HIGH SCHOOL EDITION
Journal of Student Research
Volume 13 Issue 3 (2024)

Plastic to Electricity (P2E) Using Biochemical Degradation

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ABSTRACT

Plastic pollution is a major concern in today's environment. It could be in the land, ocean or environment pollution caused by dumping the plastic or burning the plastic. This concern is growing everyday exponentially and eventually becomes unsolvable if we do not find sustainable and fundamental solutions starting from the homes to communities. This paper brings a feasible and plausible solution in the form of a Plastic to Electricity (P2E) product, which is built on a biochemical solution to degrade plastic and produce electricity leaving behind residue useful for the compost. The biochemical ingredients are eco-friendly and cheap so the P2E product itself is very affordable and the solution is sustainable. The cost analysis and return on investment calculation were done on the P2E product to prove the value it brings to the community. The experimental results show the plastic quickly degrades to Hydrogen in minutes and then fuel cell will convert the hydrogen to electricity.

Introduction

Plastic pollution is a serious threat to the environment, people, and aquatic life. In the United States, an average family generates 884 kg (about 1948.88 lb.) of plastic annually (OECD iLibrary (oecd-ilibrary.org). One of the leading causes for the global warming due to Carbon dioxide emissions is a result some of the current plastic disposal methods such as burning of plastic and residue from burning is dumped in landfills, which will eventually runout of space with the rate of plastic waste generation we have today. This poses a serious threat to the environment. Plastic is dumped into the oceans affecting aquatic animal life. Our oceans face a growing pollution crisis. About 8 million metric tons of plastic waste end up in our oceans every year. There is already an estimated 150 million metric tons of plastic in our oceans because this problem hasn't been addressed effectively. Plastic recycling is very expensive [1] and is becoming practically impossible. We need a cheaper product to degrade plastic faster and reduce pollution in our community.

Bioplastics were considered but it takes 10-10000 years to degrade [2]. Research is being performed to develop plastic chemical degradation methods such as those developed at Cambridge university using Palladium catalyst, Sodium hydroxide, sunlight and heat. Another research group [3] in Nanyang Technological university, Singapore has developed a chemical method and using sunlight to convert plastic to electricity, but it is a very slow process. But in this paper, we have developed biochemical degradation method to speed up the plastic degradation along with the reside generated to be useful to the environment. Biodegradation [4] of plastic using microbes and enzymes was considered but again the speed of degradation is very slow [2] and most of the commonly available plastics are not degradable by this method. But by the combination of the chemical and bio degradation methods (Biochemical), we were able to successfully degrade plastic but also faster compared to the existing methods due to chemical or biodegradation methods.

The biochemical ingredients in the P2E are cheaper. Electricity costs have risen 15% due to inflation over the last year, P2E decreases dependency on electricity providers. Supply chain disruption caused shortage of silicon needed for electronic parts of gas car (EV cars are preferred and cheaper with Hydrogen fuel). P2E is a viable solution since

1. Solar panels are expensive [5].
2. There is less work for plastic recycling centers and less pollution since recycling involves burning plastic [6] which releases carbon dioxide gases into the environment.
3. Residue from the P2E process can be used for composting.
4. Reduced pollution in ocean due to decrease in dumping of plastic.

Product P2E deployment locations:

- Plastic Recycling Centers
- Stadiums example: Football stadiums
- Malls
- Household backyards
- Community parks
- Apartment / Office Buildings
- Hydrogen generated can be sold directly to Electric Vehicle companies

Biochemical Ingredients

The current method consists of combining chemical and biological ingredients to degrade plastic better, faster and eco-friendly. The key Ingredients used to convert plastic to Hydrogen

- Catalyst(s) - Vanadium, Cadmium Sulfide Quantum
- Water
- Sodium Hydroxide
- Green Algae (Microbes)
- Soil (Enzymes)
- Sunlight (UV radiation)
- Heat to 85 deg C

Experimental Results and Discussion

Table 1. Plastic mass measured with time for various plastic material types.

Material Type	Plastic Type	Total Time (min)	Initial Mass (g)	Final Mass (g)	Mass Degraded (g)
Plastic Packaging	Polyvinyl Chloride	10	0.480	0.462	0.018
Plastic Packaging	Polyvinyl Chloride	20	0.480	0.458	0.022
Plastic Packaging	Polyvinyl Chloride	30	0.480	0.455	0.025
Plastic Bottle	Polyethylene Terephthalate	10	0.251	0.249	0.002
Plastic Bottle	Polyethylene Terephthalate	20	0.251	0.248	0.003

Plastic Bottle	**Polyethylene Terephthalate**	**30**	**0.251**	**0.247**	**0.004**
Plastic Produce Container	**Polypropylene**	**10**	**0.339**	**0.338**	**0.001**
Plastic Produce Container	**Polypropylene**	**20**	**0.339**	**0.337**	**0.002**
Plastic Produce Container	**Polypropylene**	**30**	**0.339**	**0.336**	**0.003**

The experiments were conducted by taking a plastic sample, heating the biochemical gradients to 85 deg C and putting it in the sun light. The plastic starts to degrade a seen from the Table 1 below over time. Plastic degrades to hydrogen due to the breakdown of the chemical bonds and ultimately hydrogen can be used to produce electricity. Mass degraded increases with time as seen from Figure 1 for all the different plastic types used. The plastic starts to degrade quickly within minutes as seen from the Figure 1 with the novel biochemical ingredients. Green Fuel cell [7] was used to measure the electricity. The experimental setup is shown in Figure 2 of the green fuel cell. Below are the ingredients

- P2E Ingredients
- Multimeter
- Phosphate buffer solution, Yeast, Glucose, Potassium Ferrocyanide
- Carbon Electrodes
- Strip paper

Figure 2 shows the Polyvinyl Chloride plastic release the most Hydrogen. Figure 3 shows the electricity generated and increases with the plastic mass. The increase in electricity is due to the increase in more hydrogen release. Plastic packaging material seems to release the most hydrogen and hence produce the most electricity. The residue after the degradation is eco-friendly due to the ingredients used in the degradation process and can be used further for composting.

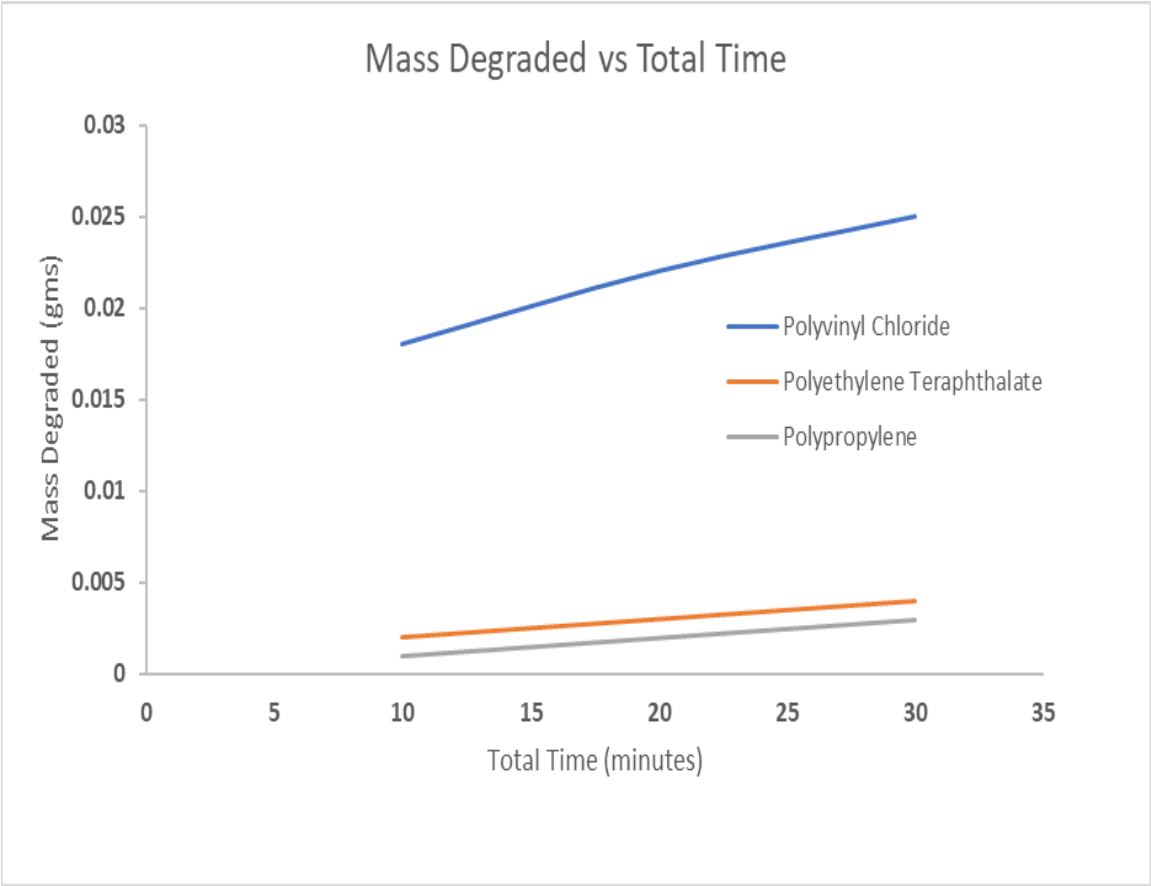


Figure 1. Mass degradation with time for different plastics.

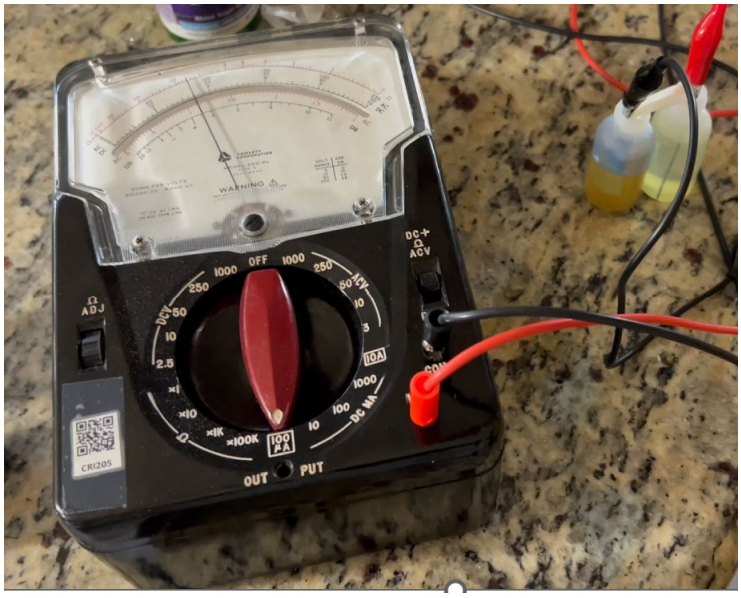


Figure 2. Multimeter reading for the electricity generated from P2E.

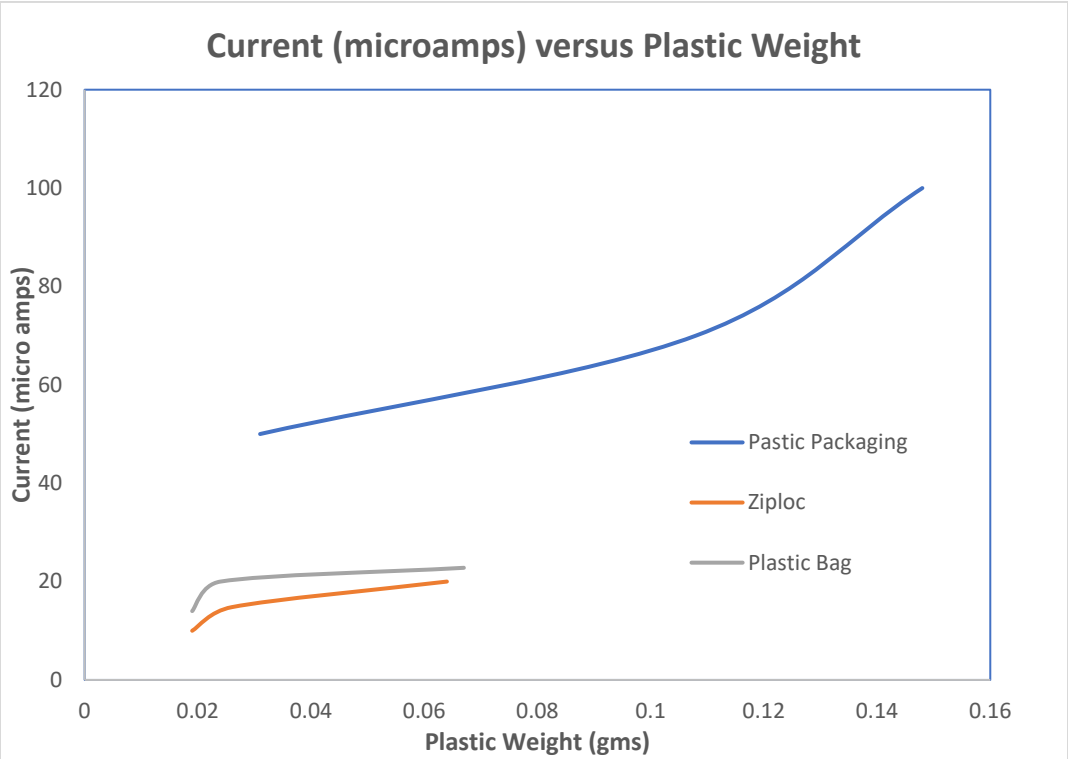


Figure 3. Electricity generation with plastic weight for different plastics.

Product P2E

The prototype shown in Figure 4 below is built in tinker CAD. Fuel cell [8] converts the hydrogen produced to electricity. Components of P2E are

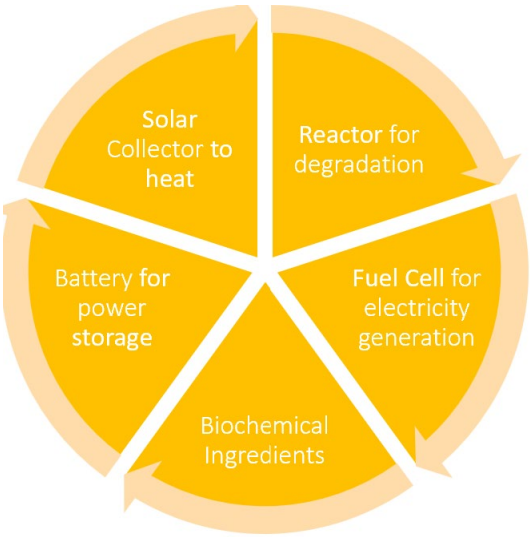


Figure 4. P2E components

Figure 5 shows the Tinker CAD model of the assembled P2E product. The ingredients react with the plastic in the reactors and the hydrogen gas released passes to the fuel cells to produce electricity using the heat from the solar collector. The electricity is stored inside the battery.

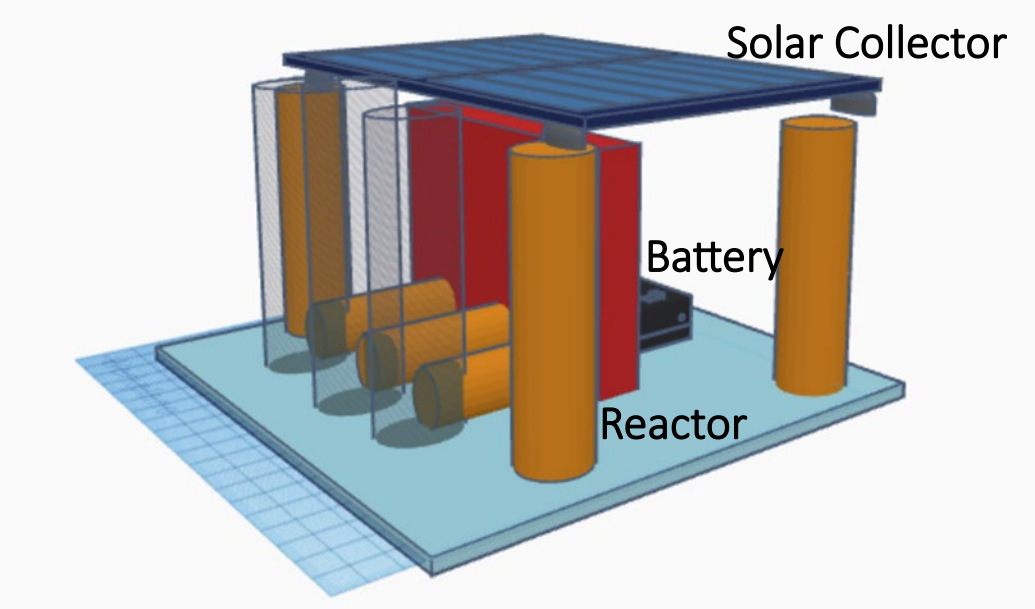
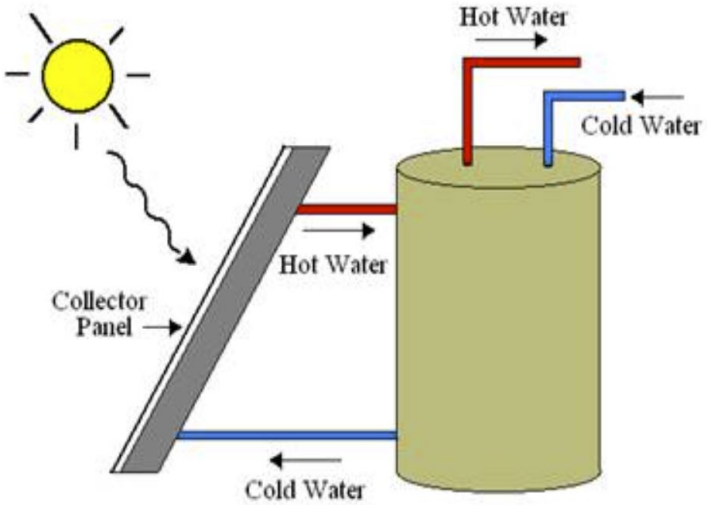


Figure 5. Tinker CAD design model for P2E

Figure 6 shows the solar collector which operates on copper tubes rather than on solar panels. The solar collector [9] is cheaper, does not need electronics unlike solar panels and easy to install. Solar collectors produce heat energy whereas solar panels produce electricity.



Passive Solar Water Heating

Figure 6. Solar Collector with copper tubes for collecting heat.

Cost Analysis

Below is the cost analysis done for the P2E product based on pricing given on Amazon.

- Hydrogen Fuel Cell - $200 (15 gallon)
- Power storage - $499 for 519Wh
- Solar Collector – $100 for 10 sq ft from roofingcalc.com website.
- Chemical cost for 1kg plastic – 50 cents
- Packaging and Labor costs - $200
- Total cost for 1 kg plastic – $1000.5 + One time Installation cost ($100)

Return on Investment

The return on investment (ROI) is calculated as follows

- Average plastic annually per family in US – 884 kg (OECD iLibrary (oecd-ilibrary.org)
- 33.6 kwh electricity per kg of H2 for 100% efficiency
- 1000 kg (about 2204.62 lb) plastic produces 150 kg (about 330.69 lb) H2 equivalent to 4450 kwh per year 90% efficiency
  Texas average electricity costs about 15c per kwh (approx.). In 1 year, saving is 4450*15 = $667
  The costs on the product can be recovered in 2 years.

Conclusion

P2E is a very useful product as it is proven to generate electricity, hydrogen and money that helps combat the alleviation of rising electricity costs, Making electricity more affordable. It also reduces ocean and environmental pollution, recycling centers workload and community effort. Additionally, this product Motivates people to use it since P2E generates revenue and fertilizers from the residue.

Acknowledgments

I would like to thank my advisor for the valuable insight provided to me on this topic.

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