Banana peels based bio-plastic

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Abstract

Every developed country depends on the industry as the main factor of its economy. Lack of exports, depression in both the general economy and the value of the currency are consequences of neglecting the industry. All countries work on increasing the efficiency of their industries by whether working on the input, the output, the cost or the time of the process. Plastic industry is considered one of the most important industries because plastic is an important factor in the making of many useful products such as sheets, tubes, rods, slabs, building blocks and domestic products. Making bio-plastic from banana peels instead of the traditional petroleum-based plastic is believed to be a successful solution to increase the efficiency of plastic industry. The solution produces the same amount of plastic with higher efficiency and durability and with a little cost in less time than normal plastic, so it meets the design requirements of any successful solution which are production, efficiency, and cost. The prototype of this project represents the process of manufacturing bio-plastic from banana peels and tests the durability and the efficiency of the plastic produced. The results showed that the plastic produced could bear the weight one and a half time more than petroleum-based plastic so it is suitable for being used in the making of traditional plastic products. In conclusion, test results showed that this project is the perfect solution to develop the plastic industry process.

Introduction

The dawn of industry is rising more than ever it had raised since civilization began as shown in fig (1). Its continues improvement has been saving effort and time to humankind and further needs are being met to more population. Moreover, the economic income from industry saved it the leading position amongst all national and business plans. Increasing the efficiency of the production was the chief concern to mankind to increase income and suffice the needed goods. Pollution, industry supplies, energy and the efficient use of them were the highest obstacle grand challenges came in the way of industry. If Industrial efficiency was attempted to be risen, production must increase with constant inputs, inputs decrease with constant production, time of production decreases with constant inputs and outputs or a combination of them all. Plastic industry is very important because it's important products. Plastic represents only a small percentage of recycled materials as shown in fig (2). A prior solution to

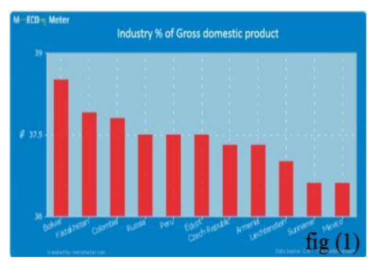


fig (1)

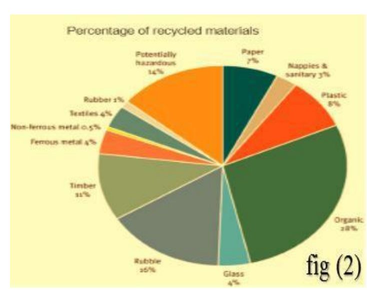
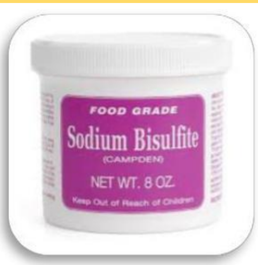


fig (2)

develop plastic industry process is using paper instead of petroleum-based plastic to make traditional plastic products such as sheets, slabs and domestic products. There are some advantages of this solution as it's cheap and environmental. Also, there are disadvantages as paper can't be used to make all plastic products such as rods, tubes and building flocks. Banana peels based bio-plastic is a lower cost, more productive and boosted efficient project. The production of bio-plastic from banana peels which are rich in starch and cellulose, important raw materials used in the bio-plastic industry, was the suitable piece of the puzzle. It uses waste material that is cheap, Massive amount of plastic can be generated due to the huge amount of unused peels which represent about 30%-40% of the fruit mass. The prototype of this solution took several steps and many local and cheap materials were used which will be addressed in the materials section. Through the data collection from tests that have been done on the prototype, it was concluded that the project achieved the design requirements.

Materials

Materials used

A Blender	A Lab oven	4 Banana peels	50g solid Sodium Hydroxide	Two petri dish
				
50g Sodium Metabisulfate	Hydrochloric acid (3ml)	Two beakers (250ml)	Lab weights (1200g)	Two gauze pads
				

Tab (1)

Methods

Preparation of banana skins:

1. An 800ml beaker was filled with distilled water and placed over a Bunsen burner.
2. The banana peels were placed in the beaker and were boiled for 30 minutes.
3. After the boiling process, the beaker was removed from the Bunsen burner and the peels were decanted off the water and placed on and covered with a dry gauze pad, left to dry for 30 minutes.
4. After the peels were dried, they were placed in a clean 800ml beaker.
5. Using a hand blender, the peels were pureed until a fluid paste was formed as shown in img (1)

Production of the plastic:

1. 25ml of banana paste was placed in each 50ml beaker.
2. 3ml of HCl was added and the mixture was mixed using a glass stirring rod.
3. 2ml of propan-1, 2, 3-triol was added to each beaker, the mixture was stirred again.
4. 50gm of NaOH was added and the mixture was stirred once more.
5. The mixture was poured into a petri dish and put in the oven at 130°C for half an hour, the resultant substance from the oven is bio-plastic as shown in img (2).

Test plan

1- Efficiency:

The following 2 experiments were selected and were repeated four times in order to produce the best quality of the plastic with the greatest durability using different amounts of banana paste:

- Dipping the banana peels in 0.5% $Na_2S_2O_5$ solution prior to the boiling and pureeing processes and using 0.1 M HCl and NaOH solutions in the production of the plastic.

- Dipping the banana peels in 0.5% $Na_2S_2O_5$ solution prior to the boiling and pureeing (after blending) processes and using 0.5 M HCl and NaOH solutions in the production of the plastic.

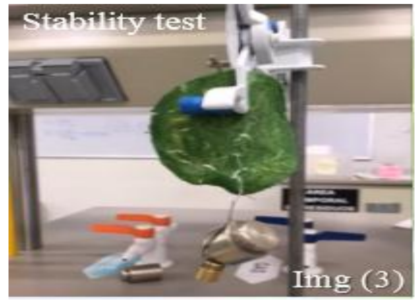
- The cost test was done by calculating the needed cost for the production of the prototype and comparing it to the cost of petroleum plastic production.

2- Stability:

- A comparison between petroleum plastic and bio-plastic was established to determine their strengths by applying a 4N pulling force on each of them from the opposite sides and determining whether or not the plastics broke as shown in img (3).

- The thickness of the plastic was determined by using a ruler.

- The shelf life (decay) was assessed by visual inspection on a daily basis (The darkening of the plastic suggested decay).



Img (3)

Results

25ml is the optimum amount of banana paste used. In trial 1 which is shown in tab (2) and represented in fig (3), while adding 0,1M HCl and NaOH, Plastic has formed but it was fragile and thin. The plastic started to decay after 1 day. While adding 0,5M HCl and NaOH, No plastic was formed. The mixture formed started to decay after 1 day. Trial 2: Plastic has formed, and it was much thicker than trial 1 but it started to decay after 3 days. It has acquired a darker color and a sharp scent and lost its strength and has become much more fragile. Trial 3: Plastic has also been fragile. Trial 4: Plastic has formed and was much thicker than trial 1 and 3. It has not shown any signs of decay for 30 days and counting. No change in strength has been recorded as well. Of course no experiment is perfect and there is always room for improvement. For example, the experiments were not all done at the same time and the bananas used were not purchased on the same day. This is a limitation which could be improved by conducting all the experiments at the same time, on the same batch of banana peels. All measurements were made as precisely as possible, however while balancing there was a measurement error of ±0.2 M.

Experiment results

	TRIAL 1		TRIAL 2		TRIAL 3		TRIAL 4	
	Molarity of the HCl and NaOH Solutions Used							
	0,1M	0,5M	0,1M	0,5M	0,1M	0,5M	0,1M	0,5M
Amount of banana peel paste used / mL	25	25	25	25	20	20	25	25
Platic Formation	YES	NO	YES	YES	YES	YES	YES	YES
Strength Test	FAILED	FAILED	PASSED	PASSED	FAILED	FAILED	PASSED	PASSED
Thickness / cm	-	-	0.3	0.3	-	-	0.3	0.3
Decay / days	1	1	3	3	> 30	> 30	> 30	> 30

tab (2)

> 30 : 30 days and counting

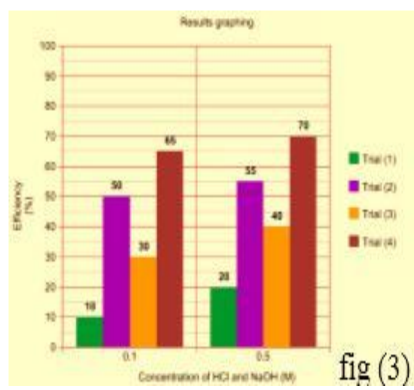


fig (3)

Analysis

After constructing the prototype and performing the test plan a lot of times, promising results showed that the prototype successfully achieved the design requirements that were selected before which are: cost, by using cheap and available materials, production, by using alternative and renewable resource, and efficiency by using specific chemicals in order to obtain the longest shelf-life for the plastic.

The material used in manufacturing the bio-plastic, banana peels, was chosen because it is one of the fruits that are very rich in starch ($C_6H_{10}O_5$), which consists of two different types of polymer chains, called amylose and amylopectin, made up of adjoined glucose molecules that are bonded together forming the plastic as shown in fig (4). The hydrochloric acid (HCl) is used in the hydrolysis of amylopectin, which is needed in order to aid the process of film formation due to the H-bonding amongst the chains of glucose in starch, since amylopectin restricts the film formation. The sodium hydroxide (NaOH) used in the experiment is simply used in order to neutralize the pH of the medium. The propane-1, 2, 3-triol (Glycerol $C_3H_8O_3$) used in the manufacturing functions as a plasticizer, an additive used to develop or improve the plasticity of a material. It disconnects the polymer chains from one another; restraining them from becoming rows of chains and acquiring a crystalline structure. The formation of the crystalline structure is undesired because it is a brittle and fragile structure which makes the plastic brittle and fragile as well. Instead of the crystalline structure, the formation of film (not becoming rows of chains of polymers) is desired. As shown in the results, the plastic started to decay after only 3 days of production, so in order to overcome this problem, sodium metabisulfite which its formula is ($Na_2S_2O_5$) as shown in fig (5), also known as E223, was used as it is a common material used as a food preservative with dried foods, and it succeeded in improving the shelf-life of the plastic.

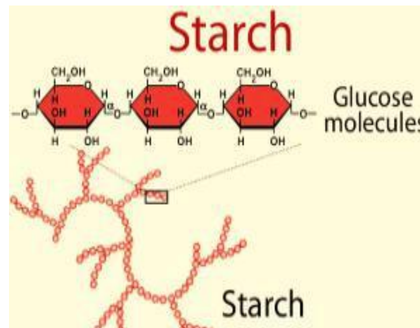


fig (4)

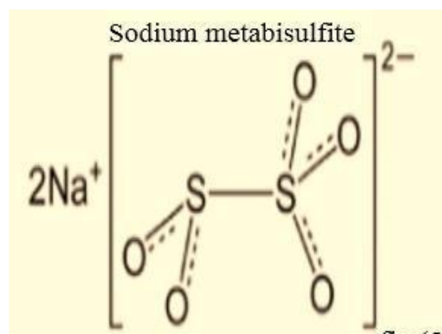


fig (5)

Conclusion

After specifying the grand challenge and the consequences of neglecting it such as lack of exports and depression in the general economy, a lot of researches have been done in order to find a suitable solution to improve plastic industry by producing plastic which has lower cost and higher efficiency to achieve the main grand challenge. A solution has been chosen and a prototype has been constructed, to make sure that this solution meets the design requirements. After performing the test plan on the prototype and analyzing the results, it appeared that the solution succeeded in achieving the design requirements by producing bio plastic from banana peels that has half the cost of petroleum-based plastic, and has higher efficiency as it could bear the weight one and a half time more than traditional plastic. The results showed that the banana peels-based bio plastic is able to achieve the main grand challenge of increasing the industry's efficiency, also it supports the general economy in many other products that plastic plays a factor in the process of their manufacturing.

Recommendation

In the future, instead of using banana peels, potato peels would be used for manufacturing the plastic and that is because this material has more starch and more polymer chains that form the plastic, so as a result it has higher efficiency than banana peels, as its efficiency is 90% while the efficiency of the banana peels is 80%. Although potato peels are available as much as banana peels, they weren't used because they require more time to dry after getting them out of the oven, as the banana peels require only 1 day, while the potato peels require at least 4 days to dry.

Another recommendation for the future is to use Sodium Bicarbonate ($NaHCO_3$) which is shown in img (4), instead of Sodium Metabisulfite ($Na_2S_2O_5$). This material is a salt composed of sodium ions and bicarbonate ions, and it is recommended to use it as a preservative for the plastic after manufacturing instead of Sodium Metabisulfite because it has higher efficiency and would the plastic bear higher temperatures and pressures without decaying, but unfortunately it wasn't used because it requires higher temperature to be efficient with the plastic (350 degree Celsius), while Sodium Metabisulfite doesn't require high temperature at all.

Finally, this project can be centralized by applying it in larger area with bigger scale by manufacturing the plastic in a factory that works using big electronic machines as shown in img (5), which gather all of the stages of the manufacturing, which are firstly: blending the peels to make a solution from it using distilled water and boiling it, secondly: drying it using dry gauze pads, thirdly: adding the chemicals, finally putting it in a big oven that can take more petri dishes which are filled with the plastic. So, the project will be a centralized project that can be applied on bigger scales to produce bigger amounts of plastic that suffices the needs of any company that would work on this project.

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For further information

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