
	2.	29	中間破洞	
	3.	35	中間破洞	
	4.	34	中間破洞	
	5.	30	中間破洞	
5. 全新晾乾的「可沖掉」濕紙巾	1.	2	分成多塊	2
	2.	2	分成多塊	
	3.	2	分成多塊	
	4.	2	分成多塊	
	5.	2	分成多塊	
6. 回收後晾乾的「可沖掉」濕紙巾	回收後已破損，並成團塊。			

發現：

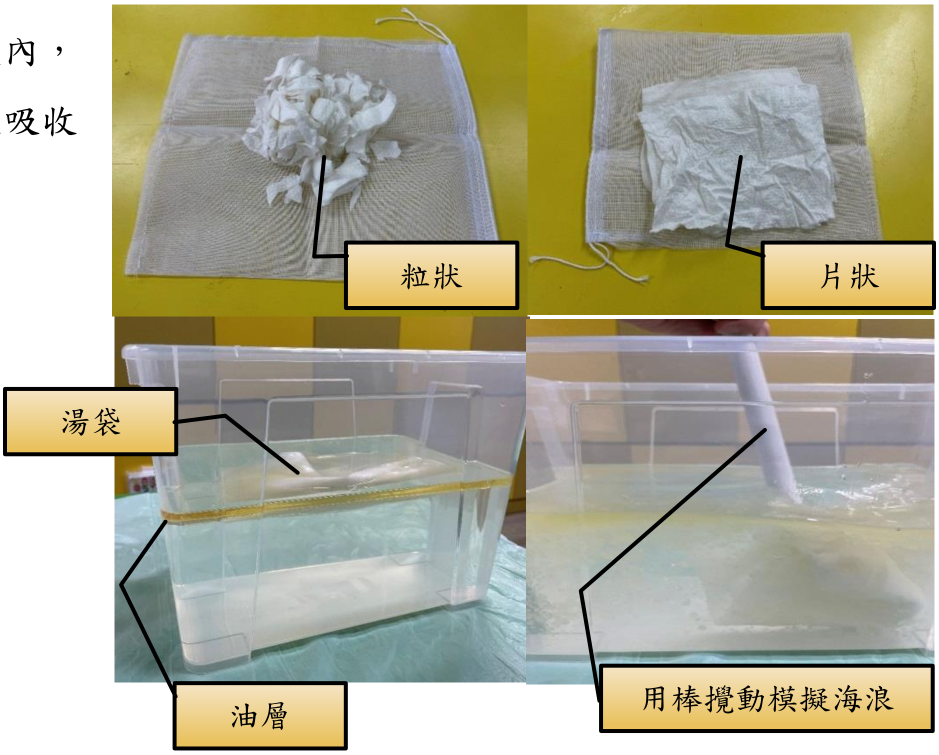
所有濕紙巾中，全新的和回收的均沒有明顯的耐用性分別，反映出即使回收也不會大大減低它的耐用程度。

5. 模擬實際環境(水上)吸油測試

實驗組			原先重量(g1)	吸油後重量(g2)	重量增加:g2-g1 (g3)	平均重量增加
1. 回收後晾乾的一般濕紙巾 **(放在湯袋內)**	片狀	1.	21g	125g	104g	110g
		2.	24g	133g	109g	
		3.	22g	139g	117g	
	粒狀	4.	23g	180g	157g	**145g**
		5.	21g	173g	132g	
		6.	25g	171g	146g	
2. 回收後晾乾的「生物可分解」濕紙巾 **(放在湯袋內)**	片狀	1.	22g	129g	107g	107g
		2.	23g	123g	100g	
		3.	25g	139g	114g	
	粒狀	4.	21g	173g	152g	**147g**
		5.	22g	160g	138g	
		6.	24g	175g	151g	

發現：

把回收的濕紙巾放在湯袋內，粒狀比片狀有較佳的效果，能吸收更多的油。



實驗分析

回收濕紙巾是可行的

總結五項實驗的數據，我們意外發現回收的濕紙巾經過清洗消毒後，它的吸水和吸油效能有被提升。有趣的是在回收的「生物可分解」濕紙巾測試中，它比全新的有更好的吸水和吸油效能，這可能是由於清洗消毒的過程中令濕紙巾的物料結構出現變化，讓它更能吸收水分子和油分子。另外，結合韌力測試中的數據，回收的一般濕紙巾比全新的更能負重，而在耐用性測試中，全新的和回收的均沒有明顯的分別，反映出回收的濕紙巾不會因使用過而大大降低它的效用，甚至在某方面有所提升。因此，我們相信回收一般含塑料的濕紙巾和「生物可分解」濕紙巾是可行的做法，而「可沖掉」濕紙巾則無法回收，因它被清洗時就已經破爛成紙糊，而它的吸油測試數據亦未如理想。

回收的粒狀濕紙巾能吸收更多油污

在回收濕紙巾是可行的基礎下，我們認為濕紙巾的吸油效能能加以應用在清理海洋上船隻漏油的油污上。因此我們進行了模擬水上環境的吸油實驗，發現若果把回收濕紙巾剪碎，能增加吸收油分的表面面積，增加吸油效能。

實驗限制

1. 由於實驗時新冠肺炎的疫情持續，未能大規模回收不同來源的濕紙巾。現時的濕紙巾主要來自家居清潔後回收的。
2. 由於實驗時間因疫情而大受影響，每組實驗只做了 5 次，實驗存有誤差。
3. 回收的一般濕紙巾中，含有不同牌子的濕紙巾，令實驗結果存著差異。
4. 在模擬實際環境的實驗中，湯袋濕紙巾的重量變化包含了油分和水分，數字未能準確反映吸油效能。

改善及延伸實驗建議

1. 在學校大規模收集老師和學生使用過後的濕紙巾，讓回收的濕紙巾中有更多不同的材質和更多不同的使用程度，令實驗更貼近現實回收的情況。
2. 增加每組樣本的實驗次數，以增加測試數據的可信度。
3. 在模擬實際環境的實驗中，湯袋從水中拿出後，可讓它在空氣中自然晾乾才磅重。這樣能讓水分子因自然蒸發而散失，濕紙巾中便只剩下吸收的油分。

結論

總括而言，我們相信回收濕紙巾是可行做法，能減少這些塑膠垃圾對環境造成破壞，但誠然在實行上需要進一步考慮到環境衛生問題，為回收設施、流程和加工事項進一步研究。再者，若回收的濕紙巾能加工並應用在吸收海上油污，便能賦予「廢膠」新生命，能物盡其用，減少浪費外，更解決海洋污染問題，為保護環境出一分力。

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「不織布」濕紙巾 是膠不是紙或棉 混物質變柔軟 難回收分解
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雞蛋殼環保餐盒

參賽學校：東華三院鄧肇堅小學
指導老師：李麗冰、賴俊彥
參賽學生：(五年級) 阮樂謙、梁舜堯
(四年級) 徐琬茜

探究意念:減少塑膠

疫情下很多人都需要購買外賣，因此棄置大量的外賣餐盒，這些餐盒多以塑膠或發泡膠製造，不能分解，容易污染環境。根據政府「海岸清潔跨部門工作小組」的報告，海上垃圾其中約五成為塑膠廢物，而種類多為包裝物料、食物容器及餐具，當中超過九成五的海上垃圾來自本地，逾八成是由陸地流入海洋。有一次我們看見有人吃烚蛋時在剝雞蛋殼，靈機一觸，我們希望使用雞蛋殼設計及製作一款輕、堅固、可以自然分解、可防水、可翻熱的餐盒，減少塑膠餐盒對陸地及海洋所造成的污染。

科學原理/方法

燒結，是把粉狀物料轉變為緻密體，人們很早就利用這個工藝來生產陶瓷。我們也透過燒結原理，先收集蛋殼並風乾，再利用攪拌機進行研磨，使蛋殼成為細粉。為了黏合蛋殼粉，我們將不同類型的澱粉按相同比例和水、蛋殼粉混合。糊化作用是澱粉顆粒的秩序被破壞後膨脹起來。膨脹了的澱粉顆粒也不能自由移動，澱粉混合物便變得黏稠。當繼續加熱，顆粒繼續膨脹，可以增加堅固度。我們最後再以微波爐加熱混合物，使其定型。為了公平測試，我們設定測試的配方比例為20克蛋殼粉:20克澱粉:18mL水，製作相同大小的粉團及以微波爐400w加熱2分鐘。然後開始測試哪款澱粉加上蛋殼形成的物料的重量、堅固度、分解性、防水性及耐熱性。

探究過程及測試

1. 重量

步驟：將相同大小的物料放在電子磅上量度重量。

材料及工具：電子磅

結果：

	沾米粉	粟粉	木薯粉	糯米粉
重量(克)	51	45.6	43.1	50
	*	***	****最輕	**

2. 堅固度 

步驟:將相同大小的物料用電線夾固定在3個並列彈簧秤的鐵勾上，拉扯物料，直到物料斷裂並紀錄斷裂時測力計的數值。

材料及工具:3個彈簧秤、電線夾

結果:

在加熱後，物料會輕微變軟。

	沾米粉	粟粉	木薯粉	糯米粉
受力度(牛頓)	>5	>5	>5	4.5
	****最堅固	****最堅固	****最堅固	*

經過一天冷卻後，物料在攝氏25度下均表現堅固。由於3個彈簧秤均未能量度出受力度。物料在70cm 高的桌子上落下，都沒有碎裂。

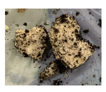
	沾米粉	粟粉	木薯粉	糯米粉
受力情況	沒有碎裂	沒有碎裂	沒有碎裂	沒有碎裂

3. 分解性 

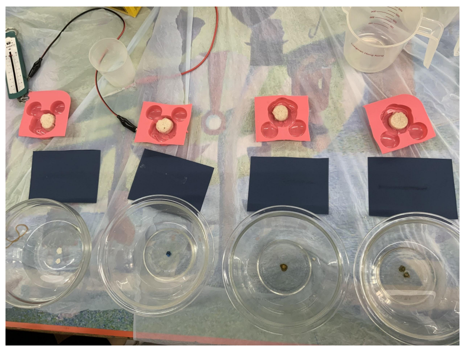
步驟:將相同大小的物料放在相同溫度、濕度的土壤中，並放置相同時間(24小時及48小時)，觀察物料的變化。泥土含有大量微生物及細菌,而這些微生物會分泌出分解酵素，引發酵素活動。酵素可分解物料成水溶性生成物。蛋殼及澱粉為天然物質,因此可被分解。

材料及工具:土壤

結果:

	沾米粉 (24小時後)	沾米粉 (48小時後)	粟粉 (24小時後)	粟粉 (48小時後)	木薯粉 (24小時後)	木薯粉 (48小時後)	糯米粉 (24小時後)	糯米粉 (48小時後)
								
顏色	黃色	深啡色	啡色	深啡色	黃色	深啡色	微黃色	深啡色
體積	減少	減少	減少	減少、散	減少、散	減少、散	沒有減少	減少
質感	變軟	變軟	硬、有顆粒分開	變軟、有顆粒分開	變軟、濕	變軟、濕	硬	硬
味道	發酵酸味	臭味	沒有特別氣味	發酵酸味	臭味	濃烈臭味	沒有特別氣味	沒有特別氣味
	***		**		****最容易分解		*	

4. 防水性



<u>步驟</u>：將相同大小的物料放在相同份量的清水中放置相五分鐘，觀察及觸摸物料的變化。再將浸水後的物料在硬卡紙上劃一筆，觀察有沒有物質留在硬卡紙上。

<u>材料及工具</u>：: 200 mL水、計時器、深色硬卡紙

<u>結果</u>：

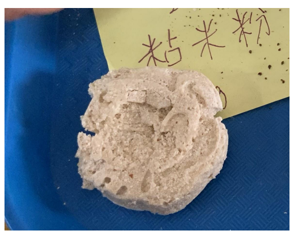
	沾米粉	粟粉	木薯粉	糯米粉
顏色	沒有變化	沒有變化	沒有變化	沒有變化
體積	沒有變化	減少	減少	減少
質感	較乾爽	變黏手	變黏手和散開	變黏手和軟
在紙卡上 留下的粉末	沒有 	幾乎沒有 	少許 	較多 
	****最防水	***	*	**

5. 耐熱性

<u>步驟</u>：耐熱性，指物質在受熱的條件下仍能保持其優良的物理機械性能的性質。我們將相同大小的物料放在微波爐800w加熱2分鐘，觀察物料的變化。

<u>材料及工具</u>：微波爐

<u>結果</u>：

	沾米粉 	粟粉 	木薯粉 	糯米粉 
顏色	黃色	焦黃及中間發黑	焦黃	焦黃
體積	膨脹	膨脹	膨脹	膨脹
質感	較硬	脆	軟	較軟及散開
味道	香味	焦味	少許焦味	少許焦味
	****最耐熱	*	***	**

總結及反思

	沾米粉	粟粉	木薯粉	糯米粉
重量	*	***	**** 最輕	**
堅固度	****最堅固	****最堅固	****最堅固	*
自然分解性	***	**	**** 最容易分解	*
防水性	**** 最防水	***	*	**
耐熱性	**** 最耐熱	*	***	**

透過多次測試，我們發覺使用沾米粉製作的物料在堅固度、防水性、耐熱性最佳，它的自然分解性也比使用粟粉及糯米粉較佳，因此四種澱粉中沾米粉的整體效果最為理想。這個探究結果讓我們發現即使是廚餘，只要留意到它的特性，結合不同的科學原理，就可以重生再用。不過實際應用中我們也要將按所需用的餐盒的大小、形狀、數量、使用的實際情況而調整。而使用的澱粉也可考慮更多選擇，例如小麥粉、綠豆粉等，因此我們建議可增加 更多澱粉混合物料的實驗。除了雞蛋殼，我們也可考慮其他廚餘，例如骨頭、蔬果衣，也許也能轉化成為不同種類的環保餐盒或餐具。

參考資料

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每日頭條·影響土壤有機質分解轉化的因素有哪些？這回講清楚了！

科學家報告書獎

優才(楊殷有娣)書院 - 小學部

第十五屆香港科學青苗獎

科學家專訪報告—梁美儀教授

指導老師：鄧兆華老師

參賽學生：林嘉晴、蔡致遠、何立行、袁梓嫣、葉澔洋

專訪教授簡介

受訪科學家：梁美儀教授

工作機構：香港城市大學、海洋污染國家重點實驗室

職銜：香港城市大學海洋污染國家重點實驗室主任兼化學系環境毒理及化學講座教授

研究範圍：海洋生態學、污染監測、生態毒理學、環境風險評估、海洋資源管理和生態海岸線工程、建構對水域毒性預測的科學模型等。

研究成就及方向

梁美儀教授於 2000 年獲得格拉斯哥大學海洋生態毒理學博士學位。到 2017 年為止，他已經編輯了六本科學著作和發表了 180 多篇同行評審的科學文章。跟據「基本科學指標 (ESI)」所顯示，梁教授是全球生態/環境科學領域中被引用最多的首 1%學者之一。

梁教授憑著他的專業成就和社會服務，於 2010 年獲青年商會選為香港「十大傑出青年」，並於 2017 年獲日本生態學會授予「第 19 屆生態學琵琶湖獎」。而於 2018 年，香港特別行政區政府有見梁教授對社會的貢獻更委任他為太平紳士。

成為海洋生物學家之奇幻旅程

梁教授小時候試過跟他爸爸到碼頭工作，因此他很熟識海洋的環境，而且對海洋生物很有興趣。但是他的求學之路絕不平坦，他在中學會考成績未如人意，後來重讀一年後成功升上中六，在高考後再修讀柴灣工業學院的文憑課程及後在香港城市大學修讀高級文憑課程。多得當時大學的教授鼓勵及加上機緣巧合，因此他選擇到外國求學，其間更取得多次的獎學金繼而攻讀碩士、環境科學哲學碩士及海洋環境毒理學博士，集中研究海洋生態的範疇，展開了不平凡的海洋生物學家之奇幻旅程。

科學研究的苦與樂

梁教授說做科學家要不怕失敗，要懂得「苦中作樂」。教授分享了一次痛苦的經驗：有一次的科學研究需要養殖 1000 條魚作飼料中氮收支平衡實驗。由於二月水溫急跌至 10 度以下，許多在漁排養的熱帶魚如石斑因此而死亡，最後竟死了 800 條魚，大家都很失望。可是，他們不怕失敗，檢討問題，努力再做實驗。於是把一部分的養在室外漁排，一部分養在實驗室內。他笑言這次經歷做他們也學懂了居安思危，要有兩手準備，他日若然極端天氣再臨，他們仍會有一些數據，不會沒有成果。

趣事方面，他想起小時候看到乾衣機的管道沒有連接乾衣機，導致整個廚房在乾衣機運行後，空氣中、牆上、甚至所有煮食用具都充斥著纖細的幼毛。長大後，小時的這件趣事竟成了他科研的主題，經實驗發現每部乾衣機原來一年運行約 200 次的話，竟能排放出一億條微塑膠及塑膠纖維。此研究最終獲得許多海外國際報章爭相報道，亦令人關注人造纖維衣物帶來的環境問題。

科學家的特質

科學家最重要的是要有求知欲，在日常生活中，當遇到自己不懂的事情就應該發問和探究去尋求答案，不然就會錯過最佳學習新知識的機會。

訪問過程中，同學最深刻的就是梁教授談到他小時候對螞蟻的研究和尋求答案的過程。梁教授提到小時候他居住的屋村大廈的牆上有很多洞，所以會有很多黃絲蟻在裡面居住。牠們會跟著一條路線行走。教授見此，便開始研究關於黃絲蟻的問題，例如：抹去牠們行走的路線會不會使牠們迷失方向？教授也曾經嘗試混合藥水和辣椒油等液體，然後用水槍把混合物擠進螞蟻洞裡，結果發現大頭蟻等不同種類的蟻都走了出來，嚇壞了他的家人！

梁教授說科學家要有很多知識和經驗。學習知識的途徑是透過多閱讀來吸取知識，從博覽群書中去了解你想研究方向過往的研究歷史，從中得到新的啟發。這樣在做實驗時就能活學活用; 做實驗時亦應多進行假設，加以觀察和研究，就算失敗了也不要氣餒，最後也能發現到新的事物。

我們的反思

經過了這次訪問，我們學到了其實成為科學家最重要的資質是要有好奇心，要細心觀察和探究身邊的事物，不要將一切當作常規，而是要突破既有和自己的思維。多角度思考和提問，引導自己跳出框框，讓我們發現事物的奧妙和有趣之處，不斷進步。

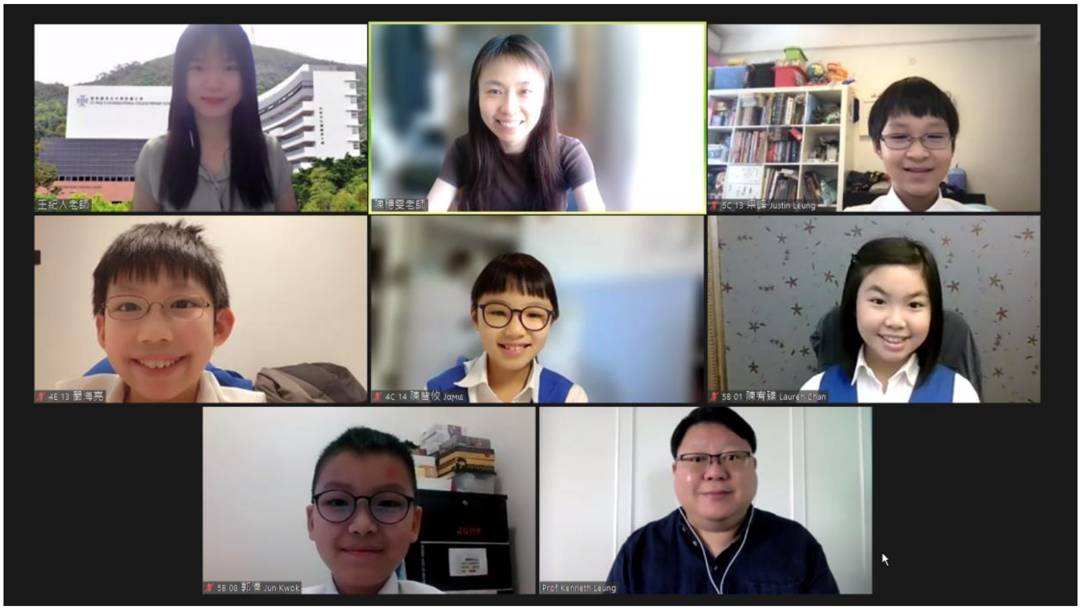
訪談間，教授提及過一句句子：「We are all standing on Giants' shoulder」，這句說話表示很多時候，科學家們之所以能做到驚為天人的研究，很多時候都是建基於別人的研究基礎上。我們發現原來即使是像他一樣厲害的科學家都是如此謙虛、懂得學無止境、多吸收前人的知識，才能更成功。

有見及梁教授的科研成果除了在海洋在保育上不遺餘力，對社會默默付出了許多，我們都被深深感動。我們會以梁美儀教授為學習榜樣，做事努力不懈，要多閱讀、多發問、多和身邊的人溝通，最重要是找到自己的興趣。希望將來也能成為一個能貢獻社會的科學家。

科學家報告書獎

第十五屆科學青苗獎

科學家專訪報告



聖保羅男女中學附屬小學

參賽學生：陳宥臻、郭溱、梁峰、嚴海亮、陳皆攸

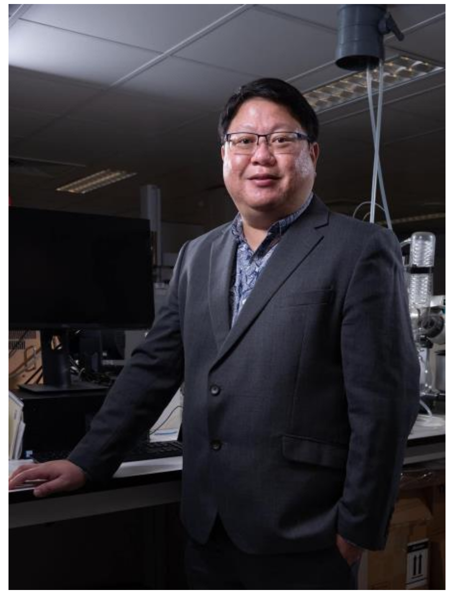
指導老師：王紀人、陳穗雯

受訪科學家：梁美儀教授

工作機構：香港城市大學海洋污染國家重點實驗室主任兼化學系環境毒理及化學講座教授

研究範圍：海洋生態學、生態毒理學、環境風險評估、生態多樣性保育、生態復原等

梁教授的成長經歷



梁美儀
香港城市大學化學系講座教授及海洋污染國家重點實驗室主任
（2010 年香港十大傑出青年）

熱心海洋研究的梁教授從小就被海洋吸引。小時候他父親是海事處的機械工程師，梁教授經常跟他出海，並在海中心游泳，每次都看到不同的生物，覺得海洋很有神祕感，從而愛上海洋。

可是能夠成為海洋研究界的權威學者，過程並非一帆風順。他憶述中五會考失手， 未能在原校升讀中六，後來報讀夜校將勤補拙，才能到英國升讀大學。回港後梁教授曾在環保處及工業學院工作，雖然收入穩定，不過他希望能從事自己喜愛的海洋研究，亦被研究科學的滿足感吸引， 於是才毅然投身科研。

梁教授的靈感來源

梁教授認為日常生活中遇到的人和事，往往能啟發科學家研究的靈感。例如他曾在冰島研究當地螺類的重金屬含量，他發現一般地區的螺類長度只有 3-3.5 厘米，但部分地區卻長達 5 厘米，而這些地區的海域往往因漁民劏魚後廢棄的內臟而染成一大片紅色，因此梁教授懷疑螺類除了用長吻來捕食外，是否還懂得「飲湯」來吸收海水中魚類內臟的營養？回到香港後，梁教授便提議他的學生去研究驗證這個疑問，並證實了這假設是真的！

又有一次於朋友聚會期間，一位主婦問梁教授如何令蜆更快吐沙，並告訴他只要放一把生鏽的刀在水中便可。於是梁教授帶着疑問回到學校，他估計吐沙速度與水溫和鹽份有關，經過實驗後，他證實使用 20 ℃水溫並在水裏放進 1.5%鹽可令蜆更快吐沙，而放生鏽的刀只會令蜆嘔吐。原來從生活中觀察、發問並深入研究，是能獲得有趣的結果，亦可將結果應用於生活之中。

梁教授亦提到：“We are standing on giant’s shoulders.” 提醒我們可以多閱書，在前人的基礎上再找出問題，然後自己研究更好的解決方案。例如：前人調查一些用肉眼難以

看到的海洋生物時，會使用環境 DNA 來尋找牠們。但這個方法需要運送大量的水，裏面也有機會摻了沙。為了解決這個問題，梁教授正在研究把不同的物料剪成條狀，然後放進大海，看看能不能利用殘留在物料上的 DNA 作研究。

科研路上的苦與樂

雖然梁教授在我們眼中是一位屢獲殊榮的科學家，但他亦曾遇過不少困難和挫敗。他記得有一次因遇上寒流，一夜之間凍死了 1000 多條研究用的芝麻班，一年的實驗就此化為烏有。此外，因梁教授所進行的研究較為偏門，所以他所需要的化學品往往很難訂購，因而拖延了研究進度。

實驗上最困難的地方就是總有不可控制的因素，不過梁教授從經驗中學習，從此學會凡事兩手準備，同時也需要有耐性、「大膽假設，小心求證」。

梁教授的展望

梁教授作為研究海洋的學者，希望能向人推廣保護海洋的訊息。他除了到學校主持講座，分享自己的經歷，吸引更多人關注海洋問題外，亦會向政府建議海洋政策，包括立法禁止拖網捕魚及設立海洋保護區等。

雖然個人的力量微小，但梁教授認為每位市民盡自己的一小份力量是能夠帶來改變的。自 2009 年起，梁教授便開始跟學校和保育機構合作「馬蹄蟹校園保母計劃」，讓中學生在研究人員的指導下，學習飼養馬蹄蟹，並觀察、記錄馬蹄蟹幼體的生長過程，最後將長大的馬蹄蟹放歸自然。這個計劃有明顯成效，令香港的馬蹄蟹數目漸漸回升，同時還能讓學生提升保育意識呢！此外，梁教授又發現蠔能過濾污水，而蠔殼之上其實是供給大約 100 種小生物的生境呢！於是他跟香港海洋生態協會合作創辦「香港富蠔計劃」，希望透過不同持份者的參與修復香港的蠔礁，從而改善本地水質和海洋生態。

「香港富蠔計劃」啟航 (攝於 2021 年 4 月 23 日)

梁教授亦於「香港富蠔計劃」中舉行海洋生物多樣性和生態復修講座

感想

梁教授在訪問裏説的話啟發了我們，之前我們以爲海洋這個話題離我們生活很遙遠，原來我們也可以爲它出一份力呢！梁教授的訓勉引起了我們一班同學的關注，並不止學習了關於科研的知識，還有現在海洋面對的挑戰。更令我們佩服的是梁教授身體力行，除了進行研究外還不忘於公民教育、海洋政策倡議等各方面出一分力，希望能提供一個富生物多樣性和可永續的海洋環境給下一代。我們也在這次訪問中學習到很多有關海洋的小知識，例如原來改變水溫和加入鹽能令蜆吐沙更快。梁教授也教了我們進行研究時要注意的事情，例如「大膽假設、小心求證」這個原則。他還給我們一些做實驗的提示，例如如何令實驗更多元化，更貼題等等，我們真是獲益良多。我們在這次專訪中學到了很多新的知識，真有趣！

參考資料

香港城市大學-梁美儀教授

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香港城市大學校友成功故事系列：上善若水的海洋保育專家-梁美儀

https://www.cityu.edu.hk/aro/alumnistories/117.htm

馬蹄蟹校園保母計劃

https://www.opcf.org.hk/tc/community-education/juvenile-horseshoe-crab-rearing-programme

香港富蠔計劃

https://zh.oystersos.org/

科學家專訪報告 － 林漢明教授

科學家報告書獎

專訪教授簡介：

任職機構：香港中文大學生命科學學院

研究興趣：氣候智能型和可持續農業、植物和農業生物技術、作物與環境相互作用的基因組學研究

港澳信義會小學

參賽學生：(五年級)尹洛瑤、黃泳心

(六年級)何子樂、林子睿

指導老師：張德文老師、葉雅賢老師

訪問日期：2022 年 5 月 7 日

研究大豆的原因

大豆既有很高營養價值，也是油的原材料，是十分重要的食物；它亦是環境友善的作物，與細菌的共生作用把空氣中的氮轉化為蛋白質，因而減少使用氮肥；它更起源於中國，時至今日中國的大豆卻有 80%是入口。為此，林教授希望通過科研力量，培種出抗逆性高的大豆，把它「帶回家」。當時他認為投身這項研究能把自己的力量發揮最好，對世界作出更多貢獻，因此在眾多農作物中揀選了大豆作為研究對象。

研究的困難與推進成功的因素

「萬事起頭難」，林教授尋找研究方向及在研究過程中都遇到不少阻礙。但在決定研究方向後，作好去開創、接受失敗的心理準備去堅持研究。期間找尋合適和志同道合的夥伴，合力邁向彼此的共同理想。

可是在步伐急速的社會，農業科研不是可快速見到成果的研究，因此在研究初期並未受到外界的關注。此外，農業研究也未有得到大眾社會認同，故此出現研究經費不足的情況，當中更要決定團隊成員的去留。不過當時林教授沒有氣餒，在得到家人的理解及共識下，墊出自己的薪金作為研究工資，使研究可以繼續進行。

雖然農業研究艱辛，又面對資源不足的問題，但林教授指作為實驗室的主持人，內心不能動搖，否則會影響整個團隊的工作和士氣。有著他堅定的決心，他與研究團隊熬過困難的時期，最後得見成果。

研究中的難忘點滴

漫長的研究路上林教授追求不同突破。在世界出現新的「基因組測序」技術時，林教授和團隊需與其他國家競賽，承受著各種壓力，但仍堅持把握機會，結合不同知識找尋到重要的抗鹽基因，結果在國際大豆基因組測序科研中佔一席位。

為能夠在測序時找出各野生大豆的分別，林教授製造首把野生大豆的「量度尺」。雖然過程困難，但通過與不同機構合作，一同製造出參考基因組，並將研究成果發表於世界，成為世界的一部分。林教授指經過多年的努力逐步實現目標，結果值得令研究團隊驕傲。

除了各項研究成就，林教授為幫助解決糧食安全問題更到訪不同地方。其中他與山西農民婦女及南非農民的經歷，令他堅持研究。他深切感受到農地對農民的重要性，卻因著環境和氣候問題令土地退化，影響農民生計。他想通過科研找出有

效而長遠地保護土地的方法，令土地的壽命更持續，對農民有更長遠的幫助。再者，林教授發現通過利用技術可幫助人們善用土地資源生產，不但能解決當地的就業問題，更能舒緩由此衍生的社會問題。

如何成為科學家？

要成為科學家，林教授認為對自己的信心及對事件的決心十分重要。科學家需要面對厲害的競爭對手，不能後退停止，每階段都需要追求突破。其次則需要考慮自己有沒有具備洞察能力、綜合能力、行動力、原創能力及親和力等各種能力及素質。作為科學家，能看穿事物表面，找出不同事物的關係和關聯性，是進行科研的首要能力。決定進行研究後，有沒有坐言起行的能力，打破傳統想法，具原創性的能力。最後更要能找到志同道合的隊員，願意與你一起合作的能力，才可推進研究。而基本的科學能力、邏輯及條理能力，卻是可將勤補拙的。

訪問後，我們的反思…

從林教授身上，我們不單學到科學知識，更學到做人的道理。要成為科學家需具備不同能力，但更重要的是正面態度。我們學會要虛心向別人學習，做事要有信心和決心，要堅持才會成功。而且單靠一人無法成就事情，找尋適合的夥伴同行，更能事半功倍。藉著與不同群體合作，做自己能做到的事，成為整個系統的一部分，合力改變世界。

林教授的大豆研究對世界有很大的貢獻，但他的研究卻不止步於此。他把研究成果貢獻於香港農業及科學教育。這都是因為他有很大決心，即使遇到困難也沒有放棄，努力解決研究經費不足的問題，甚至付出個人的工資。最後研究取得成果，不但對農業發展有幫助，令農民有較穩定的收入，更可改善環境，實現世界可持續發展目標。

(1498 字)

中學組:

冠軍

第十五屆香港科學青苗獎

化廢為肥

伊利沙伯中學舊生會中學

組員：
黎莎莎
李惠盈
簡栢康
李晉曦
李雋熙

指導老師
陳不盡老師
梁嘉裕老師

1. 簡介

1.1 世界及香港糧食問題

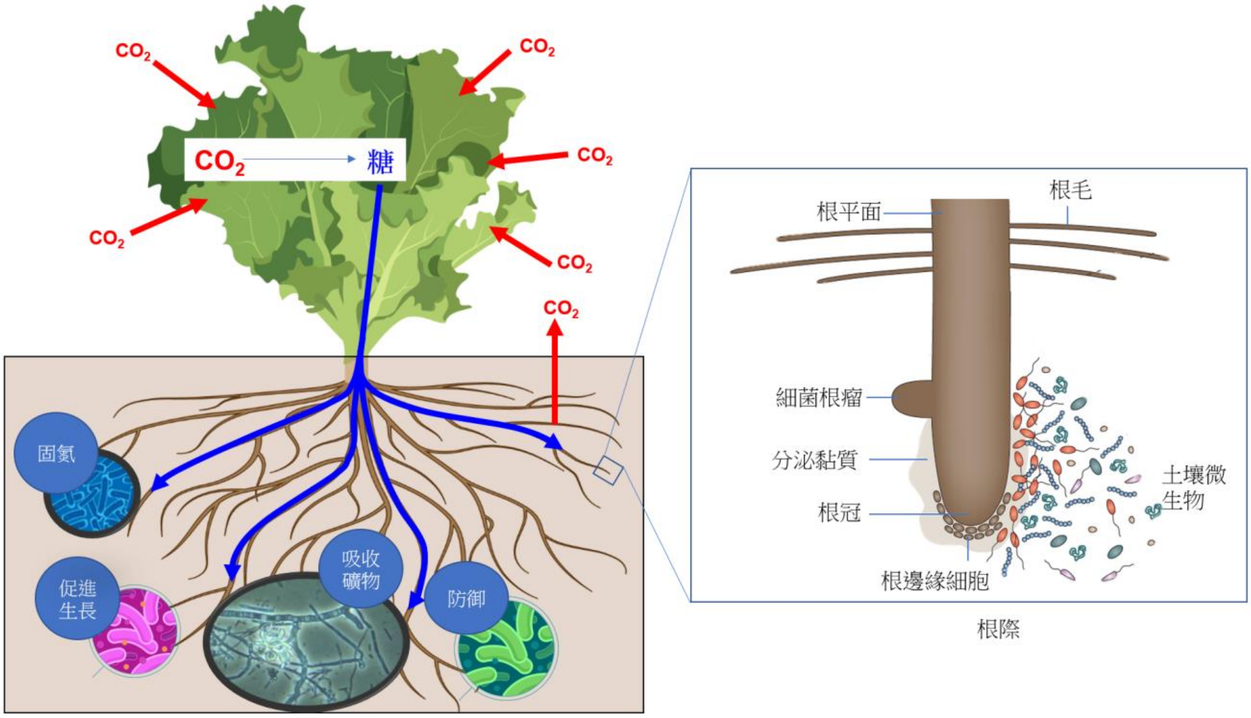
聯合國糧食及農業組織(FAO)預測 2050 年的全球人口會達至 97 億，要滿足全球人口的糧食需求，2050 年的全球糧食生產要提高 70%，才能滿足全球人口的需求。惟全球可耕種的農地面的下降、環境污染、城市發展、全球暖化、國際局勢不穩及疫症等因素都會為提升全球糧食產量的任務帶來莫大挑戰。提升糧食生產已成為國家安全的其中一個重要議題。

1.2 泥土微生物與植物生長

植物在日間會進行光合作用，製造有機物。在晚上，植物會分泌約 15%所製造的有機物進根部(Paush & Kuzyakov, 2018)，從而於根尖分泌**根系分泌物**，並在根冠形成一層**分泌黏質。**分泌黏質會刺激對植物有利的微生物群落生長，因為它們會協助植物吸收微量元素、固氮、釋放植物生長激素和協助植物防禦病原體(Philippot et al., 2013)。

然而現代農業依賴化肥、農葯和重型機械，忽略這種緊密關係，導致土壤退化。重建及鞏固泥土微生物及植物的共生關係，能促進**植物生長、產量、食物安全**(Preece and Penuelas, 2020)、**碳封存**等 (Hawken, 2017)。

圖 1　　農作物與土壤微生物的互利共生關係



根據 Jocoby et al. (2017)，土壤微生物能以以下三種方式刺激植物生長：

- 產生植物激素訊息
- 抑制有害微生物
- 增加植物獲取水份及土壤養份

植物在種子萌發直至開花結果，都會**與不同土壤微生物群落產生互動**。**植物萌發時，微生物種群會持續變化**(Gloria et al., 2018)，了解種子萌發與微生物群落的關係，有助提高植物健康及產量(Nelson, 2018)。Eldridge et al. (2021)指出陸生植物在萌發時，會與土壤微生物群落有互動關係，影響萌發。Wu et al. (2016)指出

接種 *Bacillus subtilis* strain GB03 有助黨參種子萌發和生長。常用於堆肥及廚餘分解液的 **EM 菌 (Effective microorganisms)** 更能增加落地生根(Domenico 2019)的根部生長，亦有研究報告指出**環保酵素**(ecoenzyme)能促進大花田菁的生長(Ginting et al., 2021)。

1.3 化廢為肥

參考環境局資料，香港每天產生 2500 噸家居和 1100 噸食品工業廚餘，大部份都運往堆填區處理。這些廚餘在堆填區分解後，會形成甲烷，加劇全球暖化。將廚餘進行堆肥處理是一種環保的方法，不過**香港的優質堆肥供應不足**。

綜合以上文獻，我們希望參考環保酵素的製作方法，研究**如何善用廚餘分解液及堆肥，重建泥土微生物群落，從而提高農作物的生長速度**。我們利用從健康工坊所提供的**廚餘**，包括**杏仁渣、柑橘，及獲取一些雜魚**，並以**黑糖漿**和 **EM 菌**去製造不同的**分解液**，讓特定微生物群落得以活化，再利用這些分解液、EM 菌和黑糖漿去活化於網購平台所購得的**堆肥**，和從有機菇場所獲取的**菇料**作為堆肥，以了解能否刺激農作物生長。

2. 實驗方法

2.1 廚餘分解液

(1) 準備以下廚餘

  (a) 去除雜魚的頭和內臟，並攪拌成魚碎(製作水解魚)

  (b) 柑橘渣(健康工房廚餘，含較多碳水化合物，用來製作柑橘分解液)

  (c) 杏仁渣(健康工房廚餘，含較多蛋白質及脂質，用來製作杏仁分解液)

(2) 以廚餘：黑糖為 3:1 的比例加入黑糖漿(精煉蔗糖後再經濃縮沉澱的糖漿)。

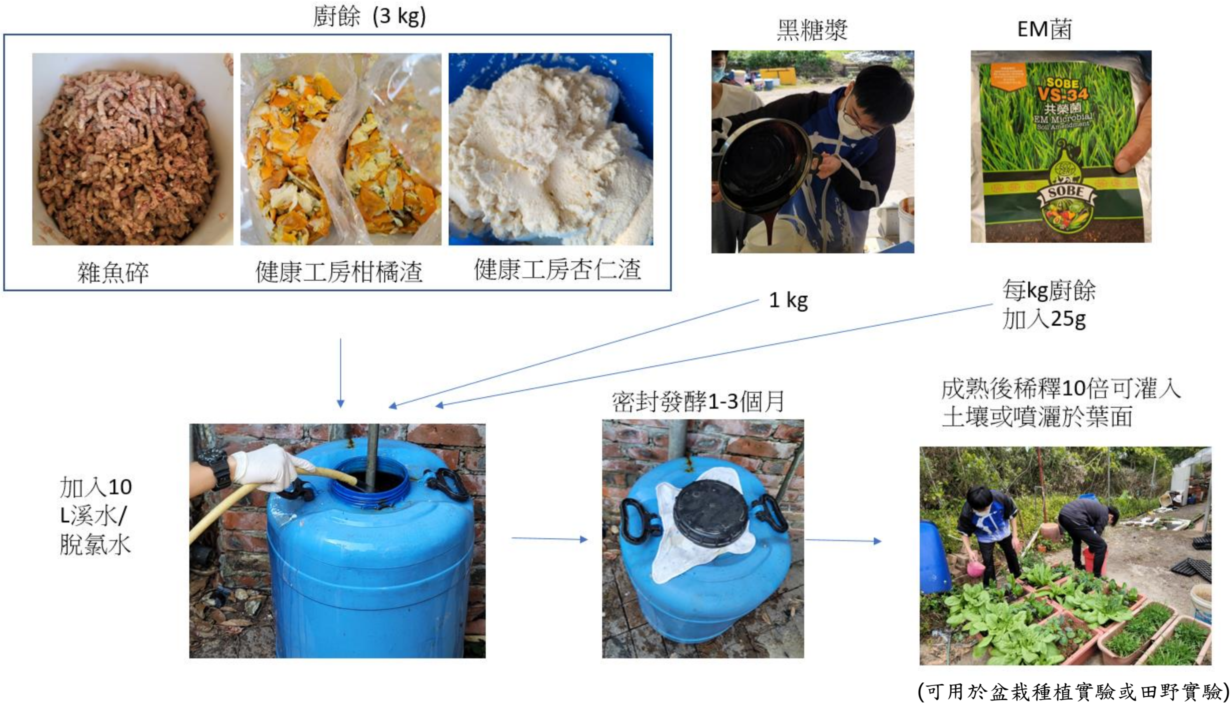
(3) 每 kg 廚餘加入 25 g EM 菌。

(4) 以每 kg 的廚餘：10 L 水的比例，加入溪水/去氯水。

(5) 用小毛巾蓋住瓶口並封好，防止昆蟲進入產卵。

(6) 放置在陰涼處，定期攪動分解液。一至三個月後成熟可用。

圖 2 廚餘分解液的製作



2.2 堆肥(包括活化堆肥及菇料)

(1) 菇料：

我們直接從有機菇場獲取廢棄的有機菇料($800 10 噸)。

(2) 活化堆肥：

我們在綠蔭家園及杉山農場的協助下，在網購平台購買了一批從國內生產的堆肥，再以以下方法活化堆肥微生物：

  (i) 加入以下物資

    (a) 40 kg 堆肥(國內產，$200 40 kg)

    (b) 2 kg SOBE EM 菌粒($300 20 kg)

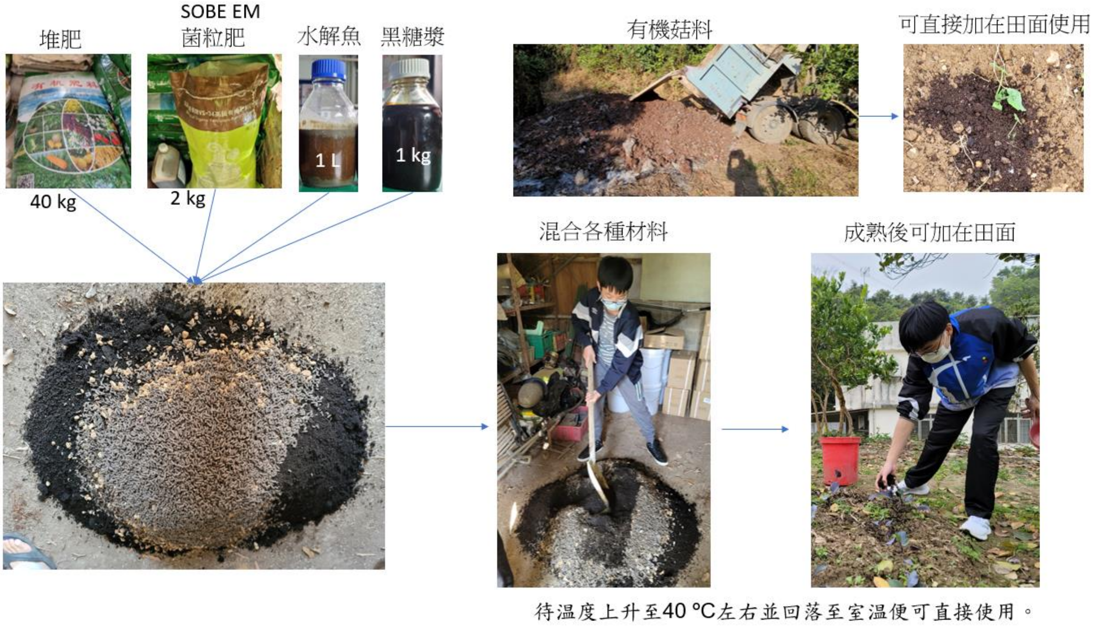
    (c) 1 L 成熟水解魚

    (d) 1 kg 黑糖漿 ($150 30 kg)

  (ii) 均勻混合後以膠膜覆蓋，防止水分蒸發

  (iii) 定期測量溫度 1 至 7 天，待溫度上升至 40 ºC 左右並回落至室溫便可直接使用。

圖 3　　兩種堆肥(菇料及活化堆肥)的應用



2.3　植物種植測試

椰菜、紅椰菜及菠菜	成長期加入營養液/活化堆肥
南瓜	移苗期間加入活化堆肥或菇料
蕃茄	成長期加入活化堆肥、10 倍稀釋綜合分解液(包括水解魚、柑橘及杏仁分解液)及/或菇料

2.4　種子萌發的生長實驗

2.4.1　瓊脂實驗

(1)　將種子加入 10%營養液內進行接種四小時。

(2)　將種子放在 1.5%瓊脂表面，每塊瓊脂可放 5 粒種子(共三種植物，生菜、菜心和莧菜)，每種蔬菜共放 10 粒種子。

(3)　側放於窗邊，然後點算發芽率、量度胚根和根毛長度、估算根毛密度。

圖 4　　以瓊脂進行萌發實驗

2.4.2 培苗基質測試

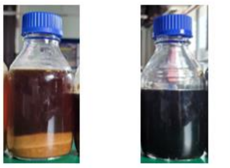
(1) 如下圖所示在發芽盤上分別放入兩種基質(菇料和培苗土)，加入去離子水濕潤培苗基質。

(2) 如下圖所示每個發芽凹穴放入一粒已接種澳洲水解魚營養液、柑橘分解液和去離子水的種子。最後以移液器加入 0.5 mL 的分解液或去離子水。

(3) 每天點算發芽情況。

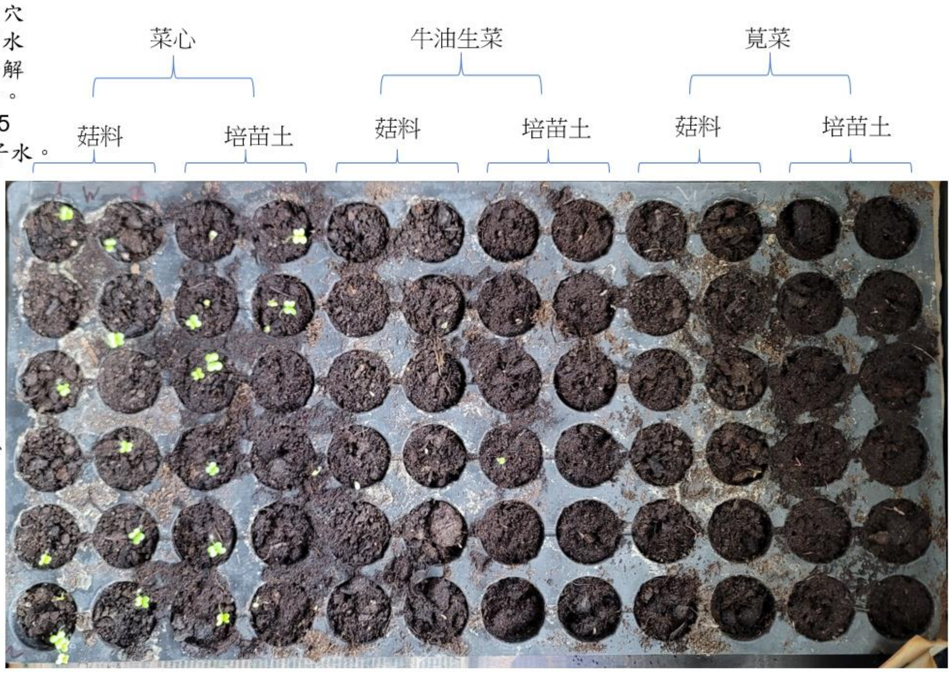
圖 5 培苗基質測試

- 如下圖所每個發芽凹穴放入一粒已接種澳洲水解魚營養液、柑橘分解液和去離子水的種子。最後以移液器加入0.5 mL的營養液或去離子水。
- 每天點算發芽情況。



柑橘分解液 澳洲水解魚

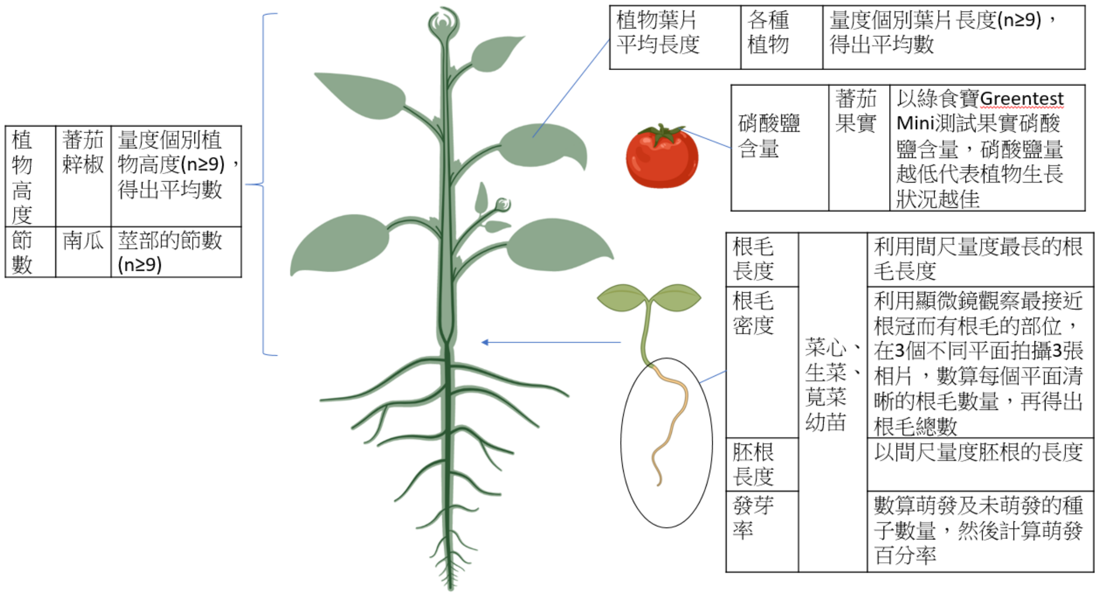
(去離子水為對照)



2.5 植物生長的量度

植物葉片平均長度	各種植物	量度個別葉片長度(n≥9)，得出平均數
植物高度	蕃茄、辣椒	量度個別植物高度(n≥9)，得出平均數
節數	南瓜	莖部的節數(n≥9)
根毛長度	幼苗	利用間尺量度最長的根毛長度
根毛密度	幼苗	利用顯微鏡觀察最接近根冠而有根毛的部位，在 3 個不同平面拍攝 3 張相片，數算每個平面清晰的根毛數量，再得出根毛平均數量
胚根長度	幼苗	以間尺量度胚根的長度
發芽率	幼苗	數算萌發及未萌發的種子數量，然後計算萌發百分率
硝酸鹽含量	蕃茄果實	以綠食寶 Greentest Mini 測試果實硝酸鹽含量(n≥9)，硝酸鹽量越低代表植物生長狀況越佳，食物安全風險亦越低

圖 6　　量度植物生長的方法



2.6 利用 Microbiometer 量度泥土微生物群落量度

圖 7 泥土微生物活性測試

3. 實驗結果

3.1 種子萌發生長結果

圖 8A

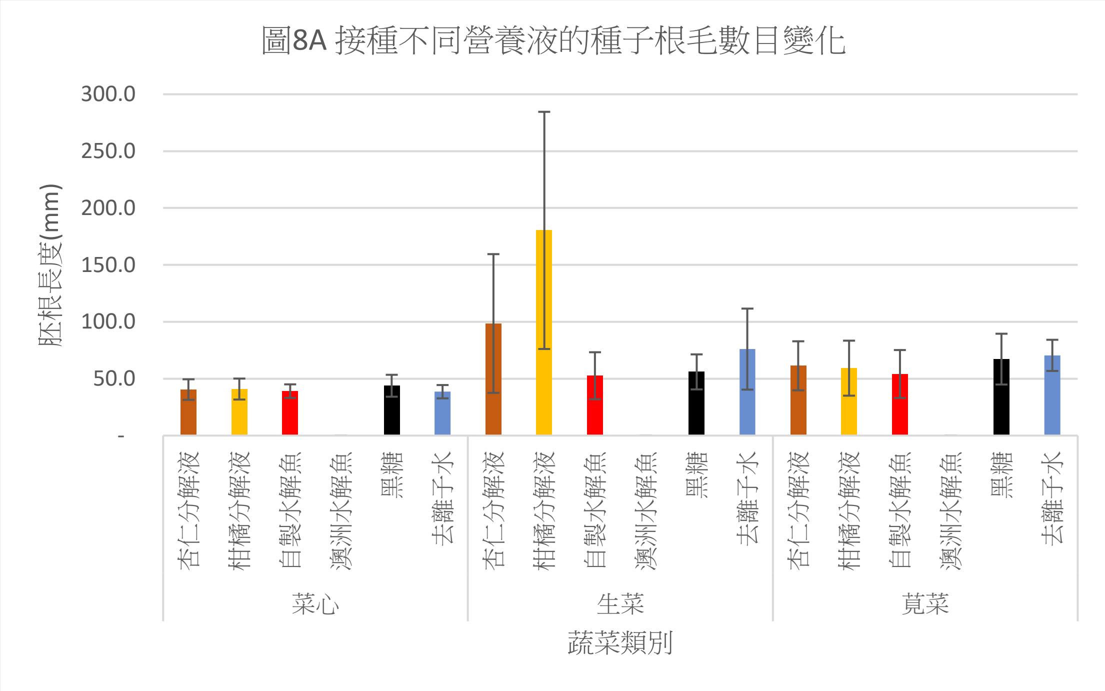


圖 8B

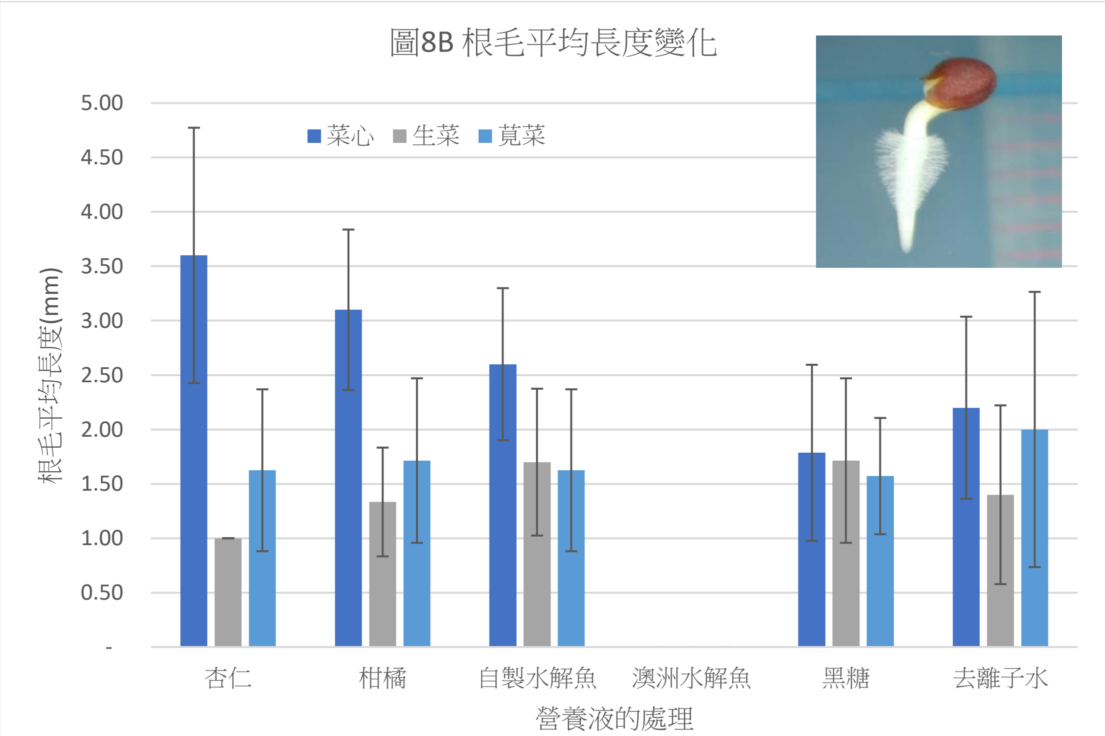


圖 9　　萌發率(瓊脂實驗)

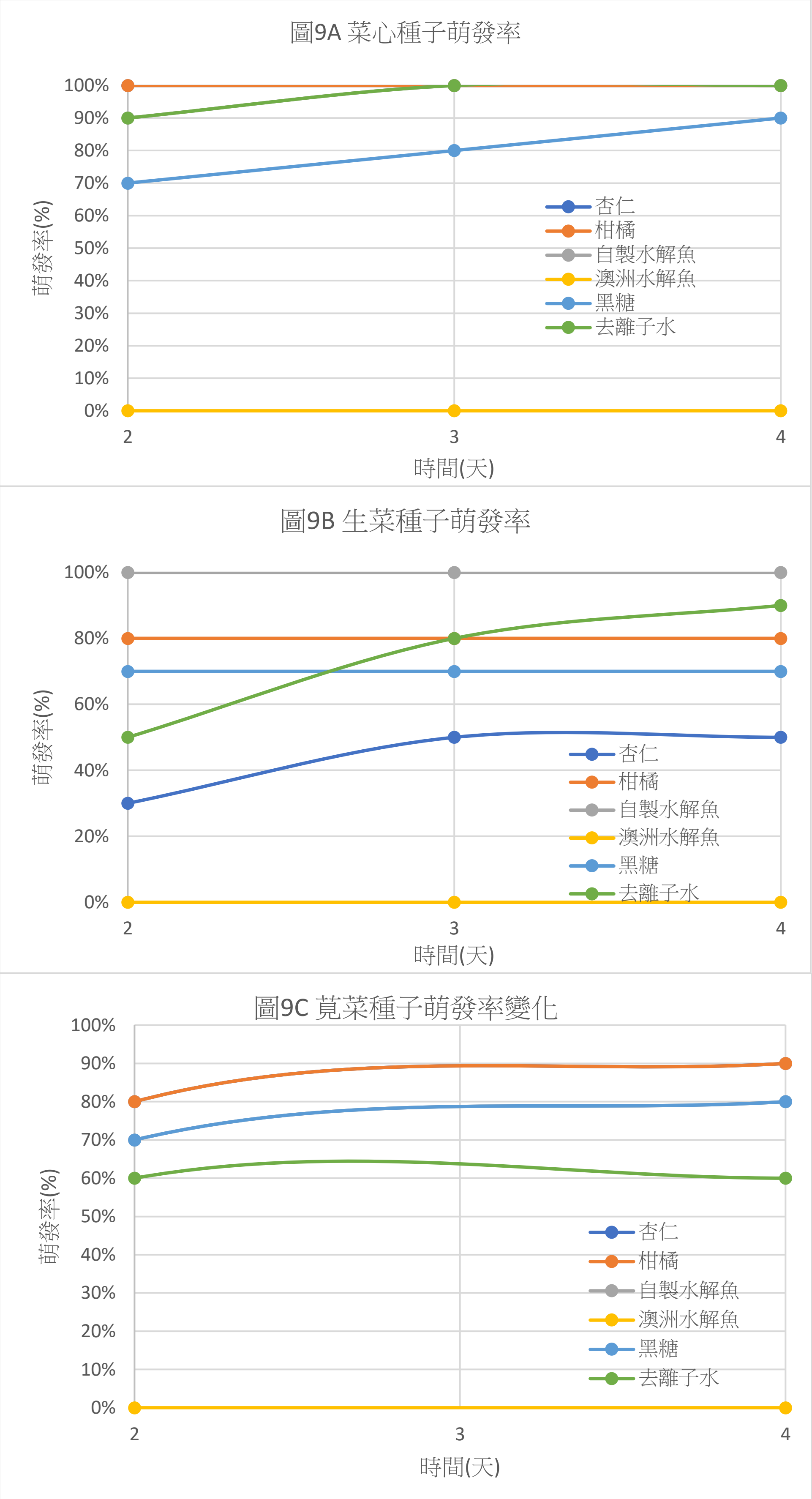
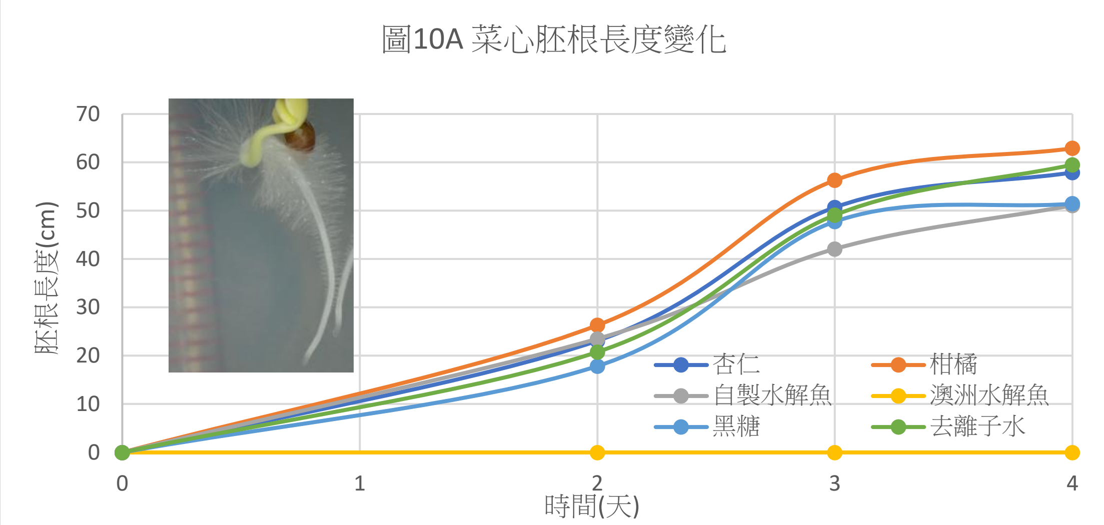
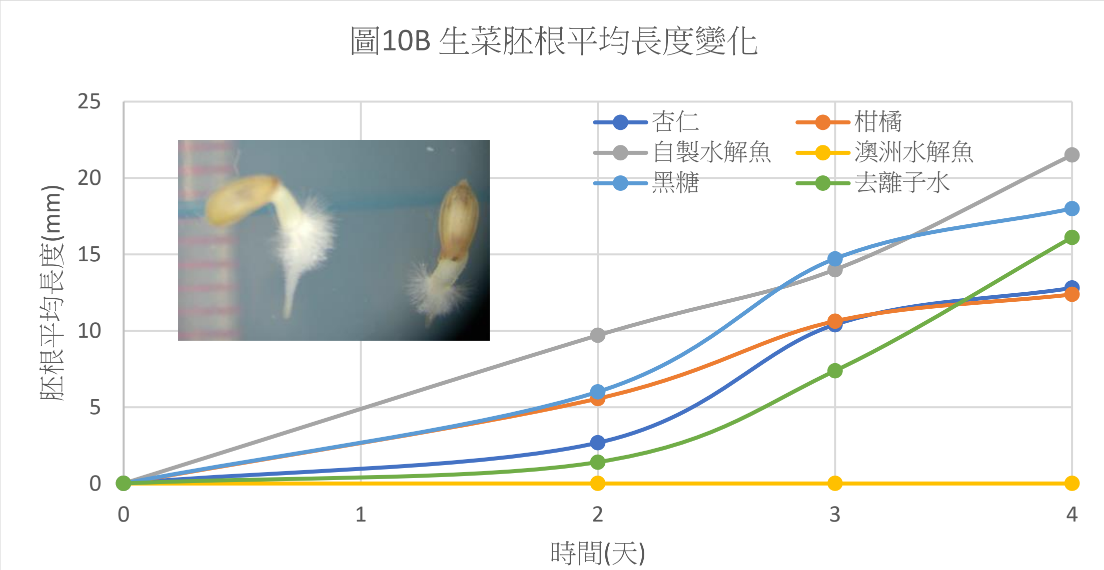


圖9A 菜心種子萌發率
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
萌發率(%)
2
3
4
時間(天)
杏仁
柑橘
自製水解魚
澳洲水解魚
黑糖
去離子水
圖9B 生菜種子萌發率
100%
80%
60%
40%
20%
0%
萌發率(%)
2
3
4
時間(天)
杏仁
柑橘
自製水解魚
澳洲水解魚
黑糖
去離子水
圖9C 莧菜種子萌發率變化
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
萌發率(%)
2
3
4
時間(天)
杏仁
柑橘
自製水解魚
澳洲水解魚
黑糖
去離子水

圖 10　胚根長度變化(瓊脂實驗)





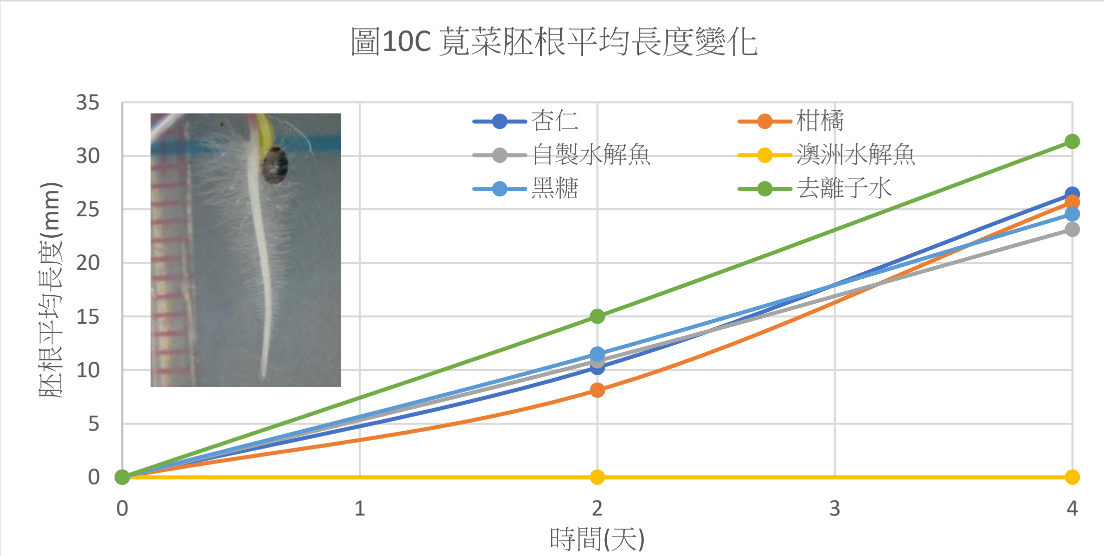
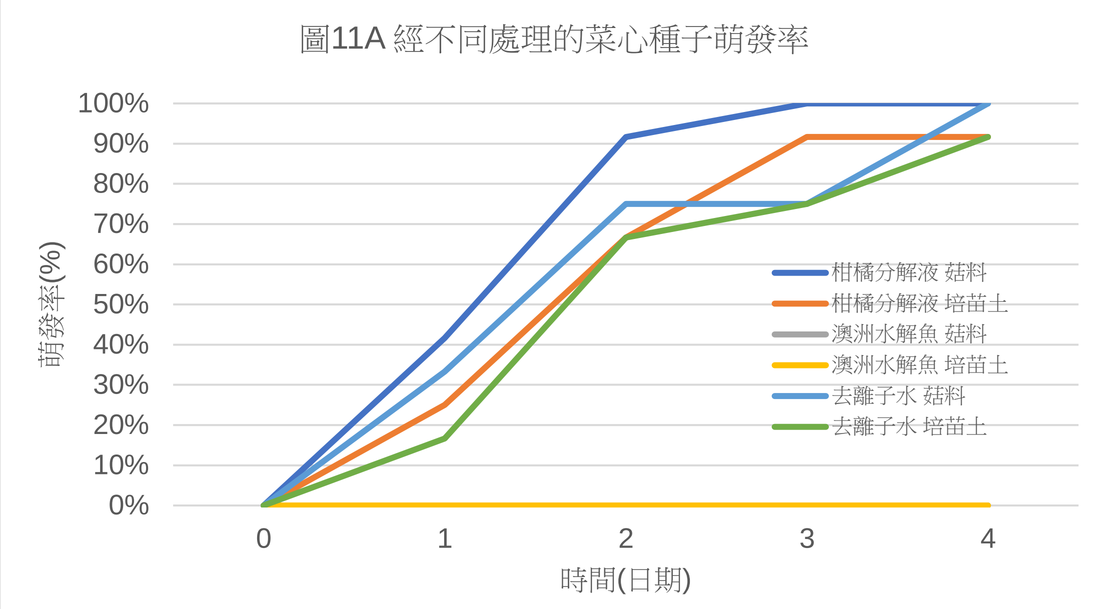
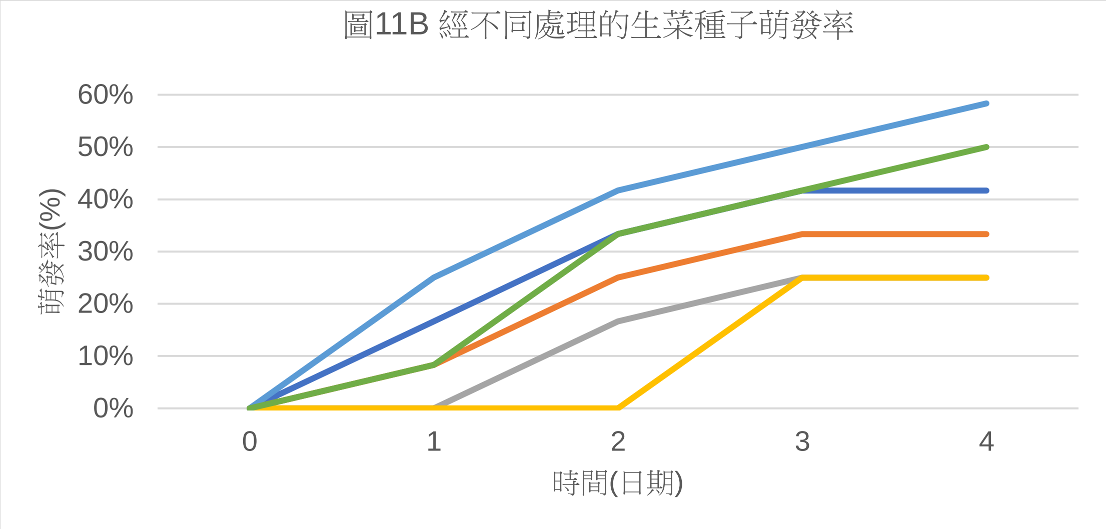
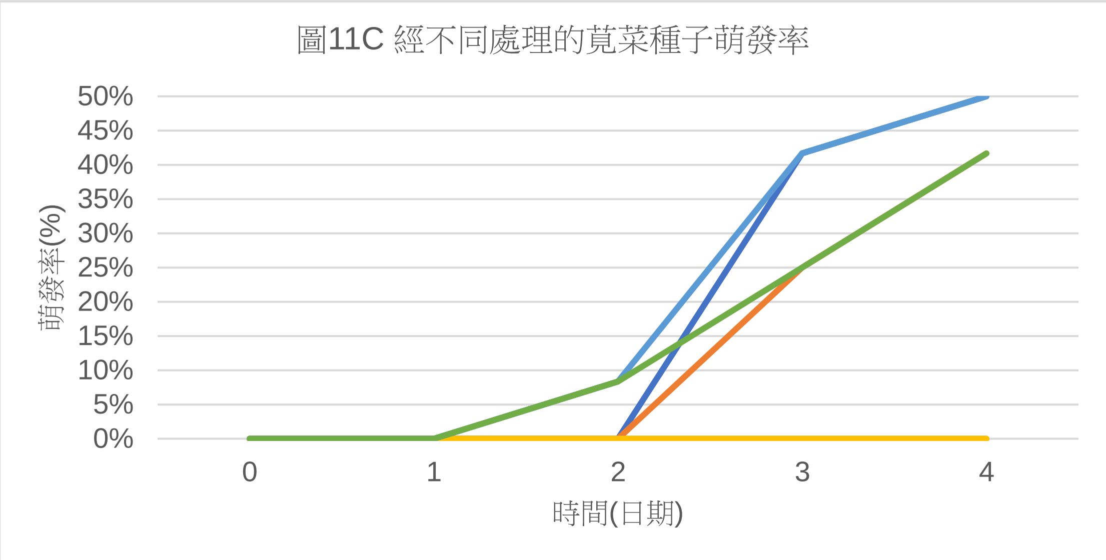


圖 11　種子萌發結果(培苗實驗)

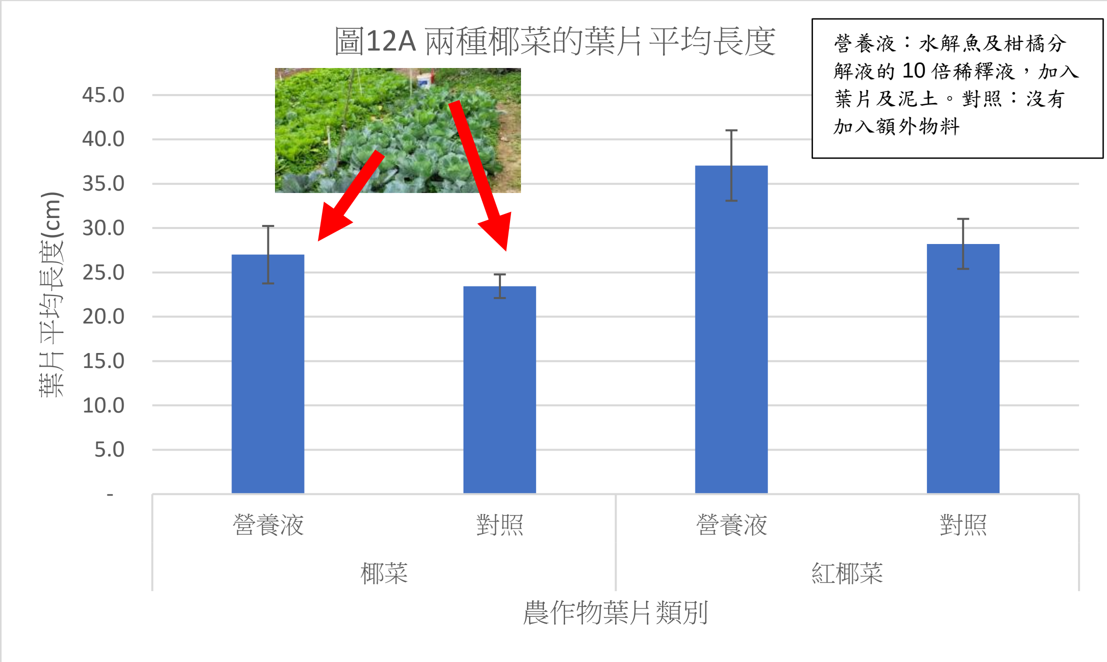






3.2 田野分析數據

圖 12 椰菜及菠菜葉片長度變化



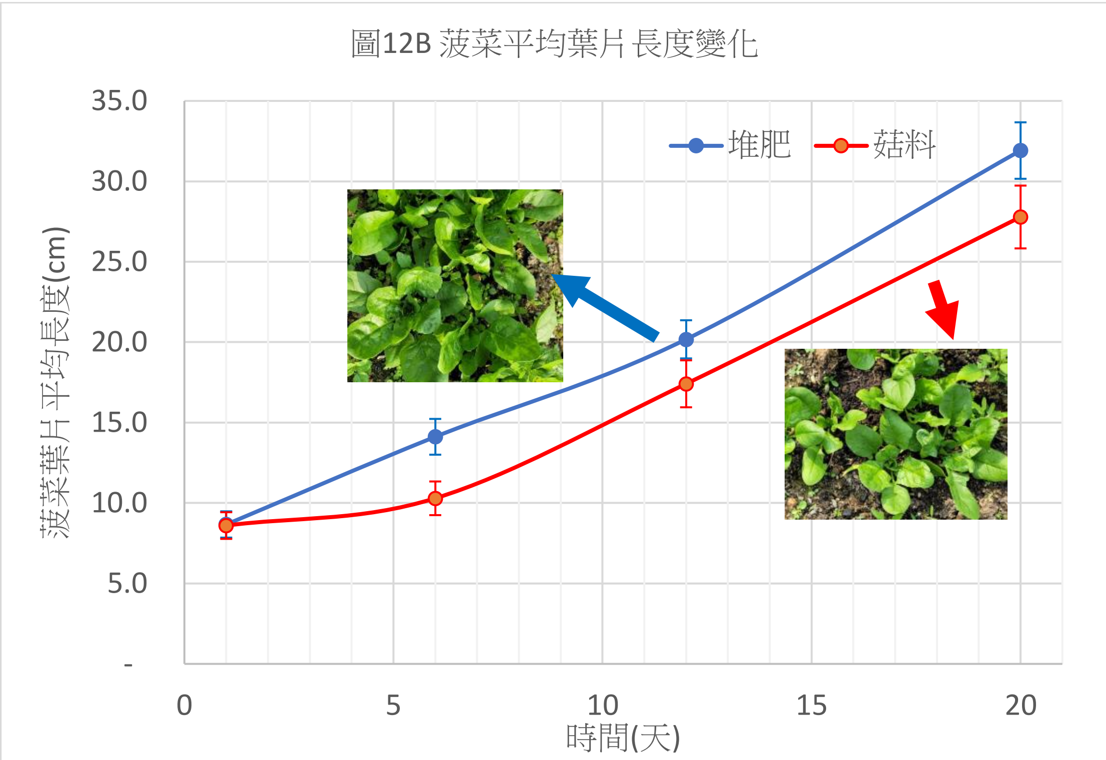
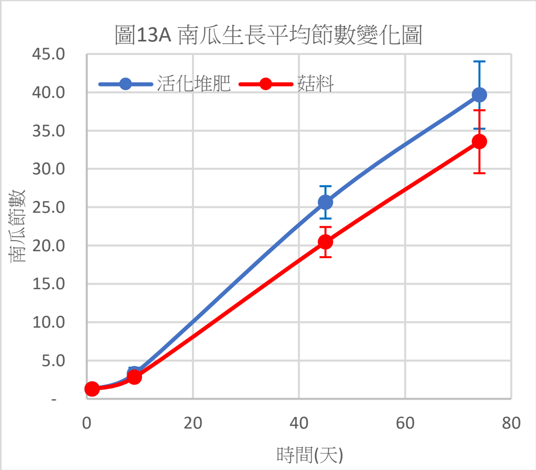
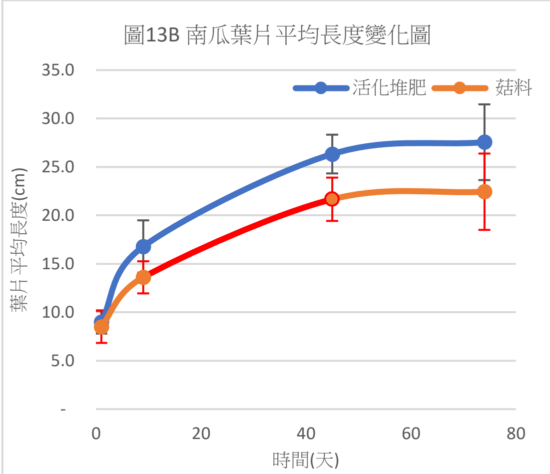
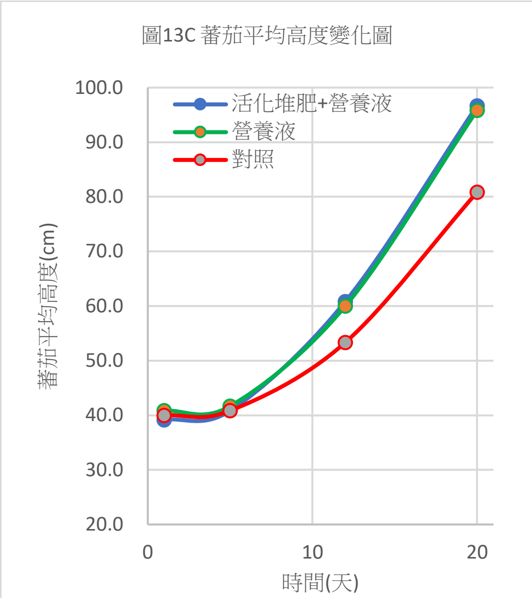
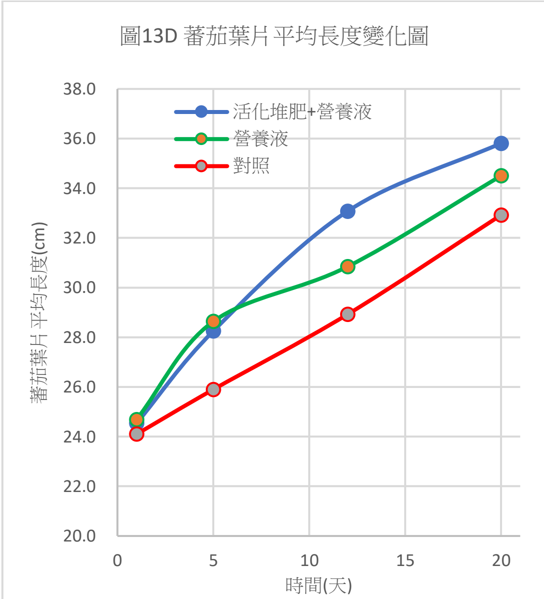


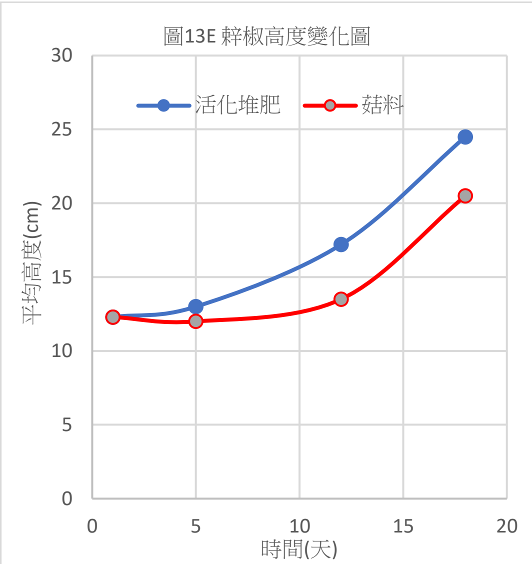
圖 13　其他農作物生長圖











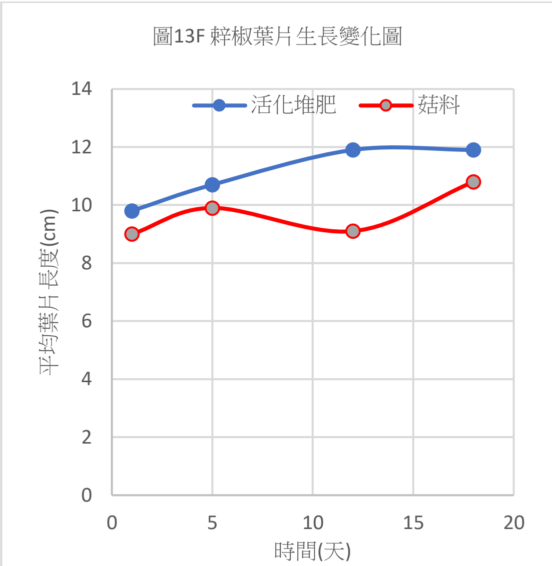


圖 14 蕃茄硝酸鹽含量

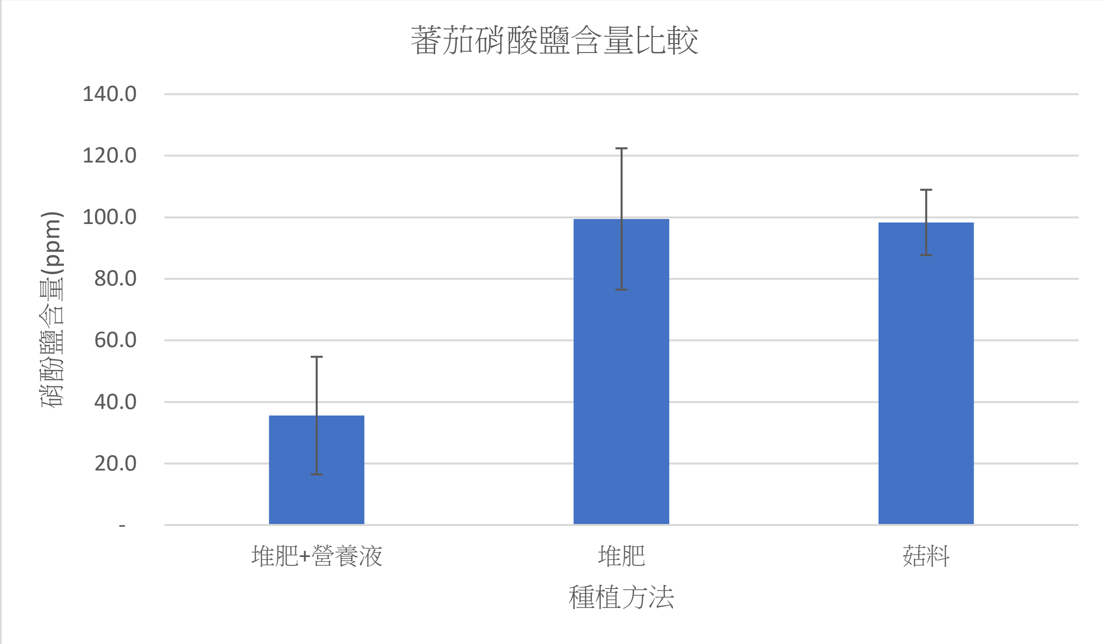


表 1 泥土微生物活性測試結果

	*泥土微生物活性 (μg C/g)
菇料	1626
未活化的堆肥	906
活化堆肥	(因疫情無法進行測試)
培苗土	1562
盆栽種植(菇料)	658
盆栽種植(菇料+綜合分解液)	1098
盆栽種植(對照，不加入任何物料)	342
紫椰菜+活化堆肥	350
紫椰菜對照	276
菠菜+綜合分解液	240
菠菜對照	87

* 註：泥土微生物活性越高，代表活躍的微生物(包括真菌及細菌)比例較高。

4. <u>討論</u>

因我們要配合杉山農場的生產，只能夠在不同的生長階段和季節，在農地加入不同的營養液和堆肥，以比較不同的農作物生長。**表二**綜合了我們的初步發現：

<u>表二　　結果總覽</u>

8A	柑橘及杏仁分解液	增加生菜根毛的密度
8B	柑橘及杏仁分解液	增加菜心的根毛平均長度
9B	柑橘及水解魚分解液	增加生菜的萌發率
9C	杏仁和柑橘分解液	增加莧菜的萌發率
10A	柑橘分解液	增加菜心的胚根平均長度
10B	水解魚	增加生菜的胚根平均長度
11A-11C	菇料	萌發率一般都高於使用培苗土
12A	柑橘分解液+菇料	萌發率高於其他組合
12	混合營養液	增加十字花科和菠菜的葉片長度
13A, B	活化堆肥	增加南瓜的葉片長度及節數
13C, D	活化堆肥+綜合分解液	增加蕃茄的葉片長度和高度
13E, F	活化堆肥	增加辣椒的葉片平均長度和植株平均高度
14	活化堆肥+綜合分解液	蕃茄果實的硝酸鹽含量最低

柑橘分解液和**杏仁分解液對菜心或莧菜種子萌發有較大的刺激作用**，而**水解魚較能促進生菜的萌發**。另外，我們利用澳洲的水解魚進行實驗時，明顯會抑制三種蔬菜種子的萌發，可見**不同微生物群落對不同農作物會有不同的影響**。柑橘渣、杏仁渣和雜魚的成份不同，這三種分解液都會促進不同微生物群落的生長。由於不同的植物所需要的微生物群落並不相同，要理解如何提升不同農作物的生長，要反覆進行更多測試，亦要提高測試的植物數量，以減低因個別差異做成的影響。

在萌發的過程中，我們只是將**種子浸泡於不同營養液 4 小時去接種**，從實驗結果所見，這種簡單的接種已可促進萌發和胚根的生長。

在田野實驗中，我們在每株南瓜或蕃茄只加入約 200 mL 及/或 50 g 活化堆肥，而各種生長指標都較使用菇料為理想，可見**混合使用活化堆肥及綜合分解液對提高農作物生長有正面幫助**。在蕃茄果實的硝酸鹽含量方面，同時使用**活化堆肥及綜合分解液的蕃茄的含量最低**。硝酸鹽含量越低，代表植物能善用所吸收到硝酸鹽去形成有機物，即代表植物**生長越健康，食物安全風險亦越低**。

參考**表一，使用活化堆肥/混合分解液後，農田土壤的微生物活性都提高了**，其中加入活化堆肥及混合營養液的指數最高。菇料的微生物活性雖然高，但對提升生長率的幫助不及活化堆肥，這可能與菇料內的微生物群落較為單一有關。

最後，**表三**總結各種營養液和堆肥的成本估算及建議用方法。各種營養液的成本很低，加上使用活化堆肥或分解液後，無需要使用其他肥料，這可**節省購買肥料的成本**。

表三　　營養液和堆肥的成本估算及建議用方法

泥土微生物促進方法	成本	建議用法
稀釋水解魚	$1/L	1. 以浸泡方法接種種子 2. 葉面噴灑 3. 灌進泥土 4. 活化堆肥
稀釋柑橘/杏仁分解液	$0.6/L	
活化堆肥	$8/kg	1. 瓜果類作物：每株 50g 2. 菜類可直接加進泥面，或混合菇料一起用
菇料	$0.08/kg	1. 直接加入泥面 2. (與培苗土混合作)培苗

5. 結論

使用柑橘和杏仁分解液對菜心和莧菜的萌發和胚根生長有較明顯的幫功，而水解魚於生菜的萌發和胚根生長效用較佳。基質方面，菇料比坊間的培苗土有較佳的萌發率。混合營養液能增加椰菜和菠菜的葉片生長，活化堆肥能增加南瓜的生長，同時使用活化堆肥亦能促進蕃茄的生長和減少硝酸鹽含量。由於我們所用的主要材料都是廚餘為主，只要適當運用廚餘，我們的方法便宜，可減少廚餘和促進農作物生長。

6. 鳴謝

- 麥陳尹玲女士(我校創校校長)及綠蔭家園的成員提供的技術支援，提供製作營養液和堆肥的物料，和聯絡健康工房取得廚餘。
- 杉山農場陳不凡先生提供場地和農田讓我們進行各種實驗和測試。
- 健康工房提供和運送廚餘

我們與合作伙伴的合照

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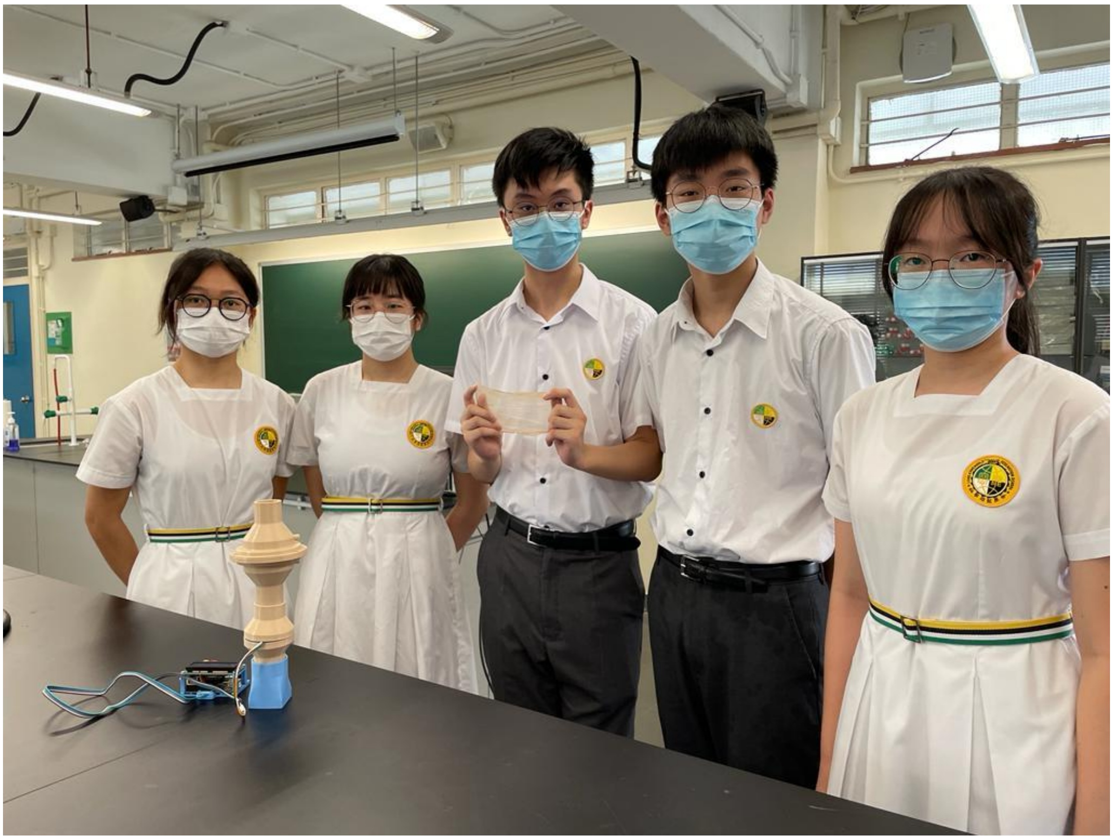
其他資料：
SOBE EM 菌粒：

- Bacillus Subtilis (1 x 109 cfu/g): Quickly decompose feed protein and starch, promote cats' intestines absorption.
- Bacillus Subtilis Natto (1 x 109 cfu/g): Generate types of vitamins that keep intestines healthy.
- Lactoacid Bacteria (5 x 108 cfu/g): Excrete lactic acid to help to maintain a healthy gastrointestinal tract by inhibiting those disease-causing bacteria.
- Saccharomyces Cerevisiae (1 x 108 cfu/g): Generate different types of amino acid that can promote cats' growth
- Aspergillus Sp. (1 x 107 cfu/g): Help in the decomposition of feed protein and starch to promote intestinal absorption.
- Microbial titer: $2x10^9$ cfu/g

亞軍

2021/22 Hong Kong Budding Scientists Award

The New Biodegradable Filter for Face Mask



Project conducted by

LEUNG Lok Hang Max

CHEUNG Ka Yu

CHEN Ka Po

YIP Wai Yu

DAI Jinfeng

Introduction and Background

Importance of Face Mask

According to World Health Organization, COVID-19 is caused by a new coronavirus called SARS-CoV-2, which spreads from an infected person's mouth or nose in small liquid particles when they cough, sneeze, speak, sing or breathe heavily [1]. These liquid particles have different sizes, ranging from larger 'respiratory droplets' (>5-10 µm in diameter) to smaller 'aerosols' (<5µm in diameter) [2].

Wearing face masks can prevent this droplet transmission from an infected person. In a research conducted in South Korea, it stated that surgical masks helped prevent the spread of severe acute respiratory syndrome and reduced the viral load of a cough in the cause of COVID-19 [3]. A recent Hong Kong research also found that wearing surgical masks are effective in significantly reducing the rate of COVID-19 transmission via respiratory droplets [4].

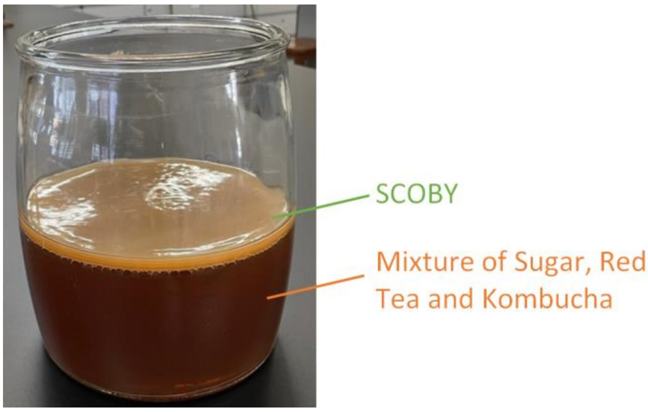
Face Mask – Working Principle and Limitations

Types of commonly found face masks are surgical mask, cloth mask, reusable mask, nano-filter mask and N95 respirator. The most popular face mask - surgical mask - has 3 layers structure and made of plastics (e.g. non-woven polymer and non-woven fabric). Outer layer isolates saliva. Middle layer is a filter which prevents virus-carrying respiratory droplets getting inside your body. Inner layer is efficient to absorb water vapour that is released from your mouth [5].

However, surgical masks are technically not reusable. Moreover, they are non-biodegradable and take over 450 years to break down [6]. According to the Environmental Science and Technology journal, there are 129 billion face masks being thrown per month [7]. Most of the disposable masks, will end up in landfills, or floating in the seas [8].

Alternative for Plastic Mask Filter

Due to the serious environmental impact, our project would like to find an efficient and environmentally friendly face mask filter. We propose to use SCOBY as the alternative to the plastic mask filter. It is a layer built of symbiotic culture of bacteria and yeast found in Kombucha. It is 100% cellulose and biodegradable [9]. SCOBY is also known as a biofilm and pellicle. It is a product of the bacteria in the brew of Kombucha, which creates strands of cellulose that weave together. Bacteria and yeast live in the SCOBY structure [10].



Researches had confirmed that the SCOBY nanocellulose is one of the most promising biopolymers due to its properties such as high mechanical strength, high surface area, chemical stability, hydrophilicity, transparency, biocompatibility, magnetic and electric susceptibility. Cellulose is the most abundant renewable organic material produced in the biosphere [11]. Due to its structure and physical properties, we deeply believe that the SCOBY is suitable for making the mask filter.

Hence, in our project, we would first make SCOBY filter, compare its filtration efficiency and water vapour permeability with filters in commercially available facial masks (surgical mask with PFE of ≥95%, reusable mask, cloth mask), and estimate its shelf life. We use these types of facial masks as they are easy to obtain and common to use. The tests enables us to study the feasibility of using SCOBY filter as the filter of a face mask to fight against the COVID-19 pandemic or other diseases caused by droplet transmission.

Experimental Details

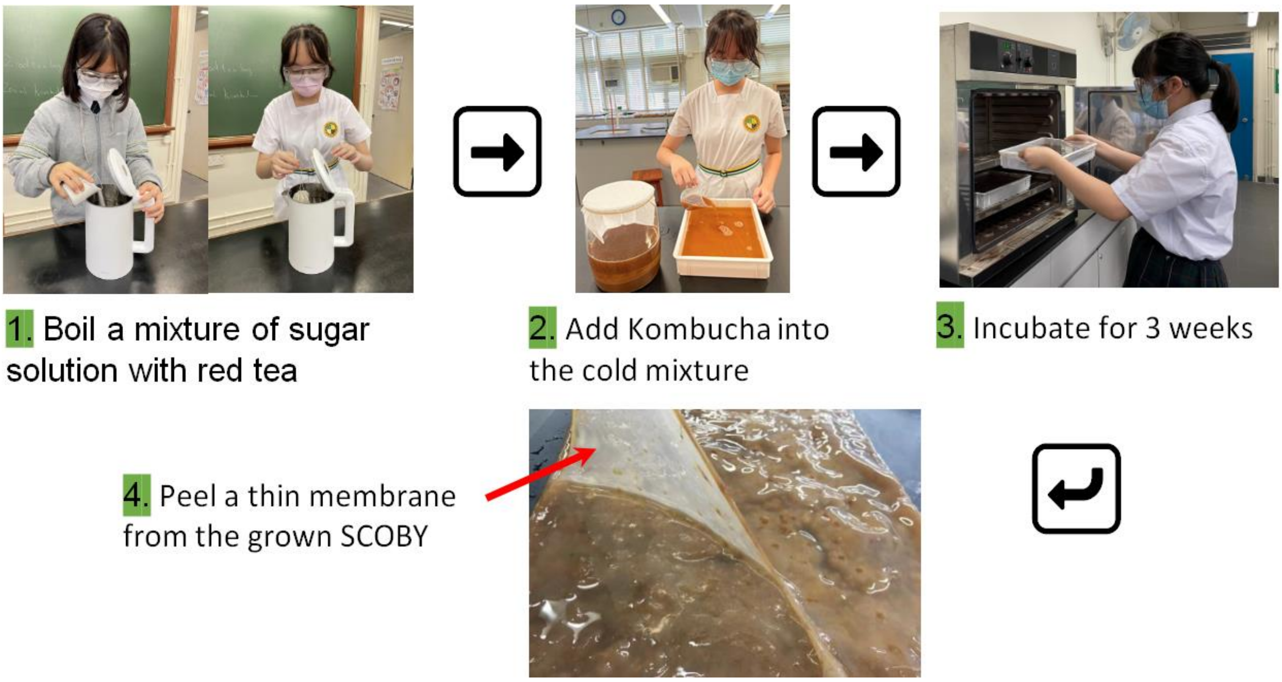
Section 1 – Making SCOBY filter

Objective

To grow the SCOBY using Kombucha and make the SCOBY filter

Procedures

1. Add 6 teabags of red tea into 1800mL water in a beaker.
2. Measure 180g of sugar using electronic balance and then add it into the red tea solution.
3. Boil the mixture for 5 minutes.
4. Cool the mixture to room temperature.
5. Measure 600 mL Kombucha using a measuring cylinder and pour into the mixture.
6. Grow the SCOBY for 21 days at 35ºC in the incubator.
7. Peel off the membrane (named as SCOBY filter in this report) from the SCOBY.



Section 2 - Filtration Efficiency Test

Objective

To compare the filtration efficiency of our facial mask with filters of surgical mask with PFE of ≥95%, reusable mask and cloth mask.

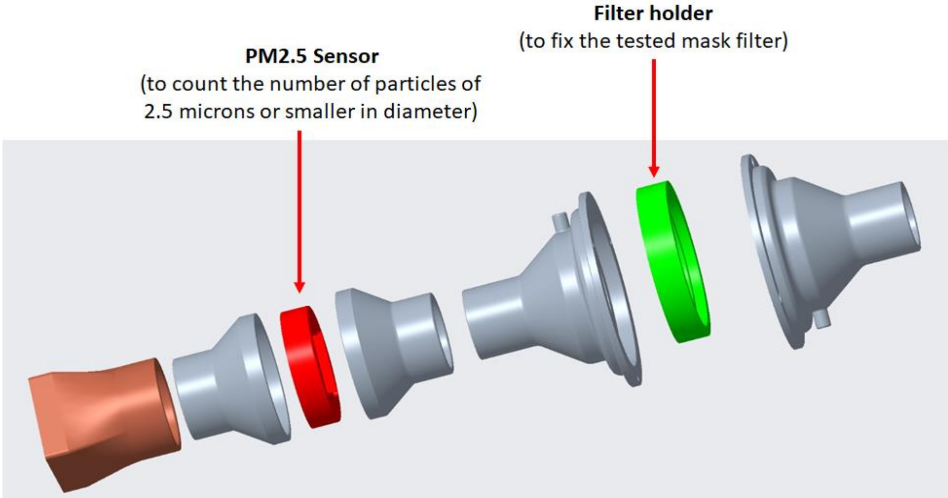
Experimental design

- **Why do we use corn flour in this filtration efficiency test?**

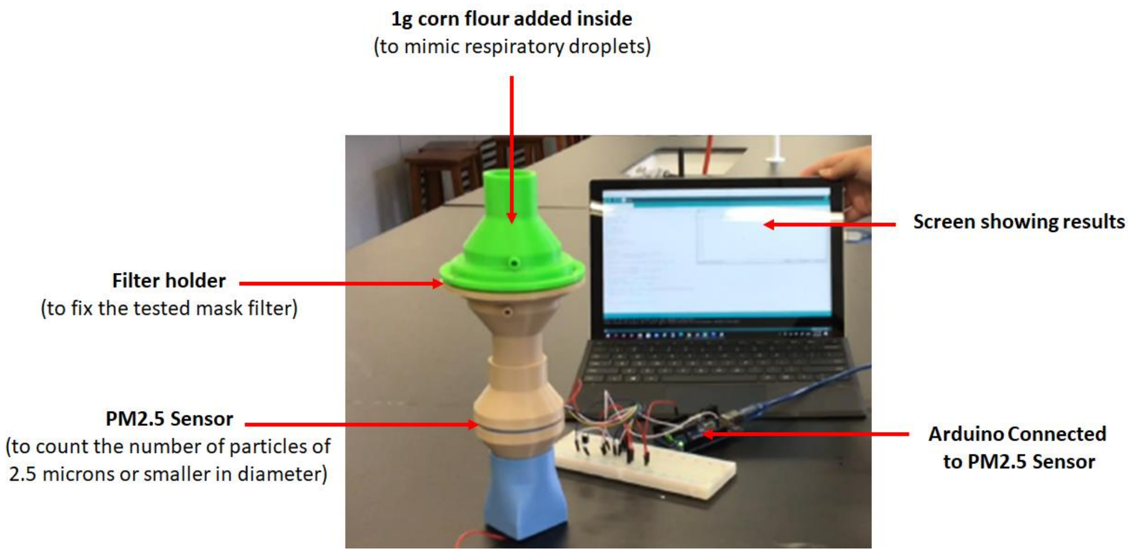
  Corn flour actually has certain portion of particles of diameters similar to respiratory droplet and aerosol [12]. Hence, we use corn flour powder to mimic the respiratory droplet and aerosol in this filtration efficiency test.

  In order to quantify the amount of corn flour passing through the mask filer, we made a device for accurate measurement of filtration efficiency of tested mask filter.

- **Our Design**



■ **Our Device**



Procedures

1. Fix the tested mask filter in the mask holder of our device (as shown above set-up).
2. Pump 1g of corn flour on the mask filter.
3. Record the amount of PM2.5 particles.
4. Repeat the procedure above until all the mask filters are tested.

Section 3 – Water Vapour Permeability Test

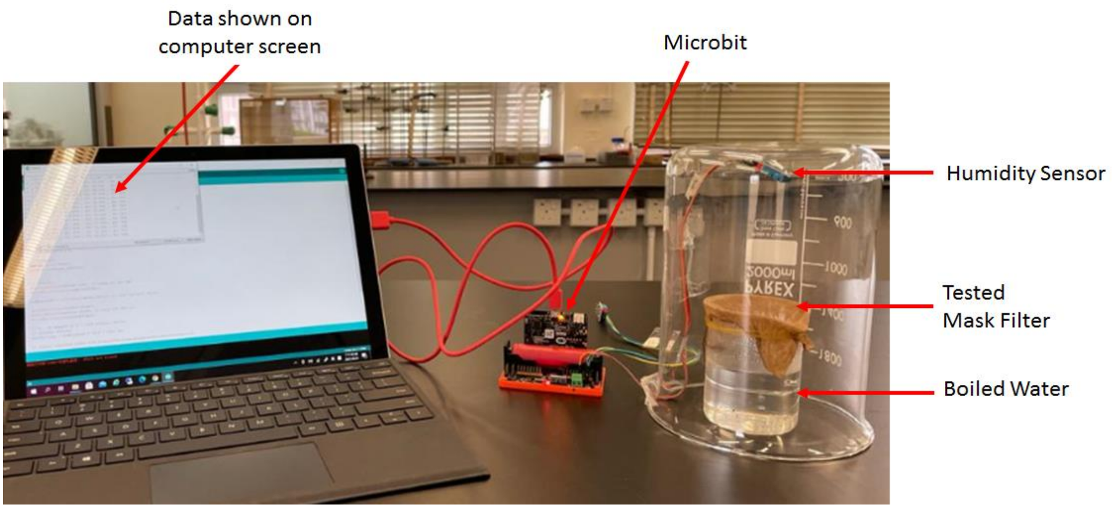
Objective

To compare the water vapour permeability of our SCOBY mask filter with filters of other facial masks (e.g. surgical mask, reusable mask and cloth mask).

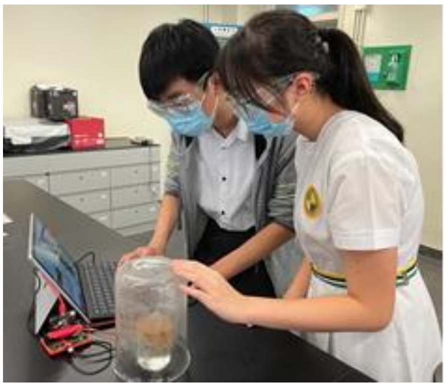
Procedures

*[*The amount of water vapour passing through the tested mask filter is checked by the humidity sensor in this test.]*

1. Stick a humidity sensor, which is connected to microbit and computer, at the bottom of a 2000 mL beaker.
2. Pour 100 mL boiled water into a 150 mL beaker and sealed it with SCOBY filter.
3. Invert the 2000 mL beaker to cover the 150 mL beaker as shown below.



4. Record the time spent to raise the humidity from 56% to 77%..
5. Repeat steps 1-4 until until all the mask filters are tested.



Section 4 – Estimate the shelf life of SCOBY filter

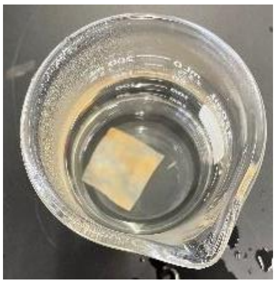
Objective

To estimate the shelf life of SCOBY filter by plate count method.

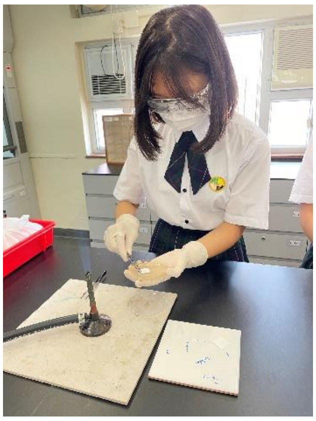
Procedures

(A) Preparation of a sterilized SCOBY filter

1. As the SCOBY filter is a layer built of symbiotic culture of bacteria and yeast, it contains bacteria. For safety reason, we first sterilize the SCOBY filter by putting it into a boiled water for 5 minutes and then dry it.



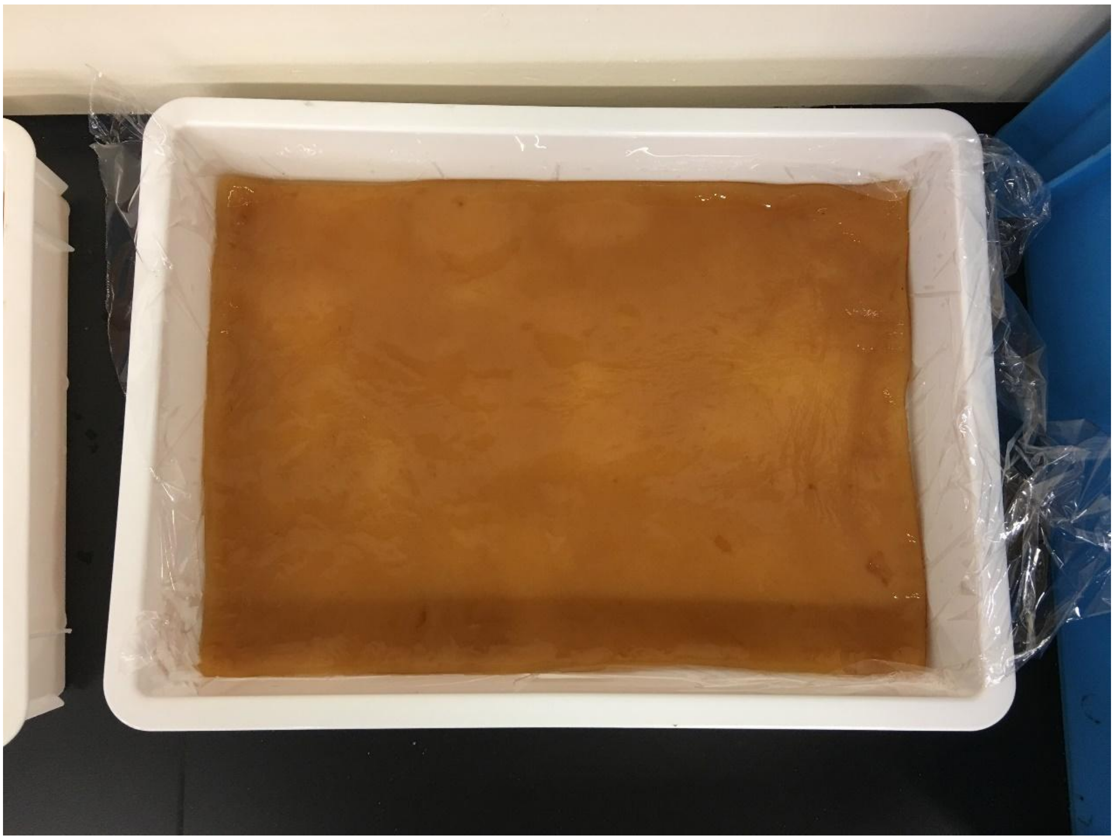
(B) Plate Count Method



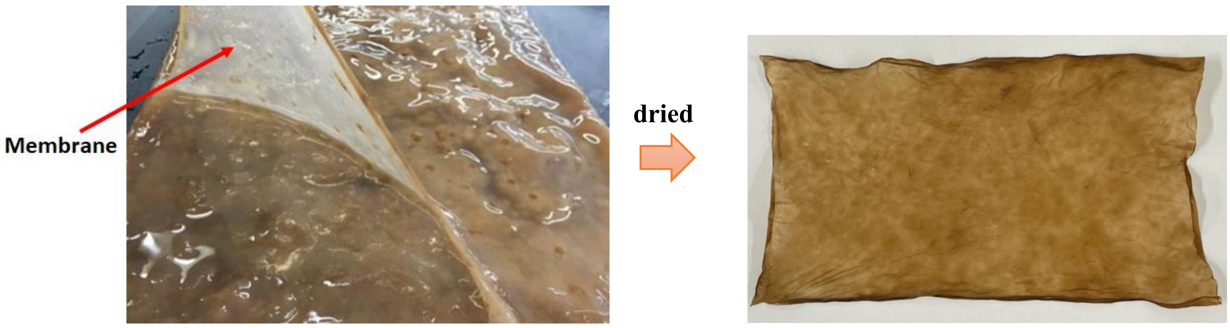
1. Using aseptic technique, apply the dried tested sample on a petri dish of plate count agar for 20 s.
2. Take out the sample and cover the petri dish immediately.
3. Put the petri dish in incubator for one day.
4. Count and record the number of colonies formed on the agar dish as time goes by.
5. Record the time it takes when colonies start to form on the agar dish.

<u>**Results and Analysis**</u>

Section 1 - Making SCOBY filter



At day 21, a thick SCOBY was successfully grown.

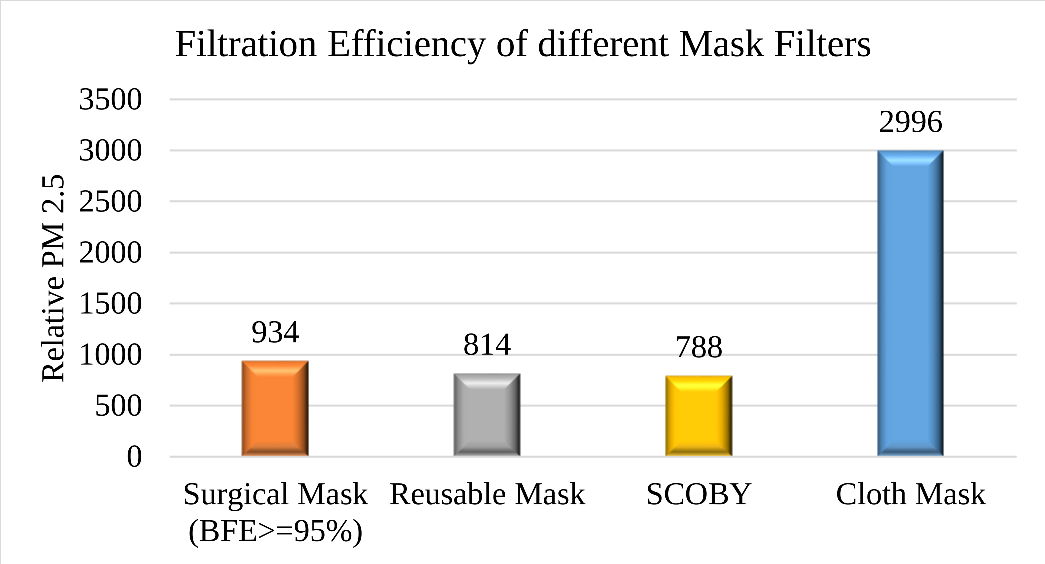


SCOBY Filter

Membranes were peeled off from the thick SCOBY growth for 21 days and dried for one day, we considered the member as the candidate for making biodegradable mask filter. **The membrane was named as SCOBY filter in this report.**

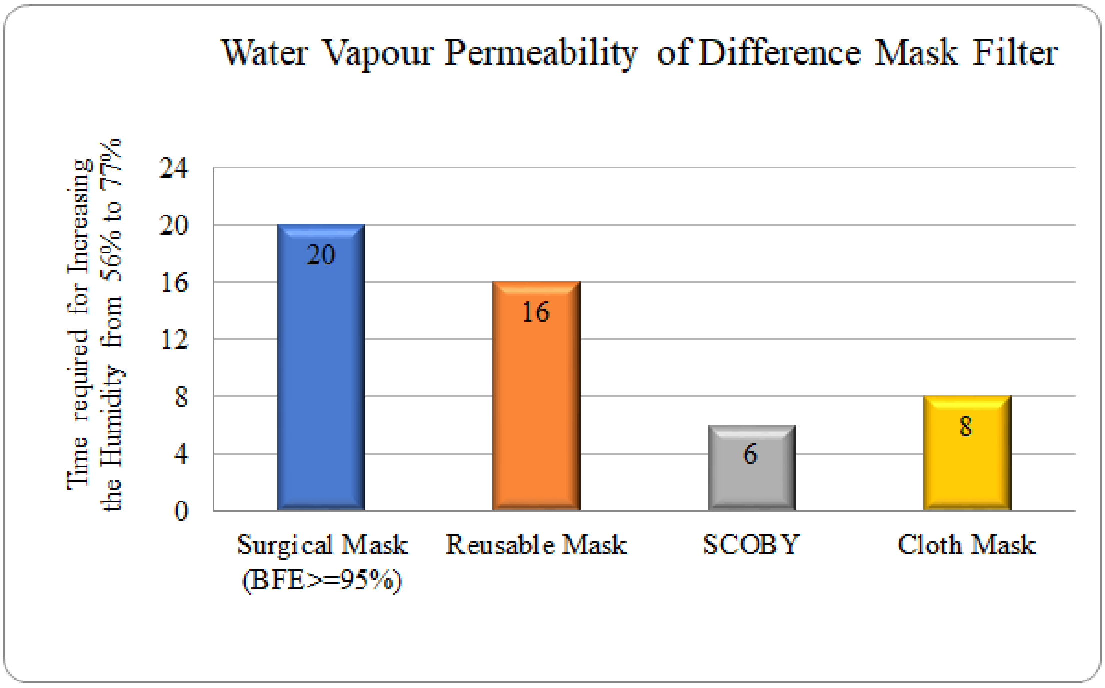
Section 2 – Filtration Efficiency Test

Using PM2.5 Sensor



From the experimental results, the cloth mask filter has the highest value of PM2.5 and much higher than the other three mask filters. This indicates the cloth can allow a lot of fine powder of corn flour passing through it. It is believed that cloth mask filter is very inefficient to filter the respiratory droplets or much smaller liquid particles. It is worth to mention that SCOBY filter has the lowest value of PM2.5. This means that it can filter the fine powder much better than the surgical mask filter and reusable mask filter. We believe that the extensive cellulose fiber network with lots of hydroxyl group in SCOBY can help attract the polar water and so has provided excellent filtration efficiency in both particle and aerosol penetration.

Section 3 – Water Vapour Permeability Test

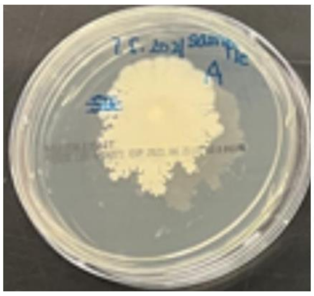


From the results, it was found that the rate of water vapour (gaseous phrase of water) passing through the tested filter is in the following order: SCOBY filter > Cloth mask > Reusable mask filter > Surgical Mask filter. The highest the rate of water vapour passing through the tested filter is, the higher the water vapour permeability of that filter. Therefore, it shows that the SCOBY mask filter performs best in the water vapour permeability test.

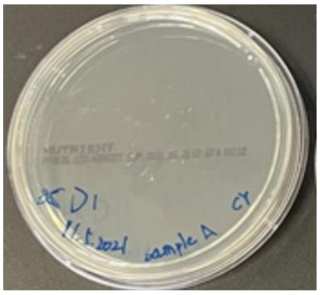
Section 4 – Estimate the shelf life of SCOBY filter

Filters exposed to air at:

Day 1



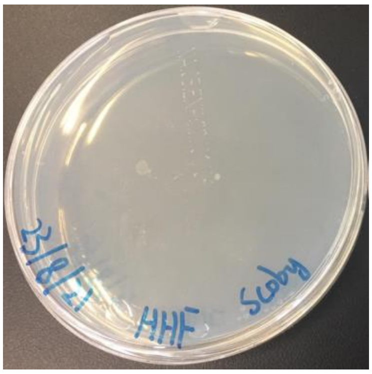
Non-sterilized SCOBY filter



Sterilized SCOBY filter

We sterilized the SCOBY filter before the experiment for safety reasons. Using plate count method, we can see the sterilization is effective as there is no colony in the dish for the sterilized SCOBY.

After 3.5 months

Filter from	Sterilized SCOBY
Result Photo	
No. of colonies	2

After exposed to air for 3.5 months, the SCOBY filter has only two colonies found. Hence, it is believed that the shelf life of a sterilized SCOBY filter is 3.5 months.

Summary and Conclusion

In this project, we study the feasibility of using SCOBY filter as the filter of a face mask to fight against the COVID-19 pandemic or other diseases caused by droplet transmission. Filtration efficiency, shelf life and water vapour permeability of SCOBY filter are compared with the filters of surgical mask, reusable mask and cloth mask.

First, we successfully grow the SCOBY and use the membrane peeled as the SCOBY filter for further testing. In the filtration efficiency test using corn flour, we found the SCOBY filter and the reusable mask filter shows the best filtration efficiency. In order to have much accurate comparison, we conduct the test again with a device installed with a PM2.5 sensor. From the results, it shows the SCOBY filter has the best filtration performance. We believe that the extensive cellulose fiber network with lots of hydroxyl group (-OH group) in SCOBY attract the polar water and so has provided excellent filtration efficiency in both particle and aerosol penetration.

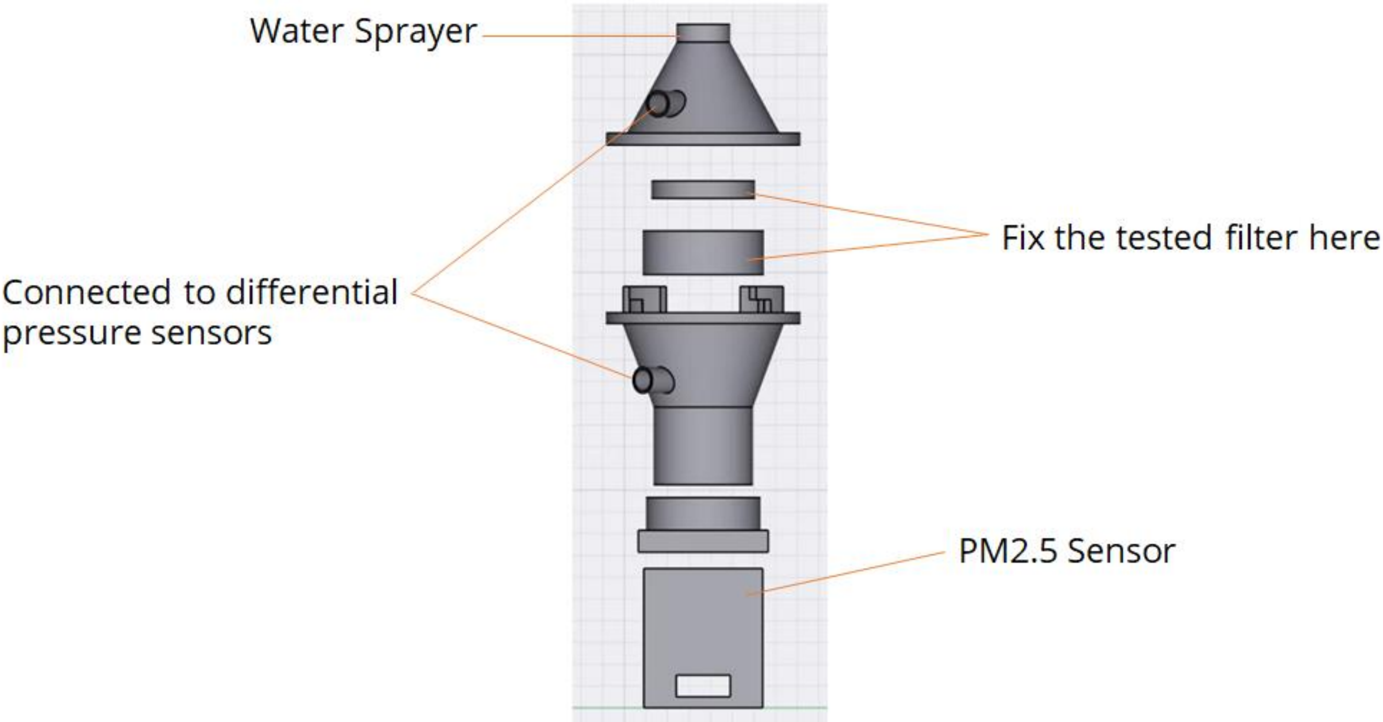
For studying water vapour permeability, we made a set-up installed with humidity sensor. From the result, it shows that the SCOBY filter has the highest water vapour permeability.

Last, we test for the shelf life of SCOBY using count plate method. For safety reason, we sterilize the SCOBY filter first by placing it in boiled water for 5 minutes. After exposed to air for 3.5 months, the SCOBY filter has only two colonies. Hence, it is believed that the shelf life of a sterilized SCOBY filter is 3.5 months.

SCOBY filter has much better performance than surgical mask, reusable masks and cloth mask in filtration efficiency. It has shelf life of 3.5 months. It also shows quite good water vapour permeability, which is comparable to surgical mask. Hence, SCOBY is a promising candidate for being mask filter. It is an efficient and environmentally friendly face mask.

Improvement and Further Study

In the near future, we would like to use water sprayer to produce water droplets of few μm in diameter for much accurate measurement of filtration efficiency as shown in our new design. Also, this device will be connected to differential pressure sensors to measure the breathability of mask filter to have better evaluation of our SCOBY filter.



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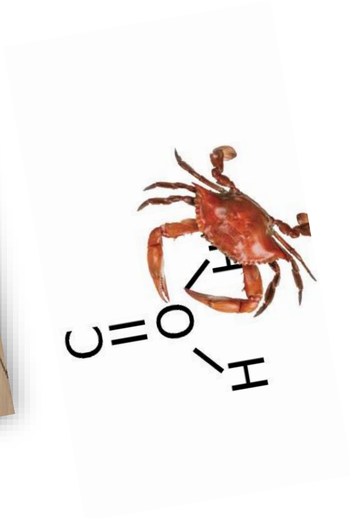
季軍

Removal of Formaldehyde by Crustacean Shells



Lau Ho Yi
Lau Ling Sze
Lau Wing Yi
Leung Ho Yin
Wom Tsz Ching

Content

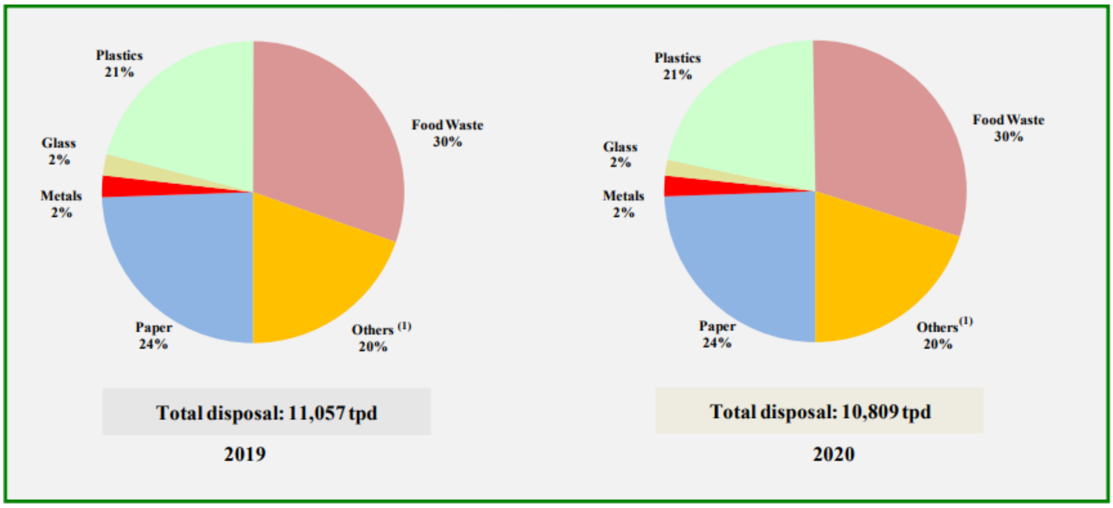
Abstract

Food waste problem become a huge global issue in recent years, we aim to use crusatceans shells in food waste to remove formaldehyde. Chitin is one of the major components of crustacean shells , which are made of 15-40% of chitin. Chitosan is a polysaccharide composed of amine functional group. Treating chitin shell with acidic substance to demineralize by removing calcium carbonate, then with alkaline solution, chitosan is extracted. In this study, chitosan extracted from demineralized crustacean shells. With the DA% and DD% from FTIR, the extraction process was confirmed to be completed successfully (DD% of >70%). The shell chitosan was then used to test for the formaldehyde absorption performance. All shells reduced the formaldehyde amount by >70% while *Scylla serrata* (crab) shell was the most effective with 76.35% reduction. In conclusion, different types of crustacean shells can remove formaldehyde and applicable in real-life situation with a reduction of 61.81% reduction in formaldehyde in a newly renovated cupboard.

1. Introduction

1.1 Food waste problem

The food waste problem has become a huge global issue in recent years. Roughly one-third of food produced for human consumption, gets lost or wasted globally, which is about 1.3 billion tons per year. [1] Global food waste has caused different environmental and financial problems. In Hong Kong, of the 10,809 tonnes of municipal solid waste (MSW) landfilled each day in 2020, some 3,255 tonnes (30% of MSW) were estimated as food waste. [2] The landfills in Hong Kong are nearly full, we need to find a new way to dispose of food waste.



Note:
(1) Others include yard waste, textiles, wood, household hazardous wastes, bulky items and miscellaneous waste materials.

Fig. 1.1 Composition of MSW disposed of at landfills in percentages in 2019 and 2020 - By major waste type

https://www.wastereduction.gov.hk/sites/default/files/msw2020.pdf

1.2 Seafood shell in food waste

After enjoying seafood for dining, their claws and legs are largely get dumped back into the ocean or into the landfill. As mentioned, an estimated 1.3 billion tons of food waste is generated each year, which included 6 million to 8 million metric tons of seafood shell waste (accounting for around 0.51% to 0.68%). [3] And these seafood shell waste is from crab, shrimp and lobster generally. [3]

1.3 Chitin and chitosan in seafood shell

Chitin is one of the major components of the shell of crustaceans. Crustacean shells are made of 20–40% protein, 20–50% calcium carbonate and 15–40% chitin. [4] The primary sources of chitin are the crustacean shells obtained from the byproduct of seafood industries. [5] These crustaceans include crabs, shrimps, lobsters and krill.

1.4 Conversion of chitin to chitosan

Chitin is a natural polysaccharide and is considered one of the most plenteous biopolymers. Chitin can be obtained from the shells of crustaceans, such as lobsters, crabs, and shrimps, as well as from fish scales and many other types of organisms like insects and fungi. Chitosan is a polysaccharide composed of randomly distributed β-(1→4)-linked D-glucosamine and N-acetyl-D-glucosamine. It is made by treating the chitin shells of shrimp and other crustaceans with an alkaline substance, such as sodium hydroxide. [6]

1.5 Use of chitosan

Chitosan has been widely studied and is used in many fields due its biodegradability, biocompatibility, non-toxicity, non-adhesiveness and film-forming properties, together with its antimicrobial and antifungal properties. [7] Selective applications of chitosan include antibacterial, antioxidant, corrosion protection, drug delivery, food packaging, water treatment, tissue engineering, etc. [8] Chitosan is also known to have the ability to remove formaldehyde from the surrounding. This characteristic will be used in the following experiments.

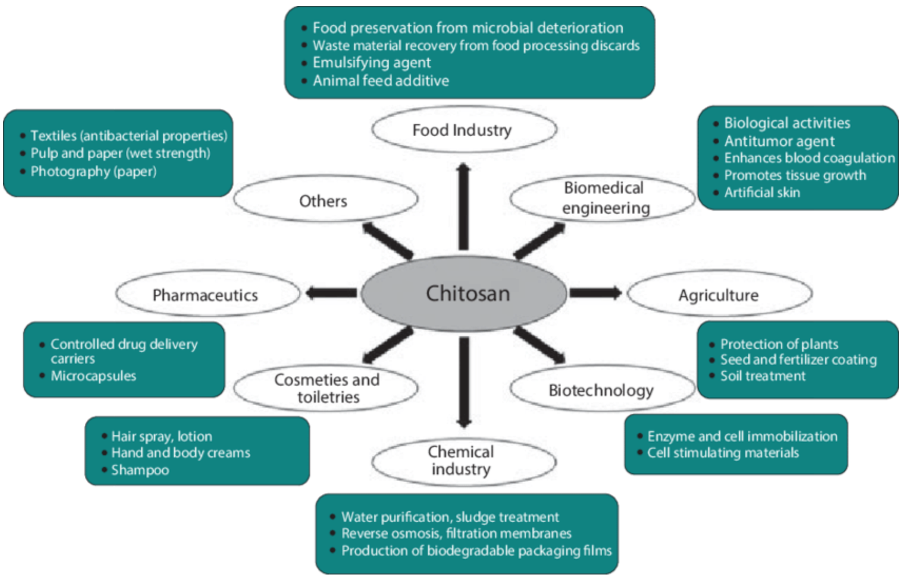


Fig. 1.2 Potential applications of chitosan and its derivatives in various sectors

https://www.researchgate.net/profile/Rahul-Patwa/publication/325464789/figure/fig5/AS:700588727738368@1544044777044/Potential-applications-of-chitosan-and-its-derivatives-in-various-sectors.png

2. Materials and methods

2.1 Different types of shell

Table 2.1 Different types of shell

Charybdis feriatus	*Scylla serrata*	*Litopenaeus vannamei*
		

2.2 Extraction of chitosan from different seafood shell

Crustaceans' shells and 100mL of HNO_3 in 6M concentration were prepared. Crustaceans' shell were put into a beaker with HNO_3 to demineralize (Fig. 2.1a). The demineralized crustacean shells were put into another beaker with 100 mL of NaOH in 12M of concentration at 70°C using a heater to deacetylate. (Fig. 2.1b)

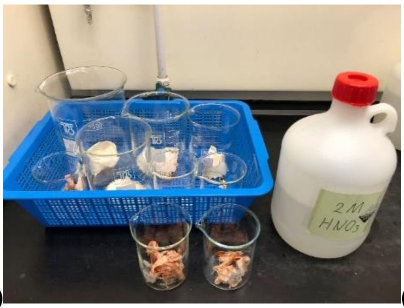
(a)  (b) 

Figure 2.1a Demineralization setup and 2.1b Deacetylation setup

2.3 Detection of chitin and chitosan by FTIR

Shells of crustaceans has a large amount of chitin which can be converted into chitosan by deacetylation. FTIR can detect different absorbance of NH and C=O. Therefore, formula of DA% and DD% are used to show the amount of C=O and chitosan respectively. The DA% is known as the degree of acetylation, the formula is showed in Formula 1 . The DD% is known as the degree of deacetylation, the formula is showed in Formula 2. [9] The DA% represents the amount of C=O in chitin in terms of ratio to be fair. With higher DA%, more C=O in chitin can be removed by deacetylation.

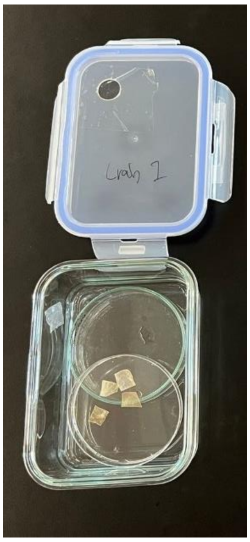
Formula 1 : $DA= A_{1655} \div A_{3450} \div 1.33 \times 100\%$

Formula 2 : $DD\%=100- A_{1655} \div A_{3450} \div 1.33 \times 100\%$

2.4 Formaldehyde test

4cm^2 of *Charybdis feriatus*, *Scylla serrata* and *Litopenaeus vannamei* shell were prepared as shown in Table 2.2. They were put in an air-tight box for 48 hours in a fume cupboard respectively with 0.5 mL of formaldehyde (1:100) They are tested with a control setup. The result was measured by 2 formaldehyde meters for 5 minutes (Fig. 2.2)

Table 2.2 Crab shell and chitosan gel used in formaldehyde test

			
Charybdis feriatus	*Scylla serrata*	*Litopenaeus vannamei*	Control (formaldehyde only)

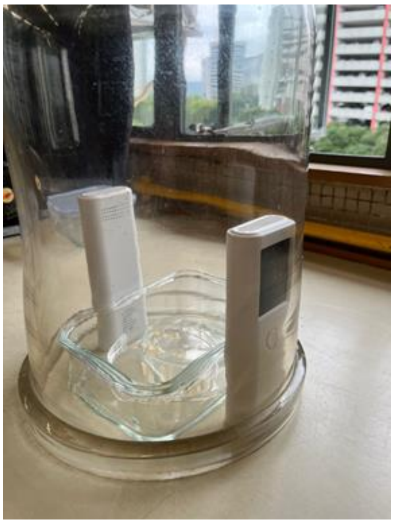


Fig. 2.2 Measurement setup for formaldehyde

3 Result of formaldehyde test

3.1 Extraction of chitosan from different seafood shell

From DA% in Fig. 3.1, chitin was found in all shell samples and *Scylla Serrata* has the most. Most of chitin was converted into chitosan after deacetylation as shown in Fig. 3.2 and both crab shells contained more chitosan with DD% of ~75%.

Table 3.1 product after chemical treatments

Types of shell	*Charybdis feriatus*	*Scylla serrata*	*Litopenaeus vannamei*
After Demineralization			
After Deacetylation			

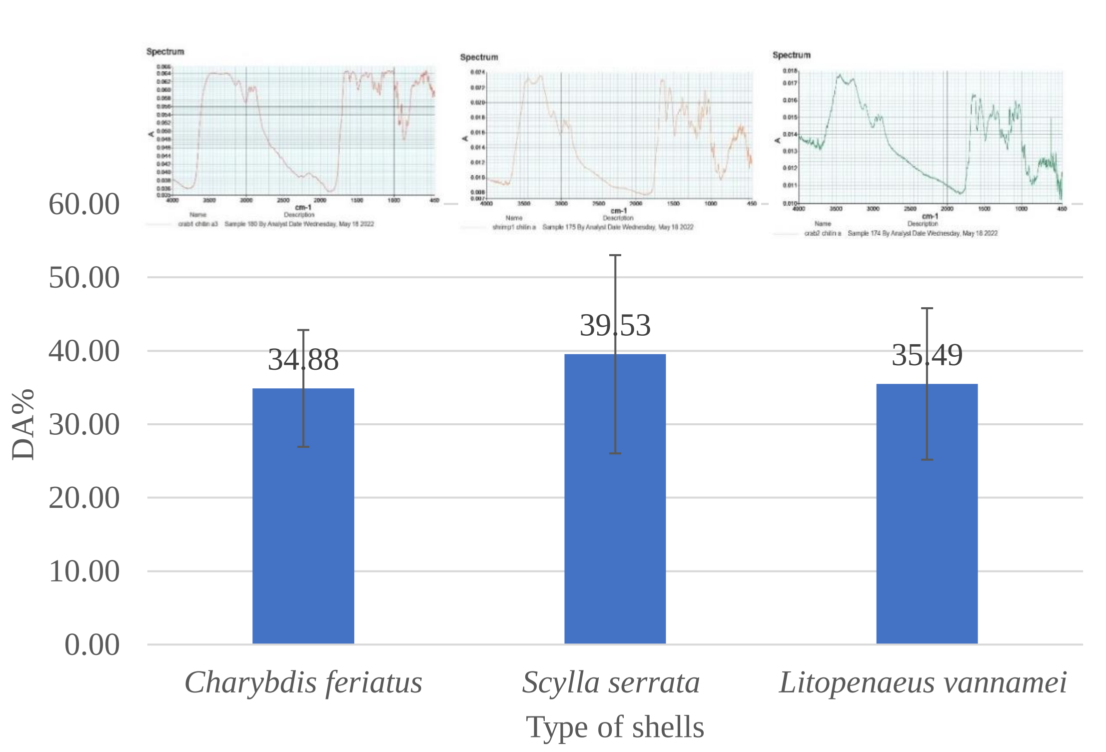


Fig. 3.1 DA% with FTIR spectrum of crustacean shells before deacetylation

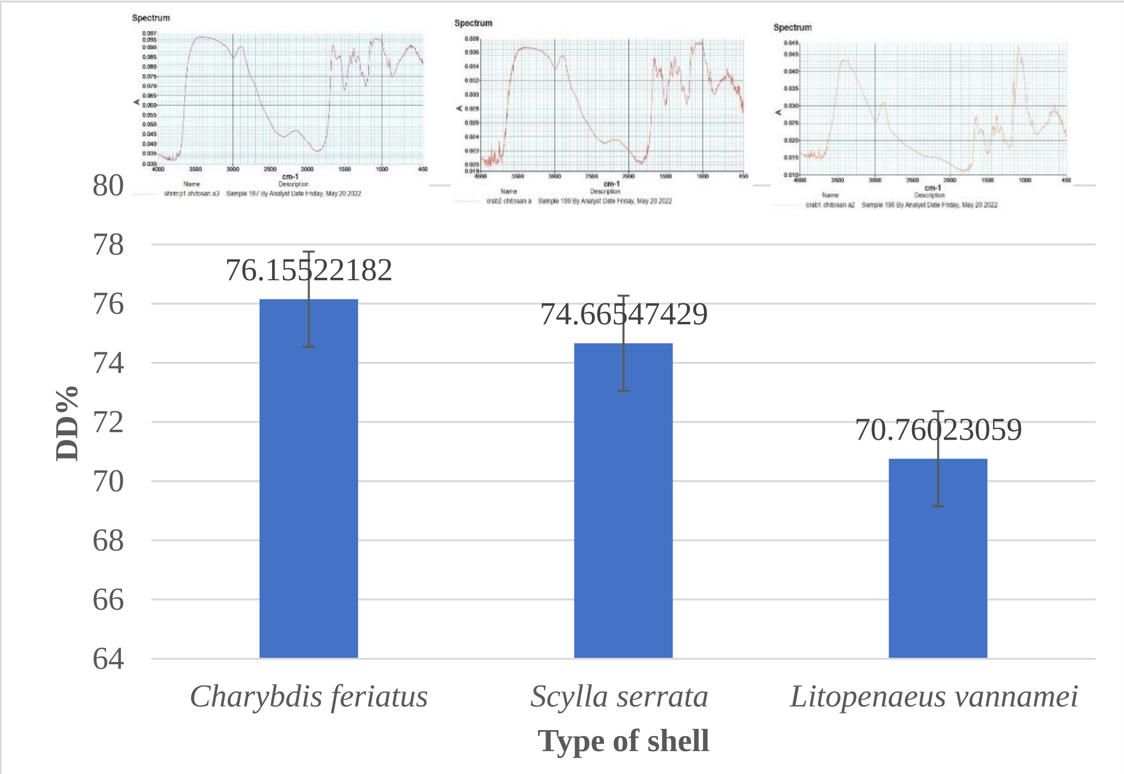


Fig. 3.2 DD% with FTIR spectrum of crustacean shells before deacetylation

3.2 Result of Formaldehyde Test

All shells were able to reduce the amount of formaldehyde to around 0.3 mg/m^3 (>70% decrease comparing to the formaldehyde only control setup). Shell of *Scylla serrata* performed best, it reduced the reading to around 0.26 mg/m^3 and reduce 76.35% of formaldehyde (Fig. 3.3 and 3.4). The DD% was reduced after the absorption of formaldehyde (Fig. 3.5) which showed the formaldehyde is chemically reacted.

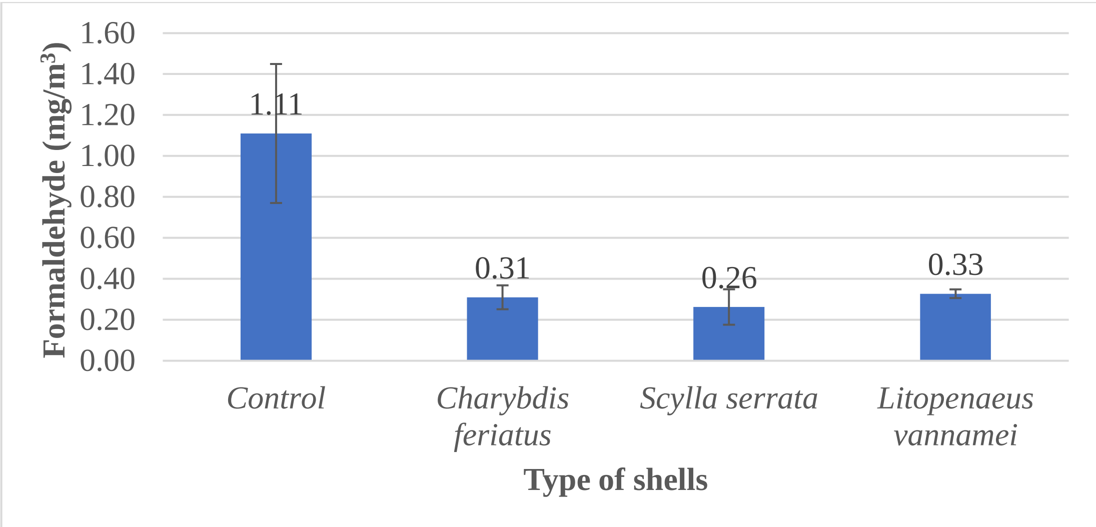


Fig. 3.3 Formaldehyde reading after 48 hours

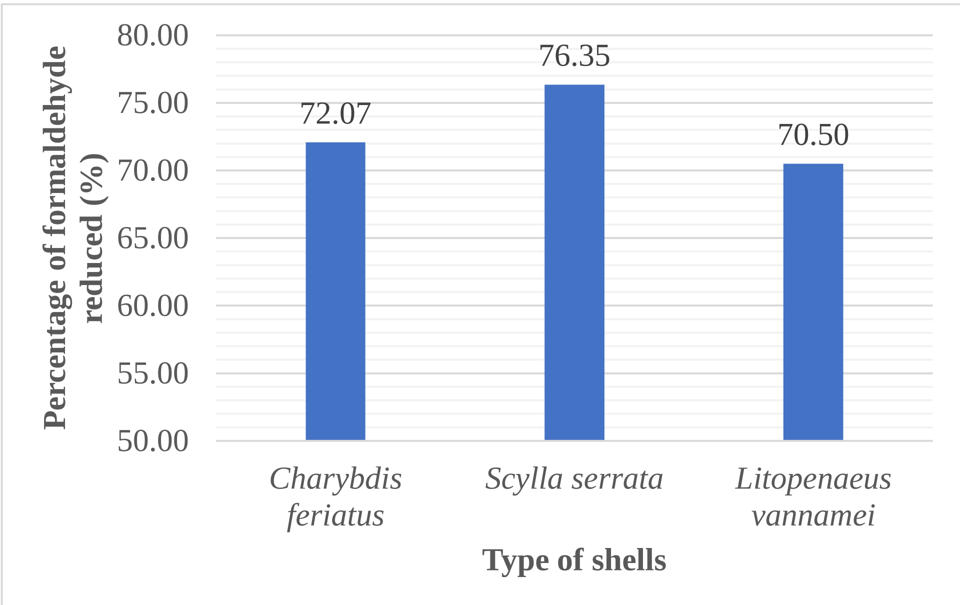


Fig. 3.4 Percentage of formaldehyde reduced

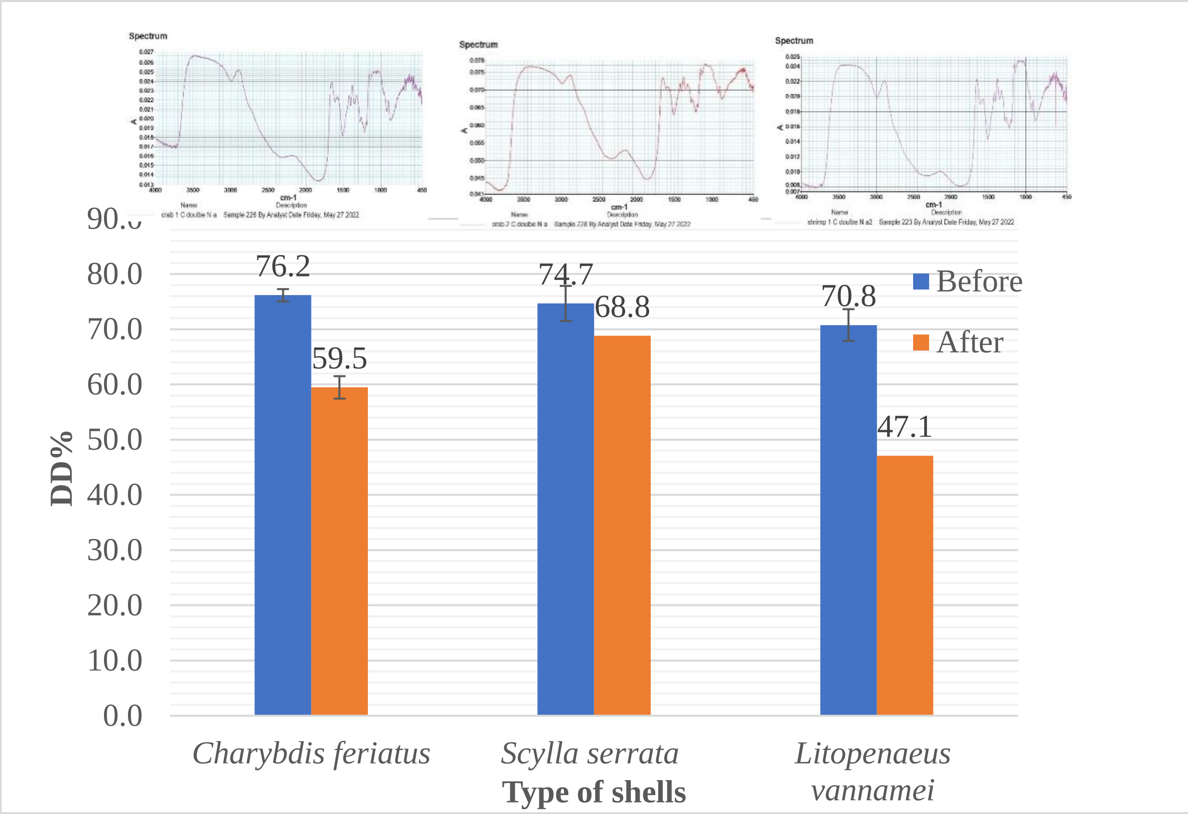


Fig.3.5 DD% with FTIR spectrum of crustacean shells after formaldehyde test

3.3 Findings

In formaldehyde test, it shows that different types of crustacean shell performed slightly different from others but all of them were able to reduce more than 70% of the formaldehyde. And the shells were still dry. (Table 3.2)

Table 3.2 Appearance of crustacean shell after formaldehyde test

Types of shell	*Charybdis feriatus*	*Scylla serrata*	*Litopenaeus vannamei*
After Formaldehyde Absorption			

4. Discussion

4.1 Chitosan Extracted from crustaceans

From Fig. 3.1, the absorbance value of C=O in amide (-CONH-) is high, so the DA% of chitin in crustacean shell are quite high. Therefore, more amide can be turned in to amine (-NH_2) through deacetylation to absorb formaldehyde.

From Fig. 3.2, the absorbance value of C=O is lower and the absorbance of NH_2 becomes higher. From Formula 1, with a lower absorbance value of C=O in chitosan and a higher absorbance value of NH_2, the DA% calculated out will be smaller. Lower value of DA% in chitosan means a higher DD% in chitosan. DD% is the degree of deacetylation [9]. DD% represents the amount of chitosan in ratio to be fair. In the procedure of deacetylation, C=O is removed by NaOH, i.e. amide (-CONH-) in chitin is converted to amine (-NH_2). All of the shells have a DD% over 70%, which means the conversion of chitin to takes place to a great extent. Therefore, more -NH_2 is in the shells. -NH_2 is used to absorb formaldehyde.

4.2 Result of Formaldehyde Test

From Fig.4.1, formaldehyde molecules are removed by condensation of water molecules with chitosan and some -NH_2 in chitosan will be lost when -NH_2 reacts with formaldehyde and condenses to water. This is consistent with the result shown in Fig. 3.5, most of DD% were decreased after formaldehyde absorption. From the result of FTIR after the formaldehyde absorption in Fig. 3.5, the DD% of the crab shells are still high (>60%), which means they are still capable to absorb more formaldehyde.

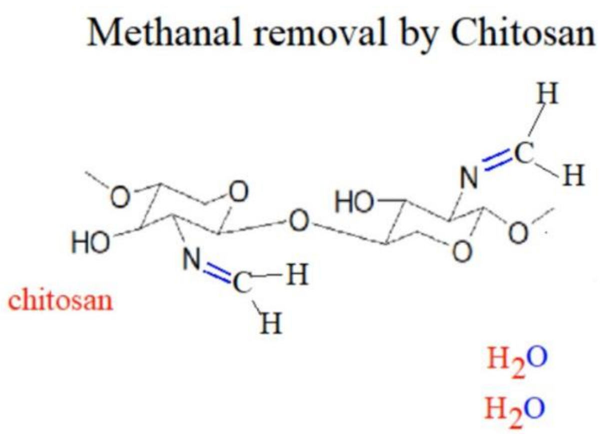


Fig.4.1 structure of chitosan after absorb formaldehyde

4.3 Application

Some crab shells are put in a cabinet inside a newly renovated room in our school. The shells were put in the cabinet for 48 hours. Then measured by 3 formaldehyde meters for 5 minutes. The setup is shown in Fig. 4.2. The crab shells reduced the amount of formaldehyde to around 0.37 mg/m^3. The crab shells successfully reduced around 61.81% of formaldehyde in the cabinet.

Fig. 4.2 Crab shells in a cabinet inside a newly renovated room

4.4 Further investigation

The extracted product of the crustacean shells is tested with formaldehyde to show that the product is chitosan and shows an ability to remove formaldehyde. However, the effect of concentration of formaldehyde on the effectiveness of chitosan in crustacean shells will be further investigated.

The method to obtain chitosan from crustacean shells in this investigation can be improved to achieve a higher yield in chitosan. Further investigation regarding which condition can achieve a higher yield in chitosan is needed.

Finally, the formaldehyde absorption ability of the shells should be compared with some common commercial products, such as photocatalysts, activated carbon, formaldehyde removal solution, etc., and pure chitosan to further confirm the effectiveness.

5. Conclusion

Crustacean shells can be used as an alternative way to obtain chitosan through demineralization and deacetylation since crustacean shells are commonly find in food waste around the world and can obtain huge amount from food waste in a low cost. The product after the extraction process shows an ability to remove formaldehyde with >70% reduction. In general, chitosan prepared from crab (72.07% and 76.35%) is better than those from shrimp (70.50%). The shells also work in the real-life condition with a decrease in formaldehyde for >60%.

(~1400 words)

6. Reference

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The 15th Hong Kong Budding Scientists Award 2021-2022

Research Study on Biodegradable Bioplastic 2.0

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Content

Abstract

The research project aims to use chitosan and starch or cassava flour to synthesize naturally biodegradable bioplastics and to find out the best ingredients. We hope to replace existing non-degradable petroleum-based plastic and to reduce plastic waste pollution.

In this project, we have successfully used naturally biodegradable polymeric chitosan and cassava flour to synthesize bioplastic prototype and to make different container product models. Our experimental results show that the best composition for bioplastics is 70% chitosan/30% cassava flour, with 15% acetic acid. Significantly, the lowest solvent absorption capacity, the strongest tensile strength and the fastest biodegradable characteristics of synthesized bioplastics can be obtained, with over 60% complete biodegradation in 32 days. These suggest that naturally polymers - chitosan/cassava flour are definitely new materials for the production of eco-friendly bioplastics in the future.

Ch.1 Introduction

1.1 Problem

Plastics are the most widely used polymers in our daily lives, especially in food packaging. In recent years, the annual output of petroleum-based plastics has exceeded 300 million tons. One of the environmental impacts of petroleum-based plastic production is pollution. It results in plastic being a material that is difficult to break down by soil microbes. Plastics waste, especially disposable plastic wastes such as garbage plastic bags, shopping bags, tableware, packaging materials, etc., have led to aggravation of environmental pollution and attracted attention to the disposal of polymer wastes, such as synthetic resin polyethylene, etc. With large molecular weight, stable internal structure, complex composition, strong corrosion resistance of plastic polymer wastes, and these needed 200 to 600 years for natural degradation. The plastic waste pollution is currently a major worldwide problem [3].

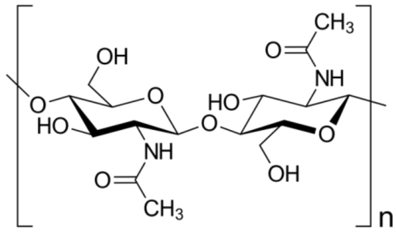
Since plastics cannot be decomposed easily, they can remain in the ocean for hundreds of years and accumulate in the food chain. If humans keep consuming plastic-contaminated seafood, their health may be harmed. Recent several studies have found consuming plastic-contaminated seafood may disrupt reproductive systems, stunt growth, diminish appetite, and cause tissue inflammation and liver damage.

1.2 Possible answers to the problem

Nowadays, recycling and burning plastic waste are two of the possible solutions to solve the problem of plastic pollution. Unfortunately, it is difficult to obtain products with the same strength as the original plastic from recycled plastic waste because it is very hard to isolate the plastic from the polymer type. Also, burning plastic waste is not a wise move since it may produce toxic gases such as cyanide, chlorine and carbon monoxide, and cause air pollution. As a result, the problem of plastic pollution still exists.

In recent years, there has been a rapid development in research into the synthesis of biodegradable plastics, and the expected characteristic of biodegradable plastics is that the resulting biodegradable products are non-toxic to the environment. Biodegradable plastics with high economic feasibility are synthesized through blends of natural polymers, which, in addition to being naturally degradable, can also be used as feedstocks that are readily available and renewable. Much of the latest research has been developed into plastics blended with environmental friendly natural polymers. For example, the cellulose, lignin and starch in plants, the chitosan, glucosamine and gelatin in animals and algae in the ocean can be used to produce bioplastics. Since starch, cassava flour and their derivatives are biodegradable, non-toxic and cheap, they are usually be modified for filling plastics. Corn eco-plastics have been synthesized from starch blends and thermoplastic chitosan [7]. The results show that the plastic film has good heat resistance. Therefore, naturally biodegradable polymers (such as starch, cellulose, cassava flour, chitosan and chitin)(Fig. 1.2.1), play a unique role in environmental protection, and their research and development have progressed rapidly [1, 2].

(a)



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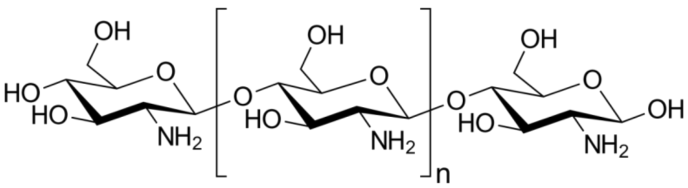


Figure 1.2.1 (a) Chemical structure of chitin (b) Chemical structure of chitosan

In this research project, it is desirable to synthesize biodegradable bioplastics and to find out the best ingredients from the natural polymers, in order to replace the existing plastics and solve the problem of the plastic wastes pollution. In the present study, we have evaluated different natural degradable polymers and used different composition of chitosan, cassava flour or starch to synthesize biodegradable bioplastics and test for their solvent uptake capacity, tensile strength and biodegradability as compared with polypropylene plastic. To the best of our knowledge, this is the first report regarding the synthesis of the biodegradable plastics by using chitosan and cassava flour, and the investigation of the best composition of the bioplastics. We aim to replace existing plastics and reduce plastic pollution. In the future, we also hope to use more precise scientific methods to use natural polymers to synthesize and test for biodegradable bioplastics.

1.3 Objectives

1. To synthesize different bioplastics from chitosan and cassava flour or starch.
2. To find out the best composition ratio of chitosan-cassava flour/starch to produce bioplastic.
3. To investigate the mechanical properties of different composition ratio synthesized bioplastics, such as tensile test and solvent absorption test.
4. To test the biodegradability of the synthesized bioplastics.

1.4 Hypothesis

Using natural biodegradable polymers (such as cassava four or starch, chitosan) can synthesize biodegradable bioplastic. It is expected that bioplastic have higher mechanical properties and rapid decomposition, which can effectively replace petroleum-based plastics. Bioplastic becomes a new material for the production of eco-friendly bioplastics in the future.

Ch.2 Experimental Methods

2.1 Synthesis and characterization tests of bioplastic

1) Bioplastic synthesis

Prepare 0.6-1.4g different composition of Starch/Cassava flour and Chitosan

Add with 10 mL distilled water and 10mL 5%-15% Acetic acid

↓

Add 1mL 5%-15% acetic acid and 1 mL Glycerol into different starch mixtures

↓

Stir with glass rod to mix and pour into Petri dish

Dry in 65-70°C oven

↓

2) Tensile Test

The dry bioplastics were cut into different length and tested for tensile strength

↓

3) Solvent Uptake Test

The dry bioplastics were cut into size of 1 cm x 1 cm

Then weigh and put into a beaker filled with four different solvent;

1. Ethanol (C_2H_5OH), 2. Sodium hydroxide (NaOH)(pH10),

3. Hydrochloric acid (HCl)(pH4), 4. Distilled water

↓

Incubate for 1 min and take out from the beaker for comparing their weight

↓

4) Biodegradation Test

The bioplastics were cut into size of 1 cm x 1 cm

Then weigh and put into soil for 7-12, 22 and 32 days

↓

Weigh again and calculate the net weight different

Compare with polypropylene (PP) plastic as control

↓

Compare different composition of synthesized bioplastics

Statistical Analysis

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

2.2 Bioplastics synthesis

Bioplastics synthesis were performed by weighing chitosan, starch, and cassava flour of different predetermined masses with different concentrations of acetic acid by electronic balance (Table 2.2.1).

Step 1	Chitosan is then dissolved in 10 mL of 5-15% acetic acid while stirring with a glass rod in beaker A.
Step 2	Pour the starch/cassava flour and 10 mL of distilled water into beaker B, mix and heat on a hotplate while stirring with a glass rod until all the starch/cassava flour is dissolved.
Step 3	Add 1 mL of glycerol and 1 mL of 5-15% acetic acid into beaker B and mix.
Step 4	The two mixtures of beaker A and B are poured and mixed together; some of the bioplastics are added with food coloring.
Step 5	After the sample begins to form a gel, the sample is poured into a petri dish or mold, and air-dried in an oven at 65-70℃ until all solvents have evaporated and a bioplastic film or product model is obtained. And use polypropylene (PP) plastic as control.

No.	Chitosan (%)	Starch/ cassava flour (g)	Chitosan (g)	Starch/ cassava flour (g)	Total (g)	5-15% acetic acid (mL)	2% acetic acid (mL)	Distilled water (mL)	Total (mL)
1	70	30	1.4	0.6	2.0	10	0	10	20
2	60	40	1.2	0.8	2.0	10	0	10	20
3	50	50	1.0	1.0	2.0	10	0	10	20
4	40	60	0.8	1.2	2.0	10	0	10	20
5	30	70	0.6	1.4	2.0	10	0	10	20
6	25	75	1.0	3.0	4.0	10	2	10	22
7	0	100	0	4.0	4.0	10	2	10	22

Table 2.2.1 Experimental design of bioplastic synthesis.

2.3 Investigate the tensile strength of bioplastics

Bioplastic samples were cut to lengths of 4.0 cm and 1.0 cm wide. The measurement condition is a constant tensile velocity with a maximum load of 20N or 100N. The sample is clamped on a tensile test apparatus (Fig. 2.3.1), and applies forces and runs the apparatus according to a predetermined condition until the sample is disconnected. Repeated procedure above for each sample is done 3 times tensile test. Recorded tensile test results are presented in the form of tables between tensile strength and extension. The magnitude of the breaking strength of a material depends on the amount of loading applied and the cross section and lengths of the bioplastic material itself.

Step 1	The experimental bioplastics were cut into 2.0 cm to 4.0 cm in length and 1.0 cm wide.
Step 2	Place the bioplastic on a wooden ruler with the width of the bioplastic aligned.
Step 3	Use a medium-sized A-clamp to hold the ruler and the bioplastic together from 0 to 5 mm.
Step 4	Use another medium-sized B-clamp to clamp the other side of the bioplastic. The length in the middle of the two clamps is an independent variable.
Step 5	Use a spring balance (Type 1: 0-20 N; Type 2: 0-100 N) to hook the ring of the B-clamp and apply force slowly backward until the test plastic film breaks, and record the force reading (N, Newton) of the spring balance.

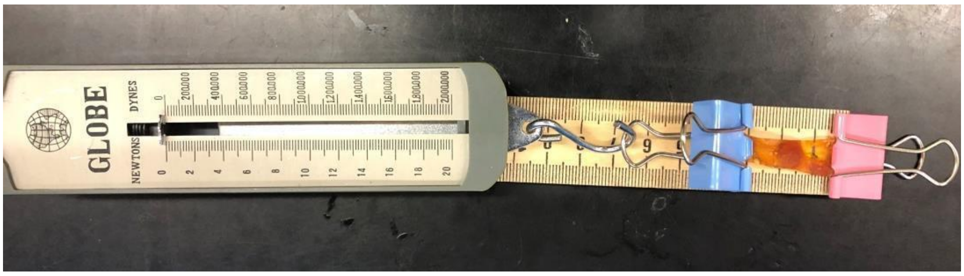


Figure 2.3.1 Tensile test apparatus.

2.4 Investigate the solvent uptake capacity of bioplastics

This test is based on the method performed in the literature [6]. In brief, bioplastic was cut to the size of 1.0 cm x 1.0 cm. The bioplastics were then weighed with an electronic balance. The bioplastic is put into a 10 mL beaker filled with 5 mL of four different solvent, then keep in room temperature. Every minute, the bioplastic was taken out. The solvent on the bioplastic surface is wiped with a tissue, and then weighed.

The absorption capacity of the solvent is calculated using the following formula:

$$\text{Solvent Uptake (\%)} = \left[\frac{W - W0}{W0}\right] \times 100\%$$

W0 = weight of dry sample

W = weight of sample after immersion in the solvent

Step 1	Cut the bioplastic film into the size of 1.0 cm x 1.0 cm and set it aside for use.
Step 2	Weigh and record the selected four small pieces of bioplastic film with an electronic balance.
Step 3	Prepare 5 mL each of 1) distilled water, 2) ethanol alcohol (C_2H_5OH), 3) sodium hydroxide (NaOH)(pH 10), and 4) hydrochloric acid (HCl)(pH 4) into four beakers.
Step 4	Place the four bioplastic films into the four beakers at the same time and start the timer.
Step 5	After one minute, the bioplastic was taken out. The solvent on the bioplastic surface is wiped with a tissue, and then weighed. The absorption capacity of the solvent in the bioplastic was calculated using the above formula.

2.5 Investigate the biodegradation rate of bioplastics

This test is based on the method used in the literature [5, 6]. Biodegradable plastics were examined by the soil burial test method. Observations were made until the samples were completely degraded in the soil and a control experiment was conducted with commonly used PP (polypropylene) plastics.

Step 1	Cut each bioplastic film into the size of 1.0 cm x 1.0 cm.
Step 2	In the beginning the samples were weight was recorded as an initial data. Samples were buried in the soil at a depth of 2.0 cm.
Step 3	Monitor the initial weight of the soil every week. If the soil quality decreases, add distilled water back to the soil and restore the original soil weight (For growth of the microorganisms). Disperse the water evenly over the soil.
Step 4	Sample checking took place once in every ten days (after 7-12 days, 22 days and 32 days), followed by weighing and putting back in soil. Observation was carried out until sample was degraded completely in soil. The initial weight was determined and the weight after decomposition of the bioplastic was measured at indicated days.

The loss of weight in degradation can be calculated using the following formula:

$$\text{Weight Loss (\%)} = \left[\frac{W0 - WT}{W0}\right] \times 100\%$$

W0 = initial bioplastic weight before placement in soil
WT = bioplastic weight after taken out and cleaned at day (T)

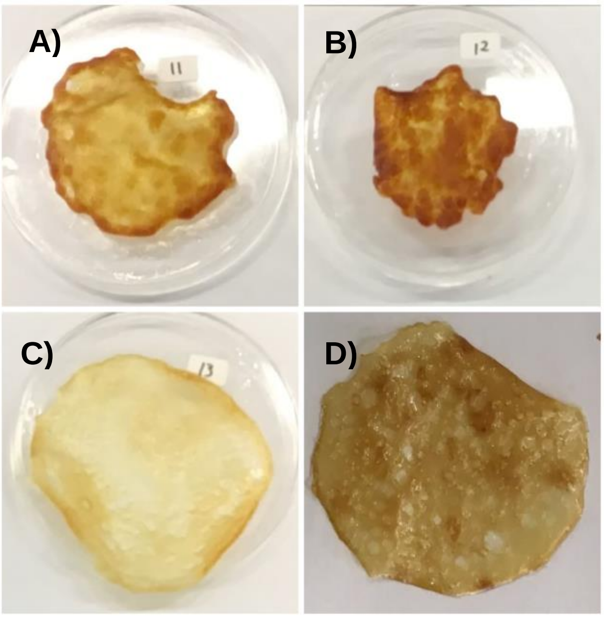
Ch.3 Results

3.1 The synthesis of bioplastics

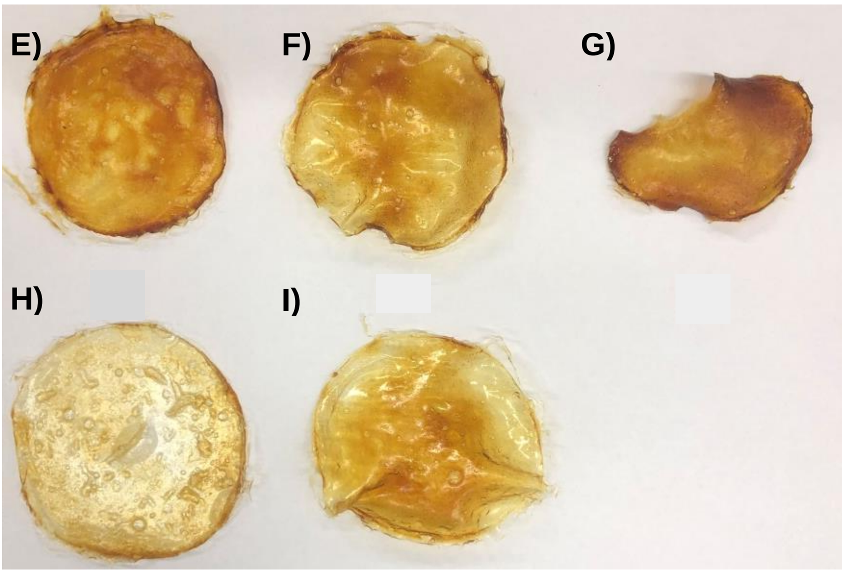
We have used naturally biodegradable polymers to synthesize bioplastics. By mixing various proportions of chitosan and cassava flour/starch (70/30, 30/70, 50/50, 60/40, 40/60, 25/75, 0/100) (Table 2.2.1) with different concentrations of acetic acid (5%, 10%, 15%), we have successfully synthesized bioplastics with various performance. To identify the best composition of chitosan and cassava flour/starch for bioplastics synthesis, the bioplastics were tested for their tensile strength, solvent uptake capacity, and biodegradation rate. Experimental results have revealed that the successful synthesis of bioplastic prototypes were used chitosan and cassava flour. This suggests that cassava flour and chitosan polymers are very promising new materials for the production of bioplastics.

3.1.1 Appearance of bioplastic prototypes

Bioplastic prototypes obtained in this study are shown in Fig. 3.1.1A-B, which is a coloured bioplastic film from light yellow to brown (plastic films without edible colouring added), with a rough surface. The resulting film colour greatly depends on the composition of the chitosan and starch/cassava flour. The higher the concentration of acetic acid and chitosan content used in the synthesis process, the darker and thicker the bioplastic film. The more cassava flour/starch used in the synthesis process, the clearer the colour and softer the texture of the bioplastic film (Fig. 3.1.1A-B).

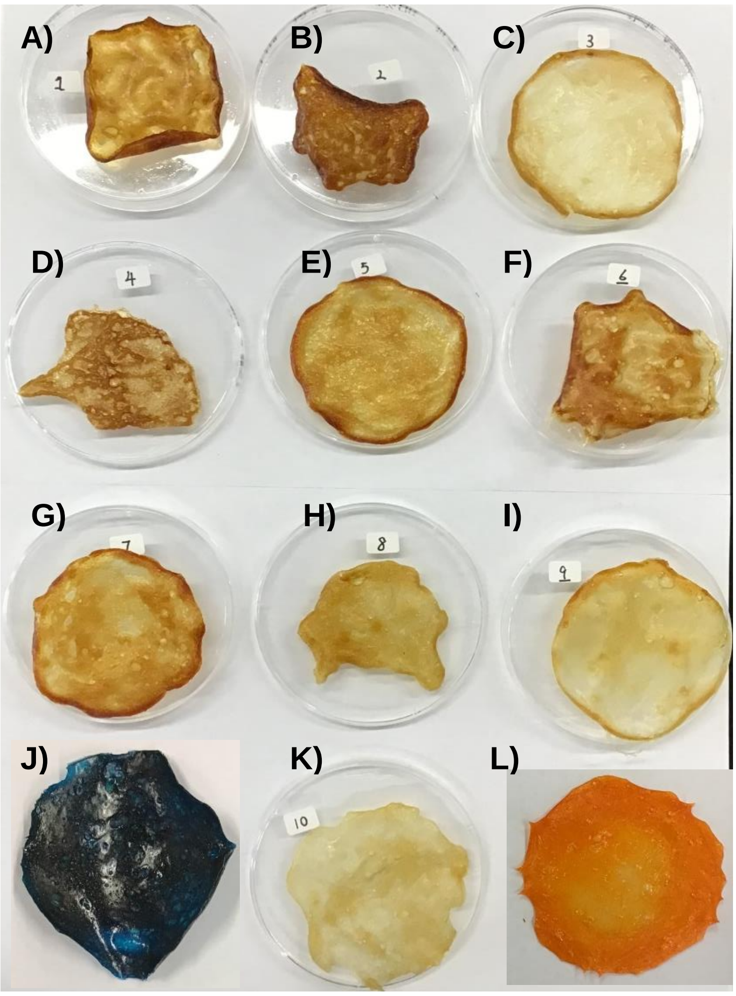


5 % Acetic acid



10 % Acetic acid

Figure 3.1.1A Bioplastic synthesized with 5% acetic acid [Chitosan/Starch % A) 70/30, C) 30/70; Chitosan/Cassava Flour % B) 70/30, D) 30/70]; Bioplastics synthesized with 10% acetic acid [Chitosan/starch % E) 50/50, F) 60/40, G) 70/30, H) 40/60, I) 30/ 70].



15 % Acetic acid

Figure 3.1.1B Bioplastics synthesized with 15% acetic acid [A-L]

	Chitosan/ starch (%)		Chitosan/ cassava flour (%)
A	70/30	B	70/30
C	30/70	D	30/70
E	50/50	F	50/50
G	60/40	H	60/40
I	40/60	J	40/60
K	25/75	L	0/100

3.1.2 Appearance of bioplastic model

In terms of applications, various bioplastic utensil product models, such as small cups, containers and spoons, have been successfully synthesized and molded (added with food coloring)(Fig. 3.1.2). The synthesized bioplastic product models look the same as the commonly used plastic products. Although the surfaces are rough, the texture and hardness are comparable to PP (polypropylene) or PS (polystyrene) plastics. There was no major problem with the usage, except that the bioplastic small cup made from 50/50 chitosan/cassava flour was less waterproof. The research study 2.0 showed that the bioplastic film synthesized from 70/30 chitosan/cassava flour was highly waterproof.

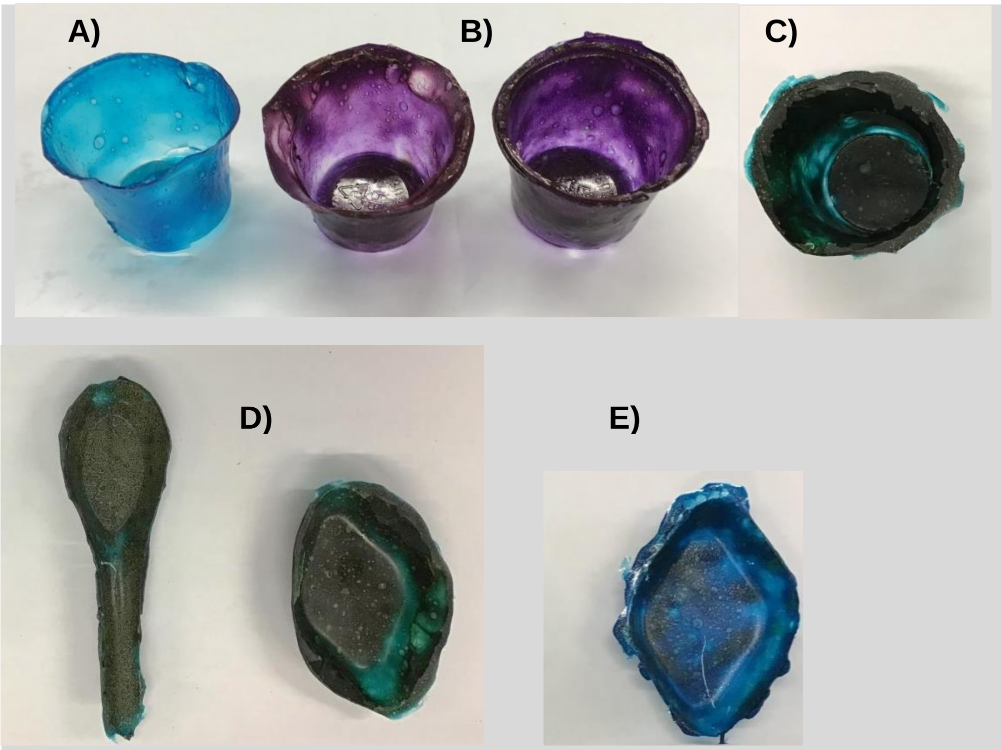


Figure 3.1.2 Bioplastic utensil product models synthesized with different acetic acid concentrations and added with food coloring [A) Chitosan/starch% 50/50, B) Chitosan/cassava flour % 50/50, C) and D) Chitosan/Starch % 25/75, E) Chitosan/cassava flour % 70/30]

3.2 Tensile test for bioplastics

The tensile strength of synthesized bioplastics was tested to investigate the ability of various synthesized bioplastics to withstand tension. The tensile strength of the bioplastic film is a specific strength obtained from the maximum pull before breaking/tearing. This measurement is to determine the magnitude of force (N) required reaching the maximum pull point on every surface area of the film. This is the result of an experimental synthesized bioplastic 1.0. Based on the result data in (Appendix Table 3.2.A and Fig. 3.2.A), the highest tensile strength (14N) is obtained from the composition of chitosan/starch 70/30 with 5% acetic acid, while the lowest tensile strength (2.7N) is from the 30/70 % composition with 10% acetic acid (Appendix Fig. 3.2.A).

Furthermore, the experimental results of synthesized bioplastic 2.0 tensile strength test are shown in Table 3.2.1 and Fig. 3.2.1. In the tensile test, the highest tensile strength (38N) is obtained from the composition of chitosan/cassava flour 70/30 % with 15% acetic acid. As shown in Fig. 3.2.1, the higher the concentration of acetic acid and chitosan content used in the synthesis process, the higher the tensile strength of the bioplastic film.

A) Bioplastic synthesized with 5% acetic acid

No.	Chitosan/starch (%)	Length of bioplastic (cm)	Tensile Strength (N)
1	70/30	2	30
2	30/70	2	13

No.	Chitosan/cassava flour (%)	Length of bioplastic (cm)	Tensile Strength (N)
3	70/30	2	23
4	30/70	2	15

B) Bioplastic synthesized with 15% acetic acid

No.	Chitosan/starch (%)	Length of bioplastic (cm)	Tensile Strength (N)
1	70/30	2	20
2	60/40	2	10
3	50/50	2	11.8
4	40/60	2	25
5	30/70	2	12.8

No.	Chitosan/cassava flour (%)	Length of bioplastic (cm)	Tensile Strength (N)
6	70/30	2	38
7	60/40	2	16
8	50/50	2	17
9	40/60	2	31
10	30/70	2	8
***11**	25/75	2	34
***12**	0/100	2	8.5

*2 mL of 100% acetic acid was added

Table 3.2.1

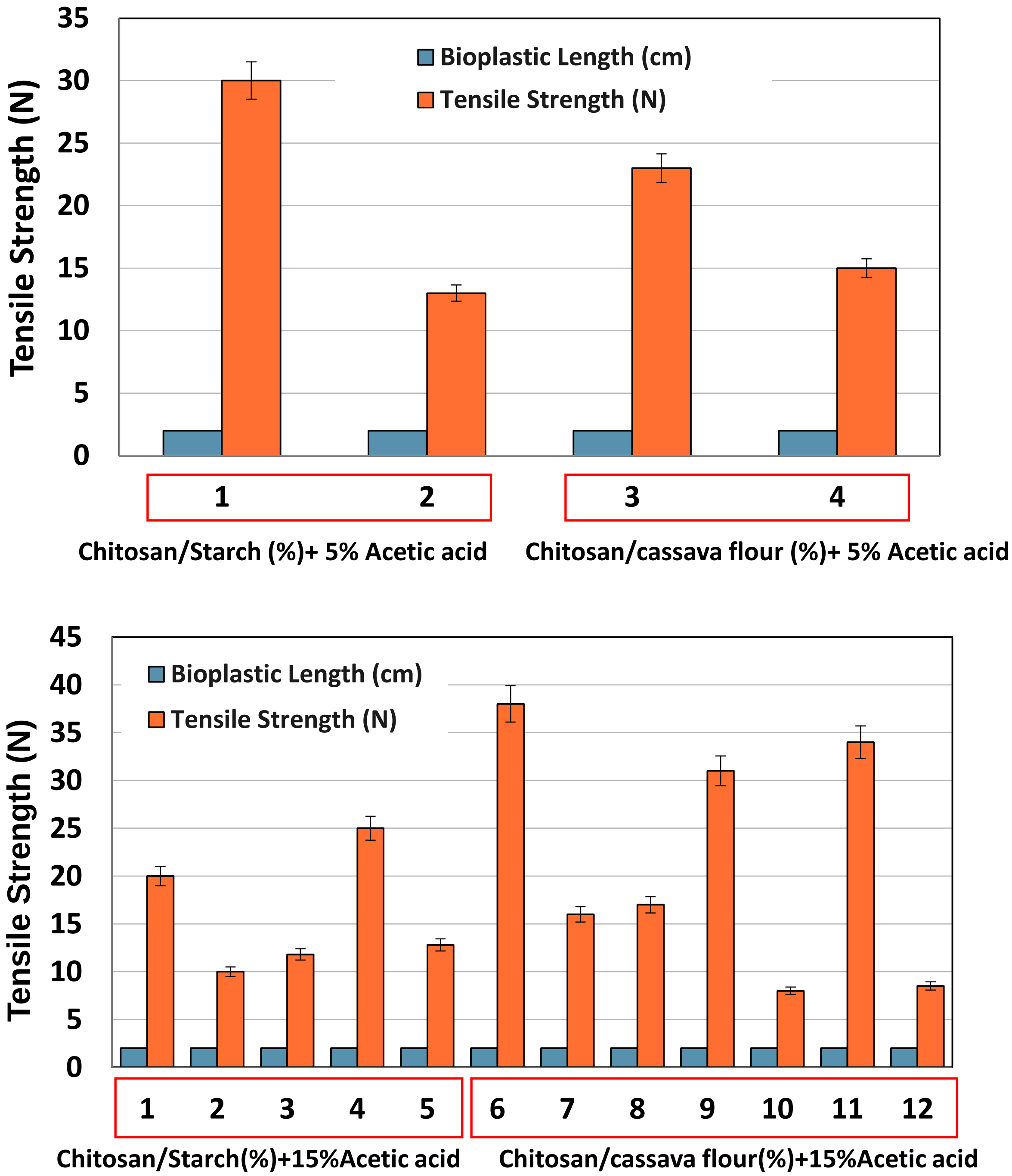


Figure 3.2.1 Tensile strength of synthesized bioplastic 2.0 with different concentration of acetic acid

3.3 Solvent uptake test for bioplastics

The solvent uptake test of synthesized bioplastics was tested to investigate the resistance of a bioplastic sample to some type of solvent. The lyophobicity test is performed by measuring the difference in weight of bioplastics before and after putting in different solvents. The solvent used in this study were distilled water (H_2O), ethanol (C_2H_5OH), sodium hydroxide (NaOH)(pH10) and hydrochloric acid (HCl)(pH4).

The results of the solvent absorption by bioplastics are shown in Table 3.3.1, Fig. 3.3.1 and Appendix Fig. 3.3.A. Based on the data, the lowest absorption capacity of water and NaOH solvents was produced by bioplastic films at a (30/70) chitosan/starch and 5% acetic acid. The lowest absorption capacities of ethanol solvent were produced by bioplastic films at a (30/70) chitosan/starch bioplastic with 5% acetic acid, (70/30) chitosan/starch or cassava flour bioplastic with 15% acetic acid. While the lowest absorption capacities of HCl solvent were produced by 30/70 chitosan/starch or cassava flour, with 5% acetic acid. In summary, the synthesized bioplastic films from (70/30) chitosan/cassava flour with 15% acetic acid had the lowest overall absorption capacity of the four solvents (H_2O: 25%, C_2H_5OH: 0%, HCl: 22%, NaOH: 14%). The results suggest that the synthesized bioplastic can be said hydrophobic as % absorption of water is less, and the lyophobicity of bioplastics is relatively high, which is very similar to that of PP plastics, which is in line with the general functions of commonly used plastics.

A) Bioplastic synthesized with 5% acetic acid

		Solvent Uptake (%)			
No.	**Chitosan/starch (%)**	**H_2O**	**C_2H_5OH**	**NaOH (pH10)**	**HCl (pH4)**
1	70/30	14	14	60	17
2	30/70	0	0	14	25

		Solvent Uptake (%)			
No.	**Chitosan/cassava flour (%)**	**H_2O**	**C_2H_5OH**	**NaOH (pH10)**	**HCl (pH4)**
3	70/30	20	7	13	13
4	30/70	50	29	50	75

B) Bioplastic synthesized with 15% acetic acid

		Solvent Uptake (%)			
No.	**Chitosan/starch (%)**	**H_2O**	**C_2H_5OH**	**NaOH (pH10)**	**HCl (pH4)**
5	70/30	25	0	22	14
6	60/40	29	0	22	11
7	50/50	75	0	67	40
8	40/60	20	0	60	20
9	30/70	14	0	0	17

		Solvent Uptake (%)			
No.	**Chitosan/cassava flour (%)**	**H_2O**	**C_2H_5OH**	**NaOH (pH10)**	**HCl (pH4)**
10	70/30	6	0	12	12
11	60/40	33	0	33	44
12	50/50	20	0	22	50
13	40/60	50	0	75	67
14	30/70	10	0	0	14
*15	25/75	50	10	33	55
*16	0/100	67	0	117	38

*2mL of 100% acetic acid was added

Table 3.3.1

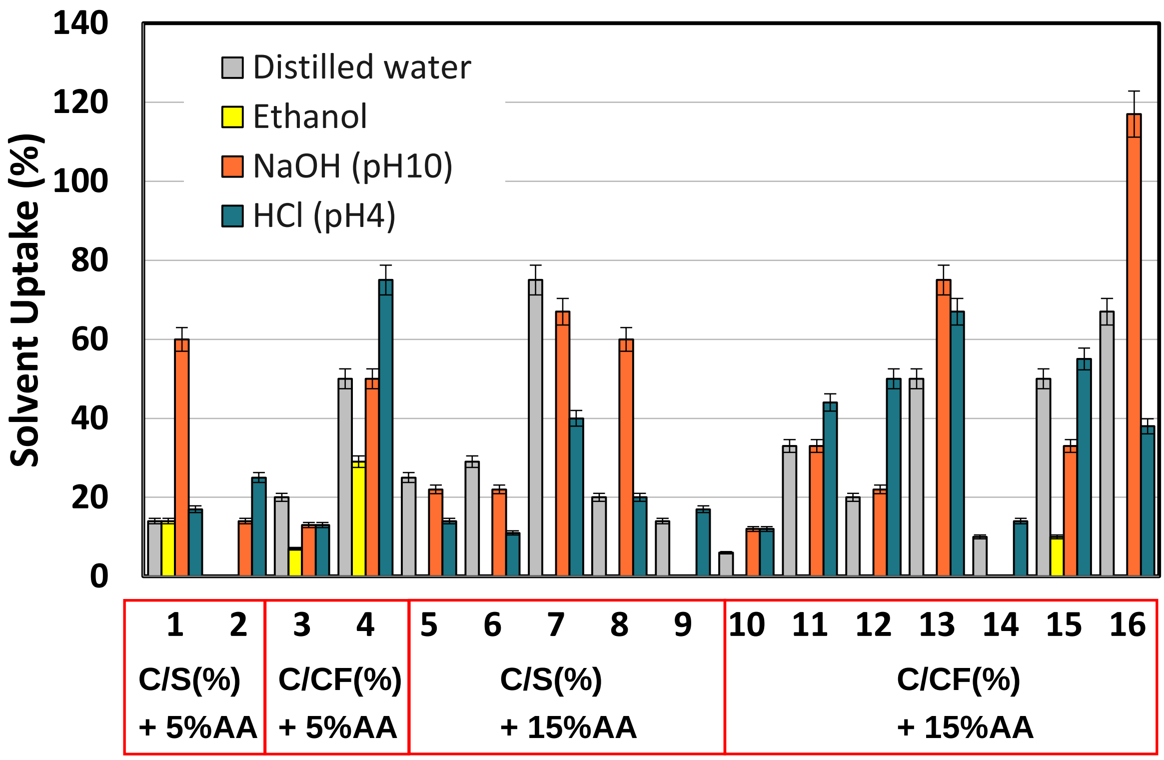


Figure 3.3.1 Solvent absorption capacity of synthesized bioplastic films with different concentration of acetic acid [Key : Chitosan (C); Starch (S); Cassava flour (CF); Acetic acid (AA)]

3.4 Biodegradation test for bioplastics

The biodegradation rate of synthesized bioplastics was tested to ensure it is fully biodegradable after being discarded, reducing the pollution of plastic waste. The soil biodegradation test was designed to investigate the time required for the complete degradation of the bioplastic. (i.e., when samples [Fig. 3.4.1] are subjected to soil burial treatment, which is common under landfill conditions) On average, all samples showed complete or nearly complete degradation within 36 days of continuous soil immersion.

Within the first week, colour and shape changes of bioplastics were observed, with most of samples showing curling and softening. After 3-4 weeks, some of the samples were completely degraded, i.e. indistinguishable from the soil, with a very low amount of the remaining samples.

In Table 3.4.1 and Fig. 3.4.2, the results of the biodegradation tests are shown for 12, 22 and 32 days. At 22 days, the synthesized bioplastic with a chitosan/cassava flour composition percentage of 30/70 and 5% acetic acid showed a 100% weight loss after degradation. In addition, the results show that the highest tensile strength and lower solvent uptake were achieved by the bioplastics made from chitosan/cassava flour 70/30 and 15% acetic acid. It was also able to degrade after 32 days, yielding a weight loss of 60%. After 6 weeks, the bioplastic samples were completely degraded, i.e. indistinguishable from the soil, with very few remaining samples, and no degradation at all as compared to polypropylene (PP) plastics.

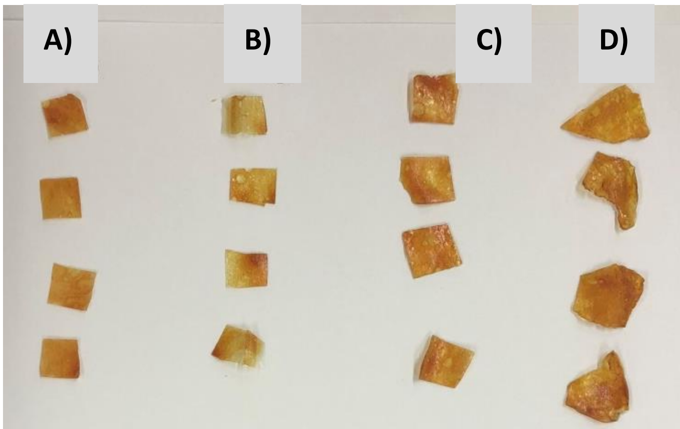


Figure 3.4.1 Bioplastic film samples before biodegradation test [% starch/chitosan; [A) 50/50, B) 60/40, C) 70/30, D) 40/60]

A) Weight loss (%) of bioplastic synthesized with 5% acetic acid

No.	Chitosan/starch (%)	Weight loss in 12 days (%)	Weight loss in 22 days (%)	Weight loss in 32 days (%)
1	70/30	25%	75%	90%
2	30/70	17%	17%	30%

No.	Chitosan/cassava flour (%)	Weight loss in 18 days (%)	Weight loss in 22 days (%)	Weight loss in 32 days (%)
3	70/30	14%	43%	60%
4	30/70	43%	100%	-

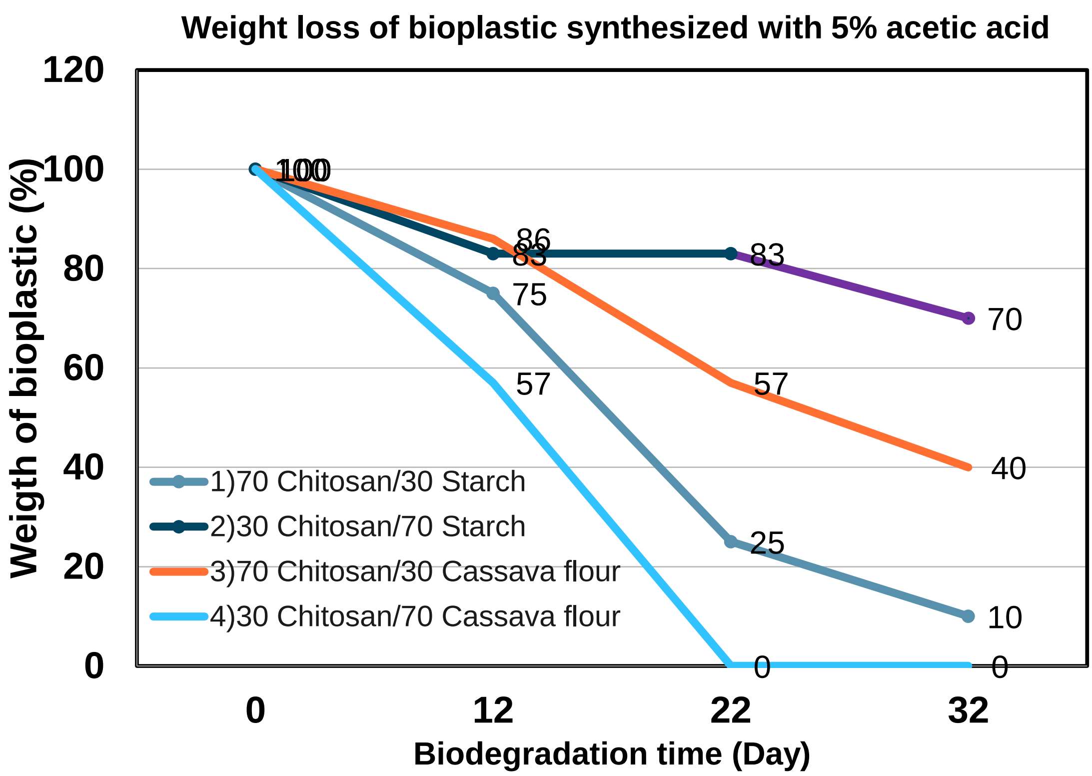
B) Weight loss (%) of bioplastic synthesized with 15% acetic acid

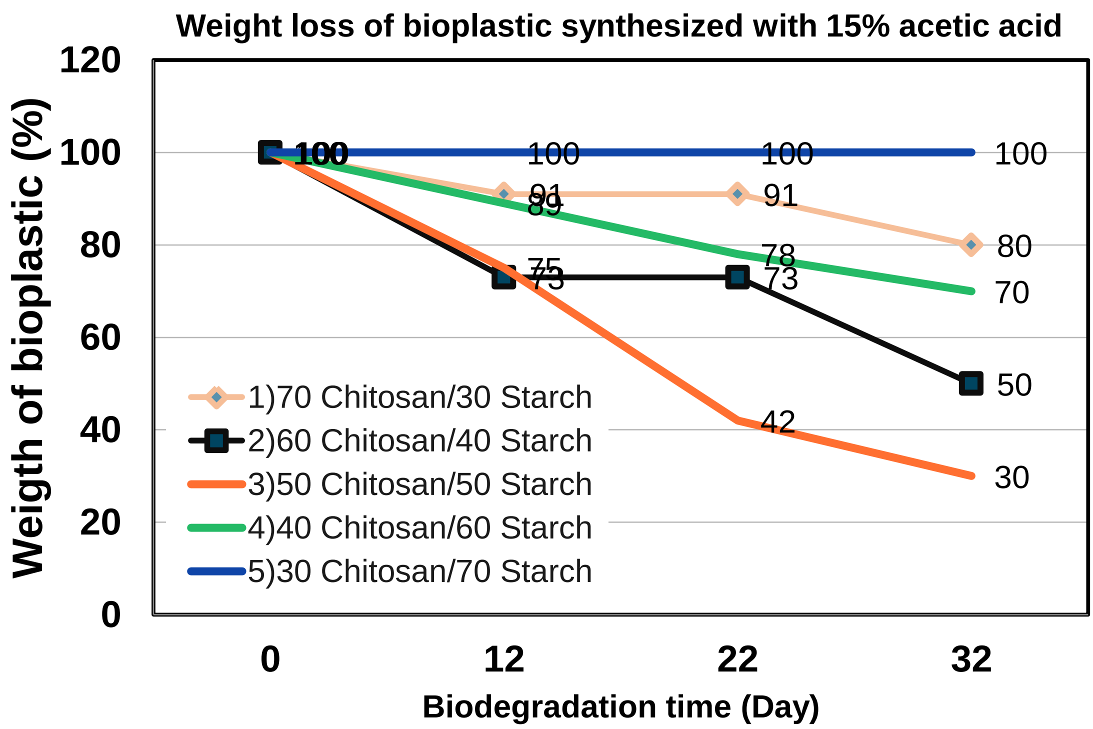
No.	Chitosan/starch (%)	Weight loss in 12 days (%)	Weight loss in 22 days (%)	Weight loss in 32 days (%)
1	70/30	9%	9%	20%
2	60/40	27%	27%	50%
3	50/50	25%	58%	70%
4	40/60	11%	22%	30%
5	30/70	0%	0%	5%

No.	Chitosan/cassava flour (%)	Weight loss in 12 days (%)	Weight loss in 22 days (%)	Weight loss in 32 days (%)
1	70/30	0%	33%	60%
2	60/40	0%	0%	0%
3	50/50	0%	45%	60%
4	40/60	10%	10%	20%
5	30/70	22%	33%	50%
*6	25/75	13%	13%	30%
*7	0/100	11%	20%	30%
8	PP control	0%	0%	0%

*2mL of 100% acetic acid was added

Table 3.4.1


Weight loss of bioplastic synthesized with 5% acetic acid
Weigth of bioplastic (%)
Biodegradation time (Day)
1)70 Chitosan/30 Starch
2)30 Chitosan/70 Starch
3)70 Chitosan/30 Cassava flour
4)30 Chitosan/70 Cassava flour


Weight loss of bioplastic synthesized with 15% acetic acid
Weigth of bioplastic (%)
Biodegradation time (Day)
1)70 Chitosan/30 Starch
2)60 Chitosan/40 Starch
3)50 Chitosan/50 Starch
4)40 Chitosan/60 Starch
5)30 Chitosan/70 Starch

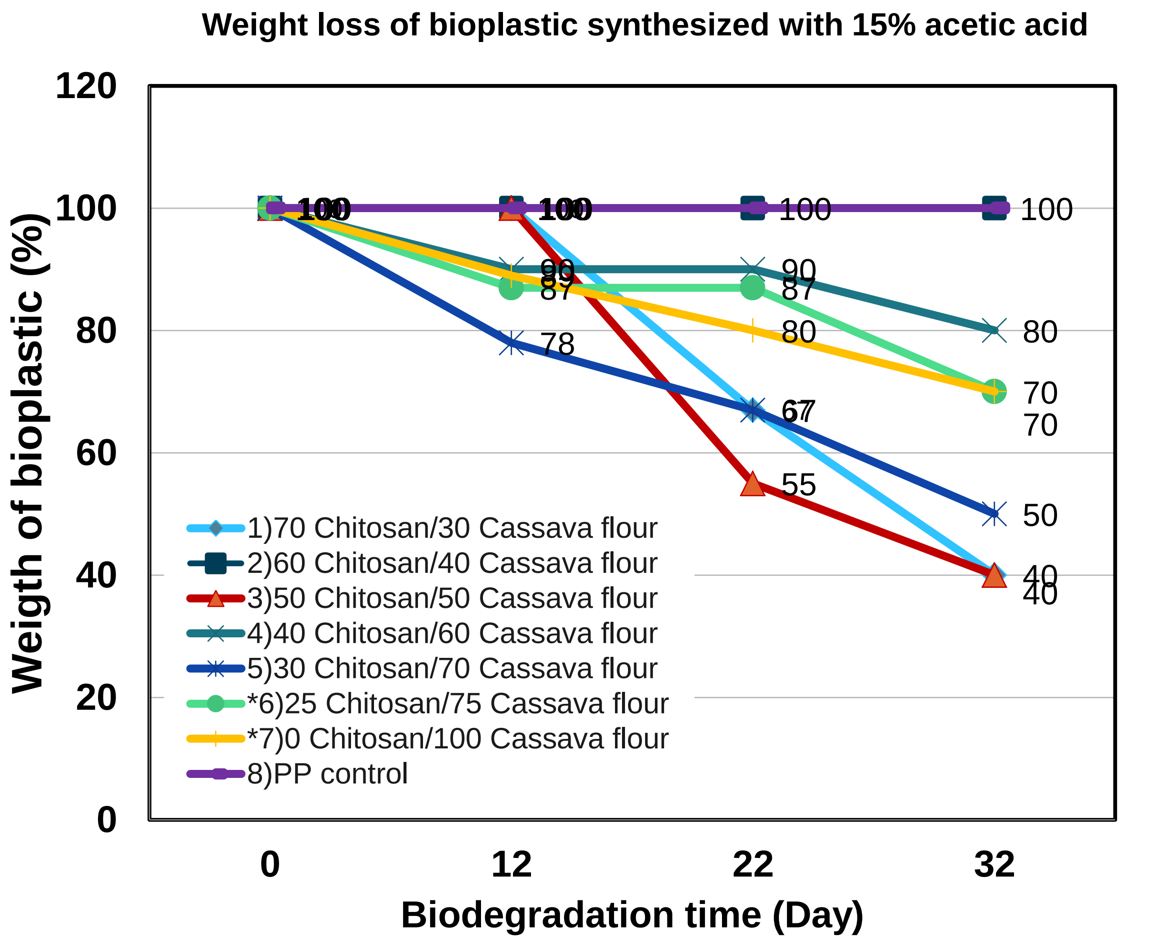


Figure 3.4.2 Biodegradation test of synthesized bioplastic films with different concentration of acetic acid

Ch.4 Discussion

We have used naturally biodegradable polymers - chitosan, cassava flour and starch to synthesize biodegradable bioplastics with different properties by mixing different amounts of cassava flour/starch and chitosan with different concentrations of acetic acid. We have investigated the solvent absorption capacity, tensile strength and biodegradation rate of different synthesized bioplastics. According to our experimental results, the best composition of chitosan and cassava flour for the synthesis of bioplastics is 70/30 % with 15% acetic acid. The synthesized bioplastics can significantly exhibit the lowest water absorption capacity, the strongest tensile strength and the fastest biodegradable characteristics, over 60% biodegradation in 32 days.

Recent studies indicated that the production of bioplastics mostly uses chitosan as a choice of material for designing environmental friendly bioplastics, because of its biodegradable characteristic. The chitosan-containing bioplastics have higher rigidity than other plastics. It arises from the presence of a large number of linear chains in chitosan [8, 9]. Chitosan contains a linear chain structure of polymers, which tends to form a crystalline phase due to the regular arrangement of polymer molecules. The crystalline phase can provide strength, rigidity and hardness [9, 15].

In addition, it is known from the literature that chitosan is a thickening agent or filler and increases the density of the synthesized bioplastic, so it will increase the elasticity and tensile strength of the bioplastic. Chitosan has amine functional groups, primary and secondary hydroxyl groups, which induce high chemical reactivity in starch suspensions. The addition of chitosan is due to the physical interaction of hydrogen bonds between cassava flour and chitosan solution, resulting in the bioplastic with good tensile strength [7,11].

Our experimental results show that the lowest water absorption capacity was obtained with the synthesis of bioplastic from the composition of 70/30 of chitosan/cassava flour. It can be said that the bioplastic is hydrophobic, since chitosan has the basic nature of hydrophobicity, the equilibrium composition between cassava flour/starch and chitosan leads to molecular interactions that reduce the hydrophilicity of cassava flour/starch [10].

In biodegradation test, studies showed that the bioplastic film with more starch content has a shorter degradation time. This is due to the presence of glucosidic bonds in the amylose and amylopectin units. The existence of this bond causes the starch molecules more easily biodegraded through hydrolyzed mechanisms [6]. This suggests that cassava flour plays an important role in the degradation performance [13].

Cassava flour is superior to starch (corn starch) as a new material for the production of bioplastics, because according to literature, the production of cassava in Indonesia is 21.8 million tons per year [13, 14]. Cassava or tapioca peels are rich in starch. The cassava skin wastes produced by cassava agriculture and industry can be used as a raw material for the production of bioplastics, so the cassava skin wastes from the cassava industry can be improved into a new material for bioplastics [10, 13].

Ch.5 Conclusions and important findings

In this research, we can successfully synthesize biodegradable bioplastic prototypes and product models using naturally biodegradable polymers - chitosan and cassava flour. Among them, the best composition that is the most suitable for synthesis of the best eco-friendly bioplastics is 70% chitosan/30% cassava flour with 15% acetic acid. Our experimental results show that bioplastic has the strongest tensile strength; its rigidity and flexibility are suitable for different plastic applications. Synthesized bioplastics have significantly the lowest water absorption capacity and acid-base solvent absorption capacity, indicating that synthesized bioplastics are highly lyophobicity (solvent repellent) and are in line with the general functions of normal plastics. In addition, the synthesized bioplastic had the fastest biodegradable characteristics, it showed that the bioplastic exhibit over 60% complete biodegradation in 32 days after continuous soil immersion.

The properties of bioplastics depend to a large extent on the composition of cassava flour and chitosan, where higher chitosan content increases tensile strength. In the solvent uptake test, the adsorption capacity of distilled water, ethanol, sodium hydroxide (pH 10) and hydrochloric acid (pH 4) was lower as the starch content in the bioplastic composition decreased. More importantly, the cassava flour and chitosan used in this study are naturally biodegradable, they can be completely degraded over time, and no toxic substances will be left after disappearing, which can effectively relieve landfills pressure, and reduce environmental pollution. **The bioplastic synthesis method is low cost, environmental friendly, simple and effective. This shows that the chitosan/cassava flour polymers are definitely very promising new materials for the production of eco-friendly bioplastics.**

Ch.6 Prospect

We hope to synthesize antibacterial bioplastics by adding silver nanoparticles from chitosan and cassava flour. Use these bioplastics in hospitals or clinics to reduce the chance of contracting infectious diseases. In the future, we also hope to use more scientific methods and high technological testing and certificating methods for research and use other naturally biodegradable polymers to synthesize high-performance biodegradable bioplastics.

Ch.7 References

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Appendix

A) Bioplastic synthesized with 5% acetic acid

No.	Chitosan/starch (%)	Bioplastic length (cm)	Tensile Strength (N)
1	50/50	1	9.4
2	50/50	2	6.5
3	50/50	2	6.7
4	50/50	3	9.4
5	50/50	5	12
6	60/40	2	12
7	60/40	4	9.4
8	70/30	2	14
9	40/60	2	4.7

B) Bioplastic synthesized with 10% acetic acid

No.	Chitosan/starch (%)	Bioplastic length (cm)	Tensile Strength (N)
1	50/50	4	7.5
2	60/40	4.5	12
3	70/30	3.5	13
4	40/60	3	7
5	30/70	7	2.7

C) Bioplastic synthesized with 15% acetic acid

No.	Chitosan/starch (%)	Bioplastic length (cm)	Tensile Strength (N)
6	40/60	4	5.6
7	40/60	2	7.6

Table 3.2.A

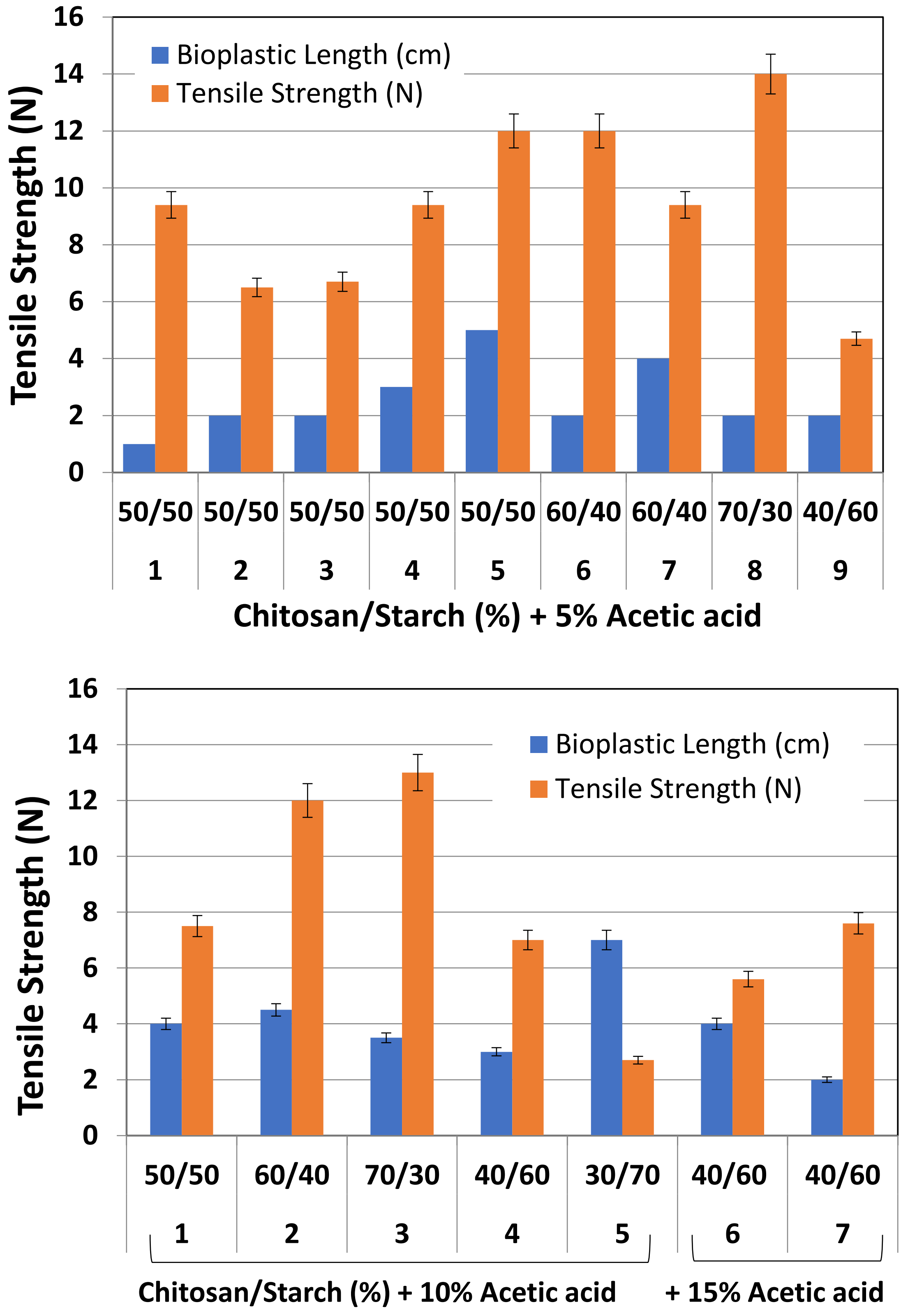
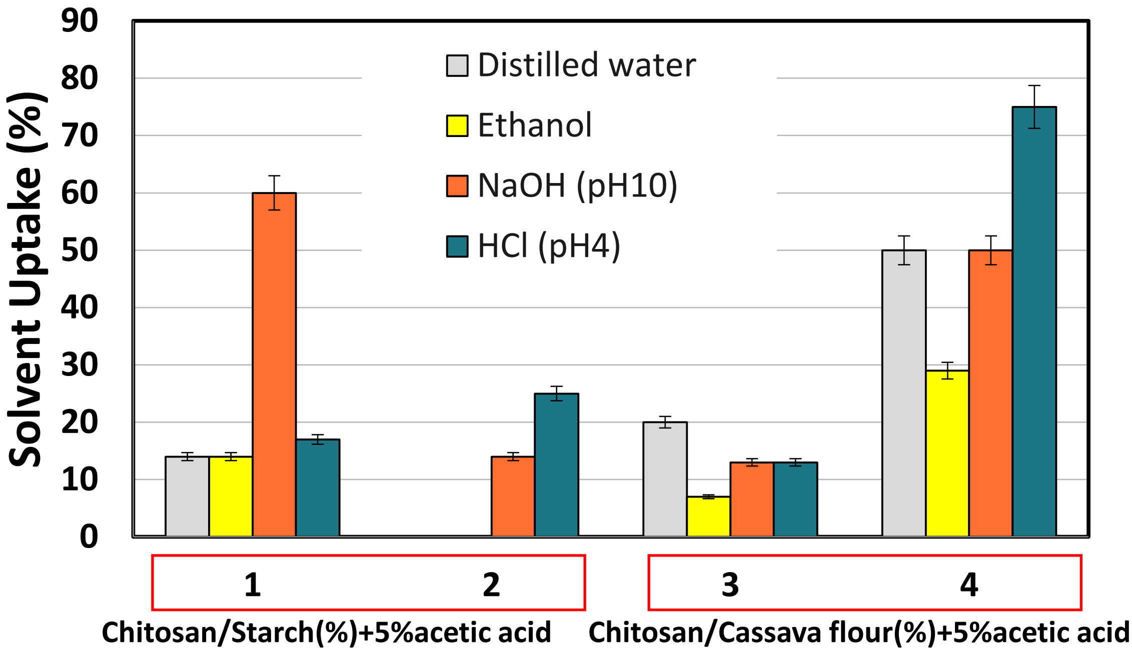
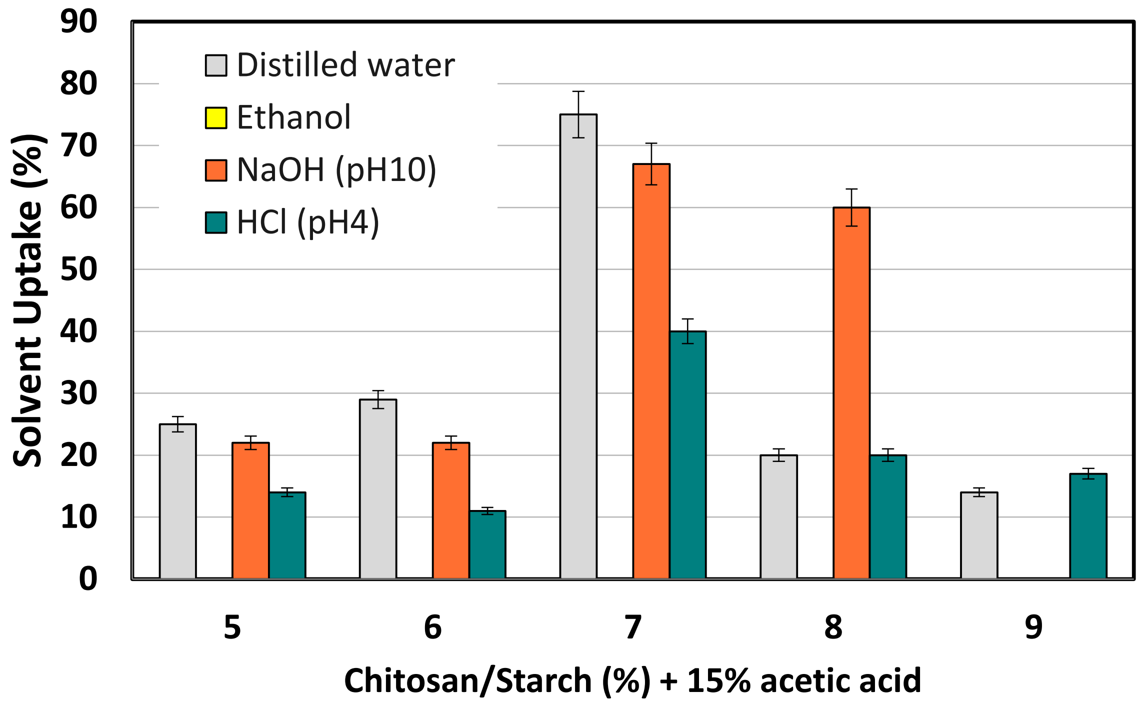


Figure 3.2.A Tensile strength of bioplastic 1.0 with different concentration of acetic acid


Solvent Uptake (%)
90
80
70
60
50
40
30
20
10
0
Distilled water
Ethanol
NaOH (pH10)
HCl (pH4)
1
2
3
4
Chitosan/Starch(%)+5%acetic acid
Chitosan/Cassava flour(%)+5%acetic acid


Solvent Uptake (%)
90
80
70
60
50
40
30
20
10
0
Distilled water
Ethanol
NaOH (pH10)
HCl (pH4)
5
6
7
8
9
Chitosan/Starch (%) + 15% acetic acid

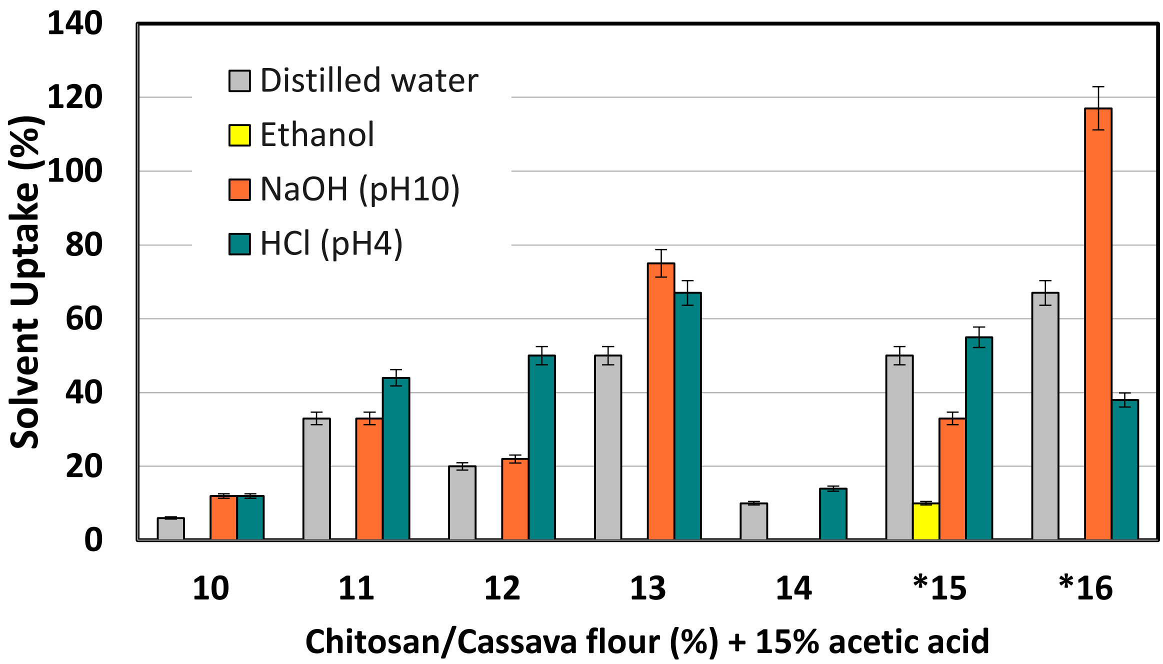


Figure 3.3.A Solvent absorption capacity of synthesized bioplastic with different concentration of acetic acid

Interview with a Scientist – Professor YUEN Kwok-Yung

MBBS(HK), MD(HK), FRCS(Glas), FRCPath(UK), FRCP(Edin, Lond & Irel),
Academician of Chinese Academy of Engineering (Medicine and Health),
Founding Member of the Hong Kong Academy of Sciences

SKH Bishop Baker Secondary School

Yeung Peony
Zeng Meng Qiu
Chau Hei Lam Zoe
Pang Sze Yan

Introduction

Our team was honoured to conduct an interview with Professor Yuen Kwok-Yung on 28th March 2022 through an online video conference. During the interview, he told us his wonderful story of becoming a successful scientist and shared his unforgettable work experiences with us. We were deeply inspired by him and have learned from his valuable words the qualities a scientist should possess.

A. Biography

Professor YUEN Kwok Yung

Professor YUEN Kwok-Yung is a microbiologist, physician and surgeon. Professor Yuen is currently the Chair of Infectious Disease at the Department of Microbiology of the University of Hong Kong (HKU). He co-directs the State Key Laboratory of Emerging Infectious Disease of China in Hong Kong. He is also a member of the Chinese Academy of Engineering (Medicine and Health section).

Professor Yuen is a world-renowned scientist in microbiology and epidemiology. He graduated from the Faculty of Medicine at the University of Hong Kong in 1981 with distinction in Medicine and worked at the United Christian Hospital as a surgeon and physician for seven years. He then left to join a microbiology research team at the Queen Mary Hospital. He started working in the Department of Microbiology of HKU in 1988 and headed the Department of Microbiology from 2002 to 2011. In 2000, he was appointed the Scientific Co-director of the HKU-Pasteur Research Centre to set up a joint research venture between the Institute Pasteur and the University of Hong Kong because of his expertise in the area of emerging infectious diseases. Professor Yuen led a research team identifying the Severe Acute Respiratory Syndrome (SARS) coronavirus that caused the global outbreak of SARS in 2003. For these achievements, he was honoured by *TIME* Asia magazine as "Asian Heroes of the year" in 2003. During the recent ongoing COVID-19 pandemic, he acts as a member of the Hong Kong SAR Government's Expert Advisory Panel under the Steering Committee cum Command Centre in relation to the Novel Coronavirus [1-3].

Professor Yuen's contribution to global public health is undeniable. Throughout his career, he has received high recognition for his research in microbiology and infectious diseases, his teaching and leadership. He has helped the government many times to control emerging infectious disease outbreaks in animals, hospitals and communities.

B. Research Interests

Professor Yuen’s research interests are focusing on microbiology, epidemiology, novel microbes and emerging infectious disease agents. He is one of the most renowned scientists in the field of infectious diseases. In the outbreak of avian influenza virus H5N1 in 1997 in Hong Kong, Professor Yuen was the first to report in the *Lancet* about the unusual clinical severity and high mortality of infected patients which could be identified by the in-house designed molecular test at his laboratory.

Professor Yuen has been widely known among specialists in infectious disease as he made his mark in 2003 when the outbreak of SARS gripped the world. He played a significant key role in the discovery of the agent causing SARS, the SARS coronavirus (SARS-CoV-1), thus leading to measures that were crucial to containing the outbreak of this disease. Throughout the years, he has led his team in the discovery of over 50 novel disease agents and many other bacteria, fungi, and parasites named after Hong Kong or China. This has helped fighting against the epidemics worldwide [1-4].

Professor Yuen and his team have also played an important role in supporting Hong Kong in response to several outbreaks of infectious diseases including the current COVID-19. Recently, they are developing the world's first novel vaccine (VectorFlu™ ONE) for COVID-19 which can be used as a nasal spray. They are now working on completing all the phases of clinical trials. Professor Yuen believes Hong Kong soon has to partner with mainland pharmaceutical firms to manufacture the nasal vaccines [6-7].

Novel nasal COVID-19 vaccine

C. Significant achievement and contribution to society

1. Academic achievement

Professor Yuen is a world-renowned leader in microbiological and epidemical research. In the outbreak of avian influenza virus H5N1 in 1997 in Hong Kong, he published the first clinical and laboratory diagnostic paper on Influenza A H5N1 in the *Lancet* which has been cited over 500 times since 1998 in a review paper on this subject in the New England Journal of Medicine in 2005. He is one of the top 1% researchers in the world, as ranked by the Essential Science Indicator (ISI web), and has published more than 950 papers in peer reviewed journals including the *Lancet*, *New England Journal of Medicine*, *Science*, *Nature*, Cell, *Journal of Virology*, and *PNAS*, with over 28,000 citations.

Professor Yuen's success is exemplified by his numerous Fellowships at distinguished institutions, including the Hong Kong Colleges of Pathologists, Surgeons and Physicians, the Fellow of the Royal College of Physicians(Lond and Edin), Surgeons(Glas) and Pathologists(UK), and also the Fellow of the American College of Physicians (USA). He was appointed by the HKU the Henry Fok Professorship of Infectious Diseases in 2005 in recognition of his significant contributions. The Ministry of Science and Technology of China has given the honour of the State Key Laboratory of Emerging Infectious Diseases – the first State Key Laboratory outside the Mainland, to HKU in recognition of its exemplary contributions this area and Professor Yuen has been the first Director of this laboratory.

Professor Yuen also received a Croucher Senior Medical Research Fellowship in 2006-2007 and was elected to the Chinese Academy of Engineering (Basic Medicine and Health) in 2007. Professor Yuen was awarded the Justice of Peace by the Hong Kong SAR in 2002 and the Silver Bauhinia Star Award of the Hong Kong SAR government in 2004 [1-4].

Professor YUEN presented in conference

Professor Yuen was awarded the "2021 Future Science Prize in Life Science", known as "China's Nobel Prize" for his research and seminal contributions to the understanding of emerging infectious diseases from SARS in 2003 to 2019 novel coronavirus disease (COVID-19), which lead to more effective responses and strategies in controlling these diseases for mankind [5].

2. Devotion to education

Professor Yuen has headed the Department of Microbiology at HKU for more than 10 years. As a lecturer in medical school, Professor Yuen not only delivers medical knowledge but also the medical ethics a doctor should have. "We should be fair to all patients as everyone can enjoy the benefits of good health, whether he is rich or poor." Apart from this, he always mentioned the importance of research to the students or young researchers. "Research is the pursuit of truth. It is dangerous when you are far away from the truth."

In addition, "Keep on having a beginner's heart" is a phrase that Professor Yuen often emphasizes. Professor Yuen mentioned to his students or young researchers that "Let this guide you on discovering a career of your passion. Let your curiosity ferments, asking question what we already know? Can there be anything more to it?" Professor Yuen's discovery of the SARS coronavirus in 2003 was simply the result of taking every opportunity as it comes. What started off with his first case control study into bacteria in bronchopulmonary infections in 1989, turned into many great opportunities with the outbreak of avian influenza virus H5N1, seasonal pandemic influenza, and finally SARS in 2003 [1-3]. “There is no winning formula, being hardworking, curious, caring, and kind can never go wrong.” says Professor Yuen.

D. Path to become a scientist

1. Interested in science

Curiosity is the fundamental element for people to discover the unknowns. It motivates us to think and investigate. Professor Yuen has had this characteristic since his childhood. He loves asking why and this endures when he grows. From studying science, his enthusiasm to explore can be satisfied. An inquisitive mind finally drives him to become a scientist.

In fact, Professor Yuen never dreamed of being a microbiologist when he was young. As a child, he was obsessed with space and solar system, and so he wanted to be an astronaut. He also wanted to be a vet as he loved animals so much. He remembers that he would excitedly bring home animals and insects he found out in the streets. His “pets” ranged from birds to cats and from rats to flying bugs. However, his family could not afford to send him to study veterinary overseas. Inspired by his grandfather, he turned out to be a medical doctor. His grandfather was a well-respected Chinese medicine practitioner in their home village in rural China. Once, young Professor Yuen was amazed by his grandfather's unusual practice of putting herbal pills under an unconscious patient’s tongue, which is now known as sublingual administration of medicine, and the patient awoke. He found being a medical doctor can help a lot of people.

When asked why he was passionate about microbiology or epidemiology, and how he became a scientist from a medical doctor, he highlighted a remark from Professor Sir David Todd, the Founding President of the Hong Kong Academy of Medicine. “No one in Hong Kong was willing to teach microbiology and infectious diseases in the past, but it is very important to the public health because it can affect a lot of people.” This comment from Professor Todd encouraged Professor Yuen to take a leap of faith in pursuit of a more uncommon career path - microbiology.

Curiosity is also the reason for Professor Yuen to pursue his career into scientific research. He emphasized that “Question about what you already know, inquire about the unknown and ask for more to learn.” With passion, creativity, an open mind, and perseverance, eventually Professor Yuen becomes a renowned scientist.

2. Marvelous research experiences

Professor Yuen excitedly shared with us that he is thrilled every day as there are often many discoveries in his research. He is surprised with the findings and impressed with the wonderful results. During the interview, he shared a recent research experience about the COVID-19 disease. Dramatic morphological damage has been observed in the testes of patients who were severely ill with COVID-19 and died from the disease [8]. Therefore, Professor Yuen and his team started to investigate the effect of SARS-CoV-2 in the testes by intra-nasally challenged golden Syrian hamsters with SARS-CoV-2 (origin, Omicron and Delta variants). They significantly found that the SARS-CoV-2 infected hamsters suffered from testicular inflammation and damage. After 120 days, the testes even shank by 60-75% (greatly reduced in size and weight) despite a recovery of pneumonia in hamsters. The sharp drop in male sex hormone and sperm count not only dramatically reduces reproductive ability but also may cause sterilization [9]. As there are many marvelous research experiences, Professor Yuen can only share with us the most recent one. He is very pleased with his research because he can contribute to the society, not because of the accolade. He shared that scientific recognition is only the 'by-product' of research, helping others in need is the source of happiness.

Marked decrease in size of both testes in infected hamsters [9]

3. Future prospects on medical research

Professor Yuen believes that the future of medical research will be influenced by artificial intelligence (AI). The research and development of AI technologies is constantly increasing nowadays. He said that doing research and reviewing or searching for literature was a lengthy and complicated process in the past. As AI can help people to search for numerous literature and review in a very short time, the time for scientific literature review can be significantly reduced. In addition, AI can formulate and propose different hypotheses for scientists and they can choose the suitable hypotheses for further experimental investigation. This can make the research process smoother and easier than in the past. However, Professor Yuen reminded that scientists should still need to come up with some innovative ideas for solving medical problems in the future. He thinks doing research is not just to prove your hypothesis, but to make new observations and draw a novel conclusion.

E. Advice for teenagers who want to be a scientist

1. Being curious and sceptical

Professor Yuen thinks that scientists should be full of scepticism and curiosity about the unknown world. First of all, scientists need to remain doubts and be creative. This helps every scientist to maintain their interests in exploring the world.

As teenagers, we always ask many questions and scientists should do so. Since curiosity goes along with asking a question and wanting to answer it, it drives and motivates scientists to try understanding and explaining the world. Professor Yuen said whether it is in the known or unknown field, we should always pursue further and use our knowledge to satisfy our curiosity!

2. Perseverance

Scientific research involves failure. Despite barriers and obstacles that should arise, Professor Yuen reminded us that scientists should never give up. If we give up easily when we are facing difficulties in the failed research project, we cannot get very far in the research journey. "If we stop to investigate any time, eventually we could not find the answer." Instead, scientists should learn from the failure and keep trying again and again with courage but without giving up. As a scientist, Professor Yuen likes to find many new ways to tackle the problems, and he will list out all the difficulties to clear one by one in his mind. He mentioned, "Failure is an essential and inescapable part of scientific research. Every failure takes you one step closer to success. Hence, perseverance will bring your mission to fruition."

3. Talents and interests

Professor Yuen decided to work on science because he loves science. He shared that we must find out where our talents and interests are. He said that being a scientist has to be good at mathematics and science, also logical and critical thinking. He reminded, "If you have a flair for what you are doing, and also enjoy working on it, you will not easily give up even if it is hard."

4. Free from external influences

When Professor Yuen's research projects are not supported by the government funds, he wouldn't complain about it. It is because he emphasized that there is no free lunch in the world. Therefore, it is absolutely necessary for scientist to make achievements and publish their research findings in renowned journals. During press conference, when Professor Yuen explained his amazing findings to the public, he told the facts and truth of his research. But no one believed him, and even it would attract a lot of criticism and denial. Actually, he would not be influenced by the public, and he had to follow the scientific truth.

Scientific research is about discovering and exploring, and what is discovered lays the foundation for the related future research. If your research is just to satisfy other people's ideas, it loses its initial meaning.

F. Epilogue

We are grateful to Professor Yuen for taking the time to have an interview with us during the COVID-19 pandemic. What impresses us most is that after decades of research life, Professor Yuen still keeps his heart of beginner and hopes to discover more important research findings, and makes contributions to public health, medical development and the society.

Commenting on the phenomenon that students choose medicine or science for a better future, Professor Yuen thinks that it is ridiculous to force someone to study medicine if they are not interested in it. It is a shame that some of his medical students work on other careers, other than being a doctor who studied medicine for seven years. He stressed that we should not force ourselves on somethings which we do not like. “Keep on having a beginner’s heart” is a phrase that Professor Yuen emphasizes. “Let this guide you on discovering a career of your passion.”

G. Reflection

Professor Yuen is an approachable person. He is not as serious as I thought before. He was very willing to share with us what he knew and what we wanted to know. After interviewing Professor Yuen, I felt his passion for microbiology, which prompted him to do it in this field. Passion is the reason to persevere in everything, no matter how difficult it is. We will not give up easily. Holding on what you think, with a passion for things is what our new generation worth learning.

(***Zeng Meng Qiu***)

Professor Yuen is one of my most appreciated scientists. His curiosity about science is admirable. Although he has great achievements in infectious diseases, he is not satisfied with them. He still keeps exploring different fields of science, such as astronomy. He is also amiable. During the interview, Professor Yuen shared many interesting things about his childhood and we know that he was already inquisitive about science at that time. After this interview, I think I should learn from him and keep my passion for science. I hope I can fulfil my curiosity by doing more research and coping with all the challenges in the future.

(***Chau Hei Lam Zoe***)

I am very glad to have such a valuable opportunity to talk to Professor Yuen. When he told us about his research experiences, I can see a twinkle in his eyes. I can feel his enthusiasm in science. Professor Yuen taught us the first step is to recognize our talents and interests since this brings us a willingness to keep on working on things. I am surprised that Professor Yuen keeps the excitement about science even though he has worked on microbiology for a long time. I think this is because he sticks to his original intention, and figures out the answer to anything make him excited. After the interview, I try to think about and explore the issue I like and enjoy the happiness of learning.

(***Peony Yeung***)

Professor Yuen shared many valuable experiences during the interview. He told us, “Don't hold back when you have a problem.” “Once you stop, you won't find the answer.” Those words inspired me a lot. And I also learned that curiosity is the beginning of being a scientist and one of the important elements of being a good scientist. Even just viewing through the computer monitor during the online video conference, we can feel his passion and enthusiasm for science and his hopes for a better future for the scientific community. This motivates us to put more effort into our studies so that we can follow our dreams and passions in the future. We are very grateful for this experience and hope to have more opportunities like this.

(***Pang Sze Yan***)

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科學家報告書獎

Interview Report

An Interview with Professor Dong-An Wang

Diocesan Girls' School

S3U

Choi Pui Yan Valerie

Kum Ho Yee

Lee Crystal

So Chun Kiu

Biography

Professor Dong-An Wang is currently a professor in the Department of Biomedical Engineering at City University of Hong Kong and the Head of Research at Ming Wai Lau Center for Reparative Medicine, Karolinska Institutet, Hong Kong. He has also published numerous journal papers related to biomedicine which were met with positive recognition from top journals such as Science and Nature Materials.

Professor Wang's research focuses on the creation and development of biomaterials to substitute human cells tissues or organs for medical purposes, including:

- Functional biomaterials for tissue engineering and therapeutic cell delivery;
- Nucleic acid delivery for therapeutic engineering;
- Applications of stem cells for regenerative medicine;
- Engineered biomimetic and pathological tissue platforms for in vitro drug evaluation.

Occupation

Biomedical engineering

According to Professor Wang, biomedical engineering encompasses a broad range of scientific fields. His work mainly concerns the interface of chemistry, biology, and engineering. He believes that his scientific knowledge can be used for creating useful products and solutions that will improve human lives logically and scientifically. His philosophy of research is to observe the interaction between non-living beings and living beings, such as the interaction between biomaterials and biological cells.

Professor Wang's dedication and passion for improving the quality of people's lives and love of science led him to explore this career path as a biomedical engineer. "I'm a scientist as well as an engineer," he tells us -- When it comes to conducting research, he also has to consider the application potential of his research on top of scientific value. The interdisciplinary nature of his work allows him to incorporate science in creating innovative products that can practically benefit people.

Teaching young people

In addition to being a researcher, Professor Wang also enjoys teaching as a professor. To him, it is like a cycle of life for the older generation to work for and work with young and bright minds, which he finds to be interesting and exciting.

The challenges and thrills of scientific research

The importance of speaking

Professor Wang believes that being a biomedical engineer is not simply about conducting research. In fact, interpersonal skills have proved to be crucial in his journey as a biomedical engineer. To establish the impact of their research, scientists often have to share and present their ideas to convince others to invest in their projects. Communication skills are therefore something we must hone if we want to be successful in this field.

Paradox of research

Professor Wang brings up a dilemma that most researchers have experienced: Innovation or practicality. He explains that the public enjoys innovation and newfound knowledge, but the process of transformation and incorporating new knowledge into useful products takes much time, effort, and risk. On the contrary, building on existing knowledge may be less risky and therefore more practical, but the findings lack vitality and excitement. We imagine that it would be challenging to compromise one for another, but Professor Wang tells us that it is possible to establish a midpoint between these two seemingly conflicting aspects. As a researcher, it is only through experimentation can we find the balance between innovation and practicality.

Time management is key

"It is a matter of managing time and effort and changing gears", we were told. Professor Wang advises aspiring scientists to learn and practice "working on two legs". Good time management allows him to juggle varying priorities and conduct his work smoothly and productively.

The most exciting discovery

Professor Wang shares with us his most memorable discovery during his time as a researcher at John Hopkins University in the United States of America. It was from a final year project of a bright undergraduate student who worked on a cell culture encapsulated in hydrogel. “We didn’t put a lot of hope in the cultured sample of the American little girl,” he recalls, yet he, among many others, was surprised to find that long after the culture was forgotten, the cells flourished outside of the hydrogel. The outgrown part of the tissue showed characteristics similar to the human cartilage, which then propelled the next 20 years of research work and clinical trials for man-made cartilage substitutes. The fact that accidents can lead to intriguing discoveries is something that Professor Wang finds memorable, and something that we are very intrigued by too.

Qualities of an outstanding scientist

Imagination is more important than knowledge

Professor Wang reinforces that imagination is crucial in the research process, suggesting that thinking outside the box is the key to innovation. He encourages young scientists to train their imaginative skills and integrate imagination into their thinking process. Needless to say, this does not mean that knowledge should not be valued -- “Knowledge is fundamental to imagination,” he tells us. With existing knowledge as a basis, we can create brand-new discoveries with imagination. Ultimately, Professor Wang believes the integration of knowledge is the key for aspiring scientists to truly “own” a skill.

No pain no gain

Professor Wang states that the norm of “happy learning” nowadays may have caused students to remain in their comfort zone. He believes that the old and somewhat cliche saying “no pain no gain” is the key to success and advises students to break out of their comfort zones and persevere in research to make discoveries. We asked him what he wanted to say to his younger self if he could, and his answer was to be braver. He states that we must be well-prepared for the scientific journey and life in general, and to do that we must be braver, and not fear the challenges and obstacles ahead.

Beauty must be made on the basis of truth and not distortion

Professor Wang shared a small story of a technical mistake with us: during his research, he observed a cell culture with the wrong lens, leading to a surprisingly beautiful image. However, he tells us that this was wrong: As a scientist, beauty must be made on the basis of truth and not distortion. Quoting Oscar Wilde, "the truth is never pure and rarely simple", yet it is a scientist's responsibility to reflect and discover the truth of things.

Epilogue

Professor Wang has encountered many teachers around the world, but the person he looks up to most is none other than the titular hero in the movie Forrest Gump. He admires the simplicity and purity of Forrest Gump, who only tries his best, works hard, and concentrates on what he really loves. Professor Wang believes that he is very much moved and affected by this figure. Perseverance, devotion, kindness… these are traits that not only apply to a fictional hero, but to the real heroes that work for the betterment of our lives through research, and traits that we should aim at having whatever we do, wherever we are. We too, when faced with difficulties, should learn from Forrest Gump, who never gives up despite what others say.

Reflection

Valerie: I think the most memorable part of the interview was when Professor Wang told us that if we were to work in a scientific career, even if the career does not involve experiments, it is important to know reality and what the world looks like in reality. Throughout the interview, he tells us about the realistic challenges and the realistic experiences of a biomedical engineer, which was indeed both interesting and practical for all of us. "I may be a bit blunt," he tells us, "but it's the truth that you need to know." His straightforwardness is what made his advice insightful, and made us more prepared for the journey ahead and the obstacles and opportunities that await us.

Ho Yee: What struck me the most during the interview with Professor Wang was his passion towards biomedical engineering and his commitment towards spreading and teaching the knowledge of this subject. His devotion to science and engineering, especially creating or improving new technologies to aid society, is contagious. His unending thirst for knowledge is something that I think everyone, regardless of their occupation or interest, should learn from. The professor also reminds us of the importance of a diverse skill set as all careers require more than just plain knowledge. His experience in the field allows him to recount all the various aspects of a biomedical engineer's career, intensifying my knowledge of this path and what it entails. I believe that his dedication and determination is the catalyst for his success and is something that I will take with me throughout my journey.

Crystal: I am deeply inspired by Professor Wang's views and advice to young scientists. I especially agree with the stress on creativity over knowledge in biomedical engineering and the importance of communication skills and also diligence. His message and advice are not limited to the field of biomedical engineering but are also applicable to other branches of science and even in life. Professor Wang couldn't have said better about "No gain, no pain" when it comes to learning, and encourages us all as budding scientists to endure through the pain and learn from mistakes, and never give up on our dreams. His insight into the industry, his interesting experience and his reason for pursuing a career in biochemical engineering reaffirms and reminds me of why I aspire to be a scientist and what I have to do to equip myself for the road ahead.

Chun Kiu: During the 1 hour interview with Professor Wang, I have acquired much wisdom which I would keep in mind when working towards my goals as a scientist. Good time management and communication skills are essential for excelling in our field of research, which is built on top of our knowledge and scientific skills. Professor Wang's belief regarding the importance of imagination over knowledge is something I fully agree with. Knowledge serves as a basis for innovation, but imagination brings our potential to the fullest. His message recalled my memory of the following quote by Albert Einstein: "Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world." Integration of knowledge and imagination is key for budding scientists to reach new heights.

Research is not easy and a number of results are out of our expectation. Not only does it require our patient and hardworking attitude, but also our sharp observation to find out any deficiency of the research design so as to improve the accuracy of our findings. As pointed out by Professor Wang, 'no pain no gain' is the universal truth which leads us to success in every field. He also placed emphasis on the fact that discoveries must be made on the basis of truth, no matter how the results may vary from our expectations. These messages have been a source of inspiration for me, and will continue to be on my journey towards my goals as a scientist.

科學家報告書獎

2020/21 - 2021/22
Hong Kong Budding Scientists Award

Interview with a Scientist -
Professor Lo Yuk Ming Dennis, SBS, JP

Sha Tin Government Secondary School

CHENG Man Hei

CHEUNG Megan Sze Yiu

WONG Ka Fun

I. Introduction

We are honoured and grateful that Prof. Dennis LO Yuk Ming was available to enlighten us with his insights through an online video conference on February 14, 2022. During the interview, Professor Lo has shared his experiences as a scientist, which included his passion in research, the trials and tribulations he faced in the research, his opinion on being a researcher and also his advice to budding scientists. It was such a pleasure to have this precious opportunity to talk to Professor Lo. We are filled with enthusiasm and also developed a better understanding on scientists' work by his inspiring and thought-provoking word.

II. Biography

Professor Dennis Lo has been invited to serve several leading roles. He served as the director of the Li Ka Shing Institute of Health Sciences and the Li Ka Shing Professor of Medicine. Back at the age of 23, he received preclinical training at the University of Cambridge He also received his Bachelor of Medicine and Bachelor of surgery at the University of Oxford. Moreover, he obtained various degrees from Oxford. Shortly after, he started his academic career.

In 1997, Professor Lo returned to Hong Kong. Later, he joined the Faculty of Medicine at the Chinese University of Hong Kong (CUHK) and was advanced to full professorship in 2003. He is currently the associate director of the State Key laboratory in Oncology in South China (CUHK), the chairman of the Department of Chemical Pathology. Professor Lo also performs duties in a number of academic, medical committees and councils.

Being capable in Genetics and Medicine, DNA testing and other aspects of chemical pathology, Professor Lo had multitudinous contributions in the medical field. One of the most significant contributions was he developed a non-invasive prenatal testing. It is a method to find out the risk of the fetus being born with certain abnormalities. This new invented testing method had advantaged many pregnant women. Usually, pregnant women had to use amniocentesis to do testing, but there is a risk of miscarriage. Nowadays, they only need to do blood draw and just bear insignificant risk of miscarriage.

III. Research Interests

When Professor Lo was studying Obstetrics and Gynaecology at Oxford University, he learnt that amniocentesis, the previous technology to detect whether a fetus has genetic disorders or a chromosomal abnormality, is invasive. If the pregnant woman undergoes amniocentesis, there will be an estimated risk of miscarriage that is about 0.5-1.0%. Therefore, he started to think about other non-invasive ways to substitute for amniocentesis. First, he tried to find foetal cells in the mother's blood cell. The experience of learning PCR at Oxford made him be better able to detect foetal DNA inside mother’s cell.

Unfortunately, the concentration of foetal cells in mother's blood cell was too low. It was almost impossible to be used as a new technology to detect genetic and chromosomal condition. Nonetheless, Professor Lo still believed that the solution was inside the mother's blood. He spent about 8 years to work on it.

During this period, Professor Lo read some research showing that cancer cells' DNAs would be released into the cancer patient's plasma. He considered that cancer cells could be similar to foetuses since they are both growing in human's body. Hence, he hypothesised that foetuses would release their DNAs into mother's plasma like what cancer cells do. He and his teammates then boiled the plasma and discovered the DNA of a man in a pregnant woman's plasma. His hypothesis was finally proved to be correct. It can be used to ascertain the foetus' sex, blood type, Thalassemia and other diseases. Moreover, with the help of this discovery, pregnant women could know whether the foetus has Down syndrome simply by a blood test. Since the Down syndrome patient has an abnormal ratio of chromosome 21, we can know the result by checking chromosome 21 of the foetus's DNAs in the mother's plasma. The accuracy rate is about 99.7%.

Professor Lo took a further step to apply the plasma DNA analysis in detecting other diseases. By the same logic, if there are any other cells in human body, the DNAs of these cells can be found in human plasma. Through detecting plasma, we can know whether there is mutation of DNA. Thus, we can determine the stage of cancer. In 20,000 Hong Kong residents, Professor Lo's team fathomed that 70% of the people who used the plasma DNA analysis was discovered of having Nasopharyngeal Cancer. This can lower the mortality rate of the corresponding cancer. The technology was also used for testing SARS too. The accuracy rate could be as high as 80%.

For the next step forward, Professor Lo wishes to extend plasma DNA analysis to ascertain monogenic diseases and hopes to lower the cost of this technology so as to popularize its use and benefit more people.

III. Significant achievement and contribution to society

a. Academic Achievement

In 2001, Professor Lo received the Ten Outstanding Young Persons of the World to recognize his work in medical innovation. A few years later, he was awarded the 2005 State Natural Science Award from the State Council of China.

In 2014, he was also granted the King Faisal International Prize for Medicine for his great contributions in Non-Invasive Diagnosis of Fetal Diseases. He was given the 'Thomson Reuters Citation Laureate - Chemistry' in 2016. He was also selected as the winner of the inaugural Future Science Prize-Life Science Prize, which was seen as China's Nobel Prize at the same year. In the following year, Professor Lo had received the Distinguished Clinical Chemist Award from the International Federation of Clinical Chemistry and Laboratory Medicine. The award is now known as the IFCC-Howard Morris Distinguished Clinical Chemist Award.

Frequently, in 2021, Professor Lo was awarded Breakthrough Prize in Life Sciences. This Breakthrough prize, well known as the 'Oscars of Science', acknowledges top scientists in the world. Making many contributions for the discovery of foetal DNA in maternal plasma, Professor Lo won the Royal Medal in Biological Sciences. He was the first Chinese scientist to win this award.

b. Influence on future generations

Professor Lo believes that it is important to leave legacy of a scientist's work to the future generations so that they can benefit from his findings. He shared his knowledge by publishing significant medical articles. He has published more than 230 articles in international journals over the years. One of his winning articles in 2007 was "Hypermethylated RASSFIA in Maternal Plasma: A Universal Fetal DNA Marker that Improves the Reliability of Noninvasive Prenatal Diagnosis." He was presented Outstanding Contribution for a Publication in the International Journal Clinical Chemistry, American Association for Clinical Chemistry in 2007.

To nurture young science minds, he is lecturing students currently at the Chinese University of Hong Kong. Professor Lo is the director of the Li Ka Shing Institute of Health Sciences and the Li Ka Shing Professor of Medicine at the University of Hong Kong. Professor Lo is delighted to see that more and more students are willing to throw themselves into the research field. 'What young people have is time, simply go and try,' said Professor Lo. Leading by example, Professor Lo has shown youngsters a way to develop a career as a scientist over the years. Through the amazing but arduous journey of research, Professor Lo has been awarded prominent fellowships throughout the years. In 2011, he was awarded Fellow of the Royal Society. Professor Lo was awarded both Foreign Associate of the National Academy of Sciences and Fellow of the World Academy of Sciences in 2003. A few years later, he was awarded Thomson Reuters Citation Laureate – Chemistry.

IV. Path to become a scientist

a. Passion

Professor Lo possesses a great passion for scientific research. Since he was a child, he has been intrigued by science. Under the influence of his father, a doctor, Professor Lo indirectly learnt some medical proper nouns. In his school library he found the journal Scientific American – which frequently told stories of scientists and the ideas they put into practice. His Biology textbook in secondary school featured a photo of James Watson and Francis Crick, the pioneers who discovered the structure of DNA, standing outside King's College Chapel in Cambridge. Soon after, Prof Lo began his education in the same city which then led to Oxford. From there he embarked on a professional journey marked by inquiry and persistence, and joy was found in seeing science as a hobby, not a job. He also likes photography and he mentioned that there is a strong connection between doing scientific research and photography. He has said that doing scientific research and photography are observing the sights of nature and explaining it to everyone in a human way. He has developed a strong interest in doing scientific research.

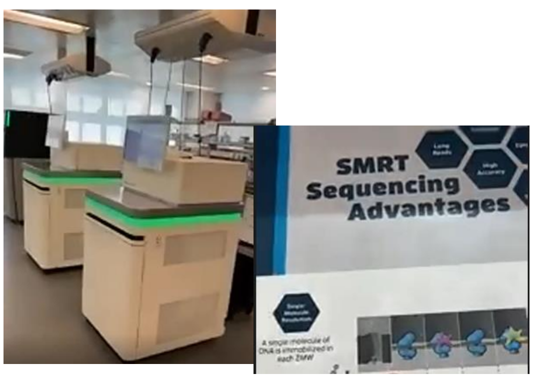
Professor Lo has said, 'We should leave no stone unturned in science.' The belief has always been driving him to continue his non-invasive production inspection project. His next step is to find out if non-invasive production inspection can work on RNA and can detect some single gene diseases. The idea came because he wanted to detect more diseases and help more patients. Professor Lo also said that science is the search for the eternal truth so he has been working hard with his students and colleagues to advance in this area.

b. Perseverance

The quality of perseverance is undoubtedly a key factor to achieve success. Professor Lo first started his research in finding fetal DNA in mother's blood for 3 years. But he ran round in circles these years. The concentration of fetal DNA was too low at that time. Therefore, he returned to his post in hospital. However tough this period was, he endeavoured to adapt to the front-line role and finance his studies for the doctorate. Despite having gone in the undesired direction of the research, he constantly reminded himself of his belief 'leave no stone unturned.' Professor Lo's character and enthusiasm for science made him persist in the research by all means. He finally gained an inspiration on how to find fetal DNA in mother's plasma. Now, his discovery has been used for testing genetic disorders or a chromosomal abnormality of feotuses and benefits lots of pregnant women.

c. Open-mindedness for innovative research means

Professor Lo reminded us of the importance of staying open-minded for new technology. He showed us around his state-of-the-art laboratory through Zoom. The novel equipment has broadened our horizons. There are several DNA sequencing machines for conducting gene mapping.



There are also machines for performing droplet digital PCR.1 oil droplet represents 1 pcr. We can know whether reaction is conducted by observing the oil droplet. It has a high efficiency. We can observe 2 million oil droplets per time. Besides, AI technology has adopted in the field of Epigenetics. Professor Lo's team has found out that the data from the DNA sequencing machine are like a photo. Using a technology similar to facial recognition technology to analyse the photo, we can observe the change in Epigenome. It has a high accuracy about 90%.

d. Dynamic interests

From Professor Lo, we realised that our interests can profit our research. He said that a good scientist needs to have a broad knowledge base, which can be accumulated through our interests. Despite the hustle and bustle, Professor Lo still developed a vast array of interests in his spare time. Other than his interest in science, he is also enthusiastic about arts. He puts his talent of designing into practice. The international prestigious science journal Genome Research recently adopted the cover designed by him and a local artist Carmen Ng. His sophisticated language skills helped him produce accurate patent documents and presentable research reports. He also enjoys watching movies from which he sometimes gained inspiration for his research. Travelling can also broaden his horizons. He has been to most of the destinations on his bucket-list. Playing golf is another hobby and allows him to immerse in nature to gain inspiration for his research. These are the indispensable hobbies that Professor Lo developed through time taking him to new heights.

e. A Grateful heart

While Professor Lo recalling the journey he has been through, he glowed with gratitude. Professor Lo ascribed his success to the support he received throughout the years. He said he was obliged to Professor KAN Yuet Wai FRS, a geneticist and hematologist, for bringing him inspiration and nominating him to enter Fellowship of the Royal Society. He was inspired by Professor Kan's article 'a slow boat from China', which ignited his interest in research in Biology and prenatal testing. Besides, he was thankful to his secondary school Biology teacher Mr. Steven Hui for nurturing his interest in DNA. He also appreciated the long-standing collaboration with Professor CHIU Wai Kwun and Professor CHAN Kwan Chee. Finally, he was in his wife's debt for her support and understanding towards his hectic research life. From Professor Lo, we learnt that we should be grateful for the people who stand by us.

f. Advice to budding scientists

One of Professor Lo's mottos is "Every day counts." He always tells himself that every time when he does an experiment, he would treat it as his last day on Earth. This mentality encourages him to work harder for his research in the hope to leave more legacy to the future generations.

He also stressed on humbleness and honesty. We should be humble about Nature which is still far beyond humans' understanding. Each of us can only see part of it but he believes that when all the individual efforts assemble, we can draw a more comprehensive picture of Nature. Moreover, as scientists, we should be honest about the progress of every research as the result pf each research could bring significant impact to the others.

Besides, creativity is one of the essential qualities that a successful scientist should have. If we did not have creativity, we wouldn’t be able to think of new innovative ideas. He also gave us a practical tip on protecting our ideas derived from the research, which is file a patent for our invention. This in turn can help gain more resources for facilitating the research.

V. Our reflection

Through the interview, we can greatly feel Professor Lo's passion for science. For Professor Lo, doing research isn't only a job, but also an interest. His passion has driven him to keep doing research over these years. No matter how much time is spent, he still chooses to continue his research. He is an enthusiastic person too. We were surprised that he would show his laboratory to us through Zoom. With his perseverance, passion, kindness and innovative ideas, he is indubitably a successful scientist.

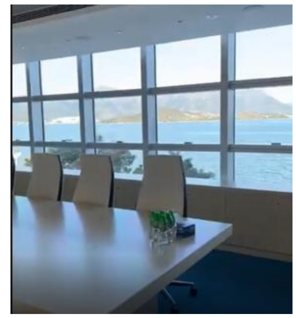
We are grateful that Professor Lo has shared a lot of valuable experience and advice with us. Professor Lo has been working hard on the non-invasive prenatal test and he plans to push this technology to the RNA side in the future. He also mentioned that if he could travel to the future, he would like to research on the irreversible diseases of the brain and see if there would be any solutions to these diseases. In retrospect, Professor Lo thought that when doing any scientific research, 10% of the time comes from the flash of inspiration while 90% is done by hard work. We should have passion and never give up! “Make sure every day counts” is a word of encouragement from Professor Lo and brings us epiphany. It is an honour to have the chance to conduct an interview with Professor Lo and it is a really great opportunity for youngsters, like us, to learn from him.

CHENG Man Hei’s thoughts: I really appreciate Professor Lo since he didn’t give up even when the research journey was not a smooth sailing. If I were him, I might desist the research easily. Without a clear finish line, it could be strenuous to keep researching. However, with his tremendous fortitude, a brand-new piece of technology is invented. His discoveries and inventions have helped a lot of pregnant women and patients. I am sure that Professor Lo can extend his technology smoothly and benefit more people around the world! After conducting the interview with Professor Lo, I want to explore more in the field of science. I hope that I can have the same attitude as Professor Lo.

CHEUNG Megan Sze Yiu’s thoughts: It was an honor to interview Professor Lo. During the interview, I gathered a lot of new information about him. He had decided to study Medicine since he started his passion for science at a tender age. Professor Lo had read many journal articles about Science and Computer Literacy. Moreover, he read Biology books, which further developed his interest in science. I think that he is a good role model for us, and I should follow his lead by starting to develop my own interest. This interest might also be helpful to society in the future!

WONG Ka Fun's thoughts: It is also my dream to become an influential scientist in the future and what Professor Lo said really woke me up and helped me a lot. I learnt that it is not enough only to have passion for doing research, but we should also have team spirit. Working with team members is like an iron triangle, making the research process and results more and more stable. Also, we should be honest about the progress of our research because any research or experiments may affect many people. Finally, we should be innovative and humble, and keep improving ourselves in different fields such as writing or programming. This word really helped me a lot. I hope I can really talk to Professor Lo face to face next time!





Professor Lo is a successful scientist. He made contributions to help our society. Not only is he a scientist but he is also a great teacher and boss. He gave a good office environment for his colleagues to relax and make them feel at home. During the interview, Professor Lo shared about his life of being a scientist. He also mentioned that inspiration only occupies a small portion during his research. The more important thing is our amount of effort used in doing it. His word has deeply inspired us and led us to work harder in our studies or hobbies.

Lastly, it was an honour to interview Professor Lo. We would like to express our appreciation and gratitude to Professor Lo for spending his time with us for this memorable interview. We also hope that everyone could work harder so that we can build a better society in the future!

VI. Acknowledgement

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