Production of Hydrophobic Bioplastic

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***Abstract*- Due to the increased environmental pollution caused by plastic, a sustainable and cost-effective way of production must be done. And also targeted to overcome the flaw of water absorptivity of conventional bioplastic. This study mainly aimed to develop a bioplastic film reinforced with silicone, silicon, clove, alum, and starch which can overcome the conventional bioplastic water absorption and microbial contamination. Here Silicone had added to the film, because of its inert, hydrophobic, non-sticky, and thermal stability properties. Whereas silicon was added to the film for its high rate of water absorption property in a way that it could help electronic gadgets against corrosion and increases food product's shelf life, whereas alum and clove were used for the presence of active substance against microbes. Here for the film formation silicone was added in large amounts and an equal amount of starch and silicon had been added (here starch was added for faster degradation). Apart from that alum and clove were also added for the biofilm formation. After the production, characteristic studies had been done, antimicrobial studies were done against *enterococcus* for studying the antimicrobial activity of film (clove and alum were added as antimicrobial extract), and other film characteristics studies like Tensile strength, elongation break, water absorption, thermogravimetric, SEM analysis, and soil degradation studies were conducted. This bioplastic reinforced with silicone, silicon, and starch has the potential to overcome the conventional biofilm flaws.**

Keywords: Silicone, FGS-Food grade silicon, Starch, Polyvinyl alcohol.

1. INTRODUCTION

It showed that 99% of plastic is made from oil and gas. The remaining is made from natural raw materials such as corn. This study says that plastic production will increase by 40% in the next 10 years. This makes the ocean carry more plastic than fish by 2050. The United Nations warns that marine life will be destroyed. Coral reefs appear to be particularly vulnerable to plastic pollution. Plastic soup will endanger the food supply of millions of people. [1] To stop the use of plastic we made a film out of silicone which is non-sticky, able to repel water and form watertight seals, thermal stability, low thermal conductivity, and low chemical reactivity. Silicone is a polymer made up of siloxane. They are colorless oils or rubber-like substances.[2] Though many renewable resources are available for bioplastic production, starch is one used commonly for its ease of getting. Starch is made up of 2 polysaccharides namely amylose (linear) with few branches and amylopectin (branched) highly molecule that contributes to low mechanical properties whereas amylose contributes to film strength and also has gelatinization characteristics. The linear structure of amylose in starch usually produces bioplastics with stronger and highly flexible mechanical properties, whereas the branched structure of amylopectin produces bioplastic that shows lower resistance to tensile strength and elongation properties.[3] Using starch as a renewable source has several advantages such as low cost, inexhaustible and renewable. Glycerol plays an important role in forming hydrogen bonds with starch by breaking the strong interaction between intra and intermolecular hydrogen bonds in starch. others used are xylitol and urea. (www.healthjade.net.com). Vinegar helps the starch to dissolve easily. Vinegar is more commonly used than ammonium acetate for its ease of getting**.** Alum (Potassium Aluminum Sulphate) is used for its anti-bacterial properties (www.sciencestruct.com). Clove oil exhibits many properties such as antimicrobial, and anti-cancer due to the presence of eugenol, and β-caryophyllene. (Shokoh Parham et al, 2020). This hydrophobic bioplastic can be used in many applications, which include hydrophobic biodegradable cups, sealants, and Silicone tubes (for transporting food & liquid products through this tube in industries), the synthesized film can be used as an outer coating over instruments which is susceptible to corrosion, food packaging, bio bottles. The synthesized bioplastic can exhibit hydrophobic characteristics, unlike the conventional bioplastic which shows a higher rate of water absorption.

2. MATERIAL AND METHOD

2.1 Collection of samples
Food grade silicon dioxide, silicone sticks, starch, alum, clove.


(Fig 1) Silicon dioxide Silicone sticks

2.2 Fabrication of bioplastic film
2.2.1 Bioplastic synthesized using Food grade silicone, silicone, and starch.
Materials required
a) Silicone sticks
b) Silicone dioxide
c) Starch

Protocol

- Firstly, collected silicone sticks were cut into pieces.
- Then it was melted along with equal proportions of starch and silicon dioxide at a high temperature.
- Along with that alum and clove were added.
- Biobased silicone sticks were obtained.
- For melting we did it at a plastic manufacturing place.

Before getting an idea of using silicone. I tried producing film using starch, silicon, and PVA with various compositions.

2.3 Anti-Microbial Activity (Fig 3)
Materials required
a) Bacterial culture (*Enterococcus*).
b) Nutrient broth (beef extract, yeast extract, peptone, NaCl)
c) Mueller Hinton Agar
d) Sterile Petri plates
Preparation of inoculum
• Bacterial inoculums were prepared by transferring a loop full of bacterial culture to tubes containing 10 ml of Nutrient Broth and incubated for 24 hours at 37°C.

Preparation of plates.

- 2.5 g of weighed MH agar was added to the conical flask filled with 60 ml of distilled water.
- Then it was sterilized and solidified in Petri plates, to which with help of cork borer wells were made.
- A sterile loop was dipped into the bacterial suspension and then evenly spread over the surface of the entire plate.
- To the well, samples were placed and left for 24hrs.
- The presence of an inhibition zone shows the presence of antimicrobial properties in the sample.

2.4 Characterization of bioplastic
2.4.1 Water absorption percentage (Table 2)
First, the Initial weight of the film was taken. Then they were immersed in the water and the absorbency was noted and tabulated every 10 mins (0, 10, 20, and 30)

2.4.2 Water solubility test (Table 3)
The water solubility of the film samples was determined according to the method determined by Saberi et al [4]. Bioplastic samples were dried at 60 °C for 2 h and weighed. The dried pieces were immersed in 20 ml of distilled water in the petri dish and kept on a rocker for 24 h at room temperature. Observed for solubility after 24hrs. The residues were dried at 110 °C for an hour and then weighed to calculate the percentage of the solubility.
where W0=initial dry weight, W1=final dry weight.

2.4.3 Tensile strength and elongation break (Graphs 1& 2)
According to ASTM D882, a Testo metric machine performed the tensile strength test. The samples were cut into a dumbbell-shaped gauge of 50 mm and fixed onto the loading unit. The test was conducted with a speed of 50 mm/min. Elongation at break is the ratio between the initial length and changed the length of the specimen after breakage when external stress was applied. An average value was considered as a mechanical property from the obtained results.

2.4.5 Thermogravimetric Analysis (Graph 3)
The sample was subjected to TGA using a thermal analyzer. The temperature was gradually raised from room temperature 35 to 1000°C at the rate of 10

°C/min and flow rate of 20 ml/min. The mass loss was recorded, which shows the stability of bioplastic.

2.5 Scanning Electron Microscope (SEM) (Fig 4)
The samples were studied at 30 s of acquisition time and accelerating voltage of 15Kv, the d emission current used was 58 µA. The working distance was 7.5mm. The samples were layered with gold before the analysis.

2.6 Biological parameters
2.6.1 Soil burial biodegradation (Fig5)
Produced samples were buried under the soil for checking the microorganism degradation at regular intervals and were compared with each other.

3. RESULTS AND DISCUSSION

3.1 Fabrication of biofilm
3.1.1 The bioplastic is produced using FGS, starch, silicone
Firstly, collected silicone sticks were cut into pieces. Then it was melted along with equal proportions of starch and silicon dioxide at a high temperature. Bio-based silicone sticks were obtained. (Fig 2)
The same procedure was done by (W. E. Cady et al,1980) but they tried using silicone rubber for improving the property of the cushion by adding silicon dioxide. Here, we tried with silicone strands due to the unavailability of getting silicone as pellets and powder form, and the result came out well.
The resultant biofilm using an equal proportion of silicon, starch, and 25 strands of silicone was combined by a melting process. It came out well as strands but there was no flexibility, because of its high thickness. If it was made as a thin sheet, it could have shown the flexible property. It showed both water-absorbing (silicon) and water repellent (silicone) properties well. It also degraded fast due to starch, which is the main difference between the referred paper.

(Fig 2) Silicone strands reinforced with starch and silicon dioxide

3.2 Anti-Microbial Activity

(Fig 3) Inhibition zone against Enterococcus

The above-mentioned samples exhibited
inhibited zone against *Enterococcus* due to the presence of clove and alum. Clove shows antimicrobial properties due to the presence of these active compounds like eugenol, eugenol, acetate, α-humulene, 2-heptanone, and β-caryophyllene.
Whereas potassium aluminum sulfate shows antibacterial properties and can take away the dirt from the water.

3.3 Bioplastic films and their properties
3.3.1 The physical property of biofilm
External features of the bioplastic film developed in this study. Smooth texture and less flexibility were seen, whereas brittleness is less and finally it showed recasting ability.

Properties	**silicone**
Texture	Smooth and very less flexible
Recasting ability	Yes
Brittleness	less

(Table1)

3.3.2 Water absorption

Biofilm type	Mass before immersion (g)	Mass after immersion (g) 5 / 15 / 30 (mins)	Nature
Silicone	8.60	14.00 14.25 14.26	Rigid

(Table 2)
Sample which was made of silicone and silicon, their initial weight was 8.60g, after 5 minutes of immersion it got increased to 14.00g, it means 5.4g mass weight

was added up. Followed by after 15 minutes of immersion weight had increased to 14.25g (i.e 0.25 weight had added up). Finally, after 30 minutes of immersion weight had to 14.26g (0.01 weight had increased)

Weight of water absorbed (Gm/m2) = Final wt (g)-conditioned weight (g) ×100 water

Absorption Index=W1/GSM

Where W= Weight of water absorbed in GM/M2, GSM= Weight of sample in Gm/m2

Water absorptiveness=(m2-m1) × F

Where

M2 = Wet mass of test piece, m1= Dry mass of test piece, and F=10.000/test area.

Water absorptiveness for the sample was m1=8.60g, m2=14.26g

= (m2-m1) × F

= (14.26-8.60) ×100

= 566.

This says that the sample showed very less water absorption due to its hydrophobic nature.

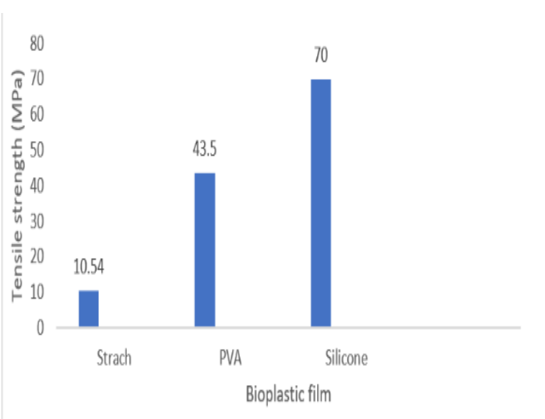
3.3.3 Water solubility

Film type	Initial dry weight(g)	Final dry weight(g)	Solubility percentage
Silicone	8.50	8.45	0.58

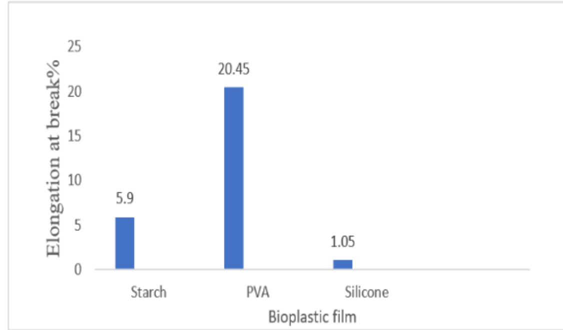
(Table 3)

Films with silicone showed less solubility because of their hydrophobic and nonsticky nature.

3.3.4 Tensile strength and elongation break



(Graph 1)

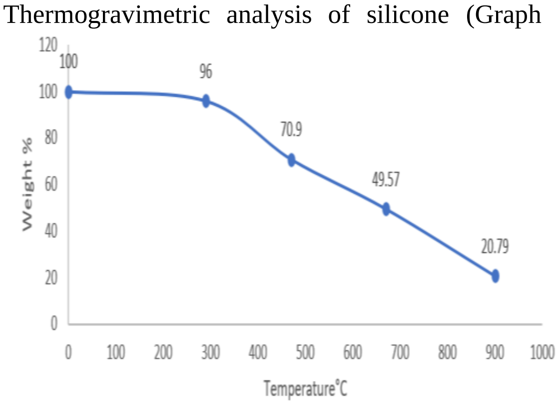


(Graph 2)

Tensile strength (TS) and elongation at break (EAB) show how film can withstand stress, which is a very important application to be studied. TS value of Silicone (Graph 1) was 70 MPa, and EAB (Graph 2) value was 1.05. The TS value had increased due to the presence of silicone which increased the interaction between silicon and starch, but in contrast, elongation strength was low due to the low ductility of silicone. TS value of starch (Graph 1) film was 10.54MPa, and EAB was 5.9%. (Graph 2). The addition of glycerol and silicon improved the mechanical property of the film, making the film flexible. TS value of PVA film was 43.5MPa, and EAB was 20.45%. From the above values, it showed silicone sample showed higher tensile strength, whereas elongation break PVA showed higher.

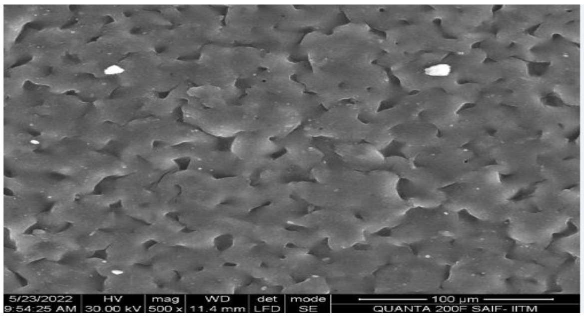
3.3.5 Thermogravimetric studies

Thermogravimetric analysis of silicone (Graph 3)



From the graph (Graph 3), it was clear that the initial decomposition of the silicone sample occurred at 290 °C where around 4% of the sample weight was reduced. Then at 470 °C, the weight came down to 70.9. This degradation process continued whereas, at 670 °C, 50% of the weight of the sample got reduced. In the end at 900 °C, only 19.79% of the mass weight was left as a residue. Initially, the degradation process started at quite a higher temperature i.e at 250°C, it shows that both the silicone and silicon presence increased the thermal stability of the sample.

3.4 Scanning electron microscope



(Fig 4)

Whereas, In silicone sample which was made of silicone and silicon showed a better smooth surface. It showed good interaction because when silicone sticks firmly solidified with silicon at high temperature, without leaving silicon on the top.

3.5 Soil degradation

(Fig 5)

Biodegradation rates of samples were closely observed. The color and size of the film changed and started to degrade slightly. whereas the silicone sample showed shrinkage in its mass (compared to the conventional silicone, It showed faster degradation property might be due to the addition of starch).

4. CONCLUSION

This study was conducted to produce an eco-friendly and hydrophobic bioplastic to overcome the conventional bioplastic flaw of higher water absorption property. This study formulated biofilm to get hydrophobic film against water and antimicrobial property against microbes. The silicone sample came out well showing the hydrophobic property with less tensile strength. whereas anti- microbial studies, it showed an inhibition zone against *Enterococcus*. I conclude by saying that this silicone sample can be used to make bioplastic which can serve as a safe and cost-effective alternative to a synthetic single use.

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