

# Agar-Agar bioplastic synthesis and its characterization

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## ABSTRACT

Screening of the biopolymer was carried out by using the different method for synthesis and optimized the agar-agar biopolymer by different modification in agar-agar weigh values and plasticizer volume so, the better results were observed in agar-agar based biopolymer. Then, characterization of the agar-agar based biopolymer was carried out using different methods like Fourier transform infrared resonance (FTIR), Solubility, etc. After the completion of agar-agar biopolymer synthesis, degradation method which includes In-vitro method and Natural degradation method was carried out and best result was observed during natural degradation method. In this degradation method plastic was completely degraded in short term period.

## INTRODUCTION

Agar or agar-agar was discovered in the late 1650s or early 1660s by Mino tarozaemon in Japan. Where it is called Kanten. The word “agar” comes from agar-agar the Malay name for red algae. (Balfour, Edward. (1885)). Agar-agar is a jelly-like substance and it contains agarose and agaropectin in its structure. Agarose is a mixture of linear polysaccharides D-galactose and 3,6 anhydrogalactopyranose (Agarobiose) whereas Agaropectin is a mixture of heterogeneous smaller molecule D-galactose and L-galactose heavily modified with acidic side-groups such as sulphate and pyruvate (Williams, Peter W.; Phillips, Glyn O. (2000)). (Rafael Armisen; Fernando Galatas (1987)). The natural biopolymer agar-agar is isolated from the cell-wall of some species of red algae, primarily from the genera *Gelidium* and *Gracilaria (Ogonori)* (Shimamura, Natsu (August 4, 2010)). Agar-agar based biopolymer is used to make biodegradable polymer which can be helpful to replace the use of synthetic polymers as they are being harmed to the environment. Naturally degradable biopolymers can be degraded by the special enzymes of microorganisms which play a major role for the conversion of complex form into the simple form so, which can be utilized to the different metabolic functions. In this mechanism two steps are involved the first one is the fragmentation of the polymer into the lower molecular mass by means of either abiotic reaction for example oxidation, photodegradation or biotic reactions (by microorganisms). This is followed by bio-assimilation of the polymer fragments by microbes and their mineralization. Biodegradation is not solely dependent on the origin of the polymer but also on its chemical structure and environmental degrading conditions. There are many applications of biopolymers

which include the most important plastic mulches. It was first noted for its ability to increase soil temperature in the 1950s (Hugh M.C., 1987). It alters the crop microclimate by changing the soil energy balance. Modification of the crop microclimate results in changes in soil temperature that may affect plant growth and yield. Higher soil temperature increases nutrient availability, enhance the nutrient uptake by roots, and increase the number and activity of soil microorganisms, and speed-up plant germination and growth. The use of clear plastic mulches in cold areas increases soil temperature and promotes germination and emergence of many crops (Lee S.H, 2010).

## MATERIALS AND METHODS

### Materials

Agar-Agar powder (HI media) type, Gelatin powder, Salt and soluble starch (potato) Extra pure ACS and glycerol solution (Glycerol anhydrous) having assay (GC) 99.5% as plasticizer.

### *Synthesis of gelatin based biopolymer synthesis*

Combine 3.0 grams (1/2 tsp) of glycerol and 12.0 grams of gelatin powder (4 tsp) with 60ml (1/4tsp) hot water. Carefully mix all the ingredients together in the same proportion as indicated above. Keep mixing until there are no clumps and it is dispersed as it is going to get. Then heat the mixture to 95°C or when it starts to froth (Whichever comes first). Stir the mixture while you are heating it, and it reaches to the right temperature (95°C) or starts frothing, remove from the heat and keep stirring. Scoop out excess froth with a spoon and make sure there are no clumps. Let it dry on the flat surface for approximately 15-20 hours. If your first batch turns out too sticky or slimy then you can try it again with slight less plasticizer.

### *Agar-Agar based biopolymer synthesis*

Combine 3.0 grams of agar-agar powder and 1% glycerol solution (1 cup=240 ml), mix with 180 ml of water. Mix all the ingredients together in the amounts above and stir. Keep mixing until there are no clumps and it is as dispersed as it is going to get. Heat the mixture to 95°C or when it starts frothing or reaches to the defined temperature value (95°C), remove the heat and keep stirring. Scoop out excess froth with spoon allow it for drying on the flat surface for 15-20 hours.

### *Starch and salt based biopolymer synthesis*

Combine 3.0 grams of starch (1 tsp), 45 mg salt and 160 ml (1%) glycerol solution. Mix all the ingredients together in the amounts above and stir. Keep mixing until there are no clumps, and heat and keep stirring. Scoop out excess froth with a spoon and make sure there are no clumps, if the mixture starts to froth adjust the flame manually. Scoop out excess froth with spoon allow it for drying on the flat surface for 15-20 hours.

#### *Optimization of agar-agar based biopolymer*

As the agar-agar based biopolymer has shown best plastic, so its optimization needs to be done. Here, volume of glycerol solution was changed and weight of agar-agar and volume did not change.

Table 1

Sample No	Agar-Agar(In grams)	Glycerol solution (1%) (In ml)	Water (In ml)
Combination1	0.840	60	50
Combination2	0.840	65	50
Combination3	0.840	70	50
Combination4	0.840	75	50
Combination5	0.840	80	50

#### *Characterization of agar-agar based biopolymer*

##### *Tensile strength (TS) and Elongation break (%E)*

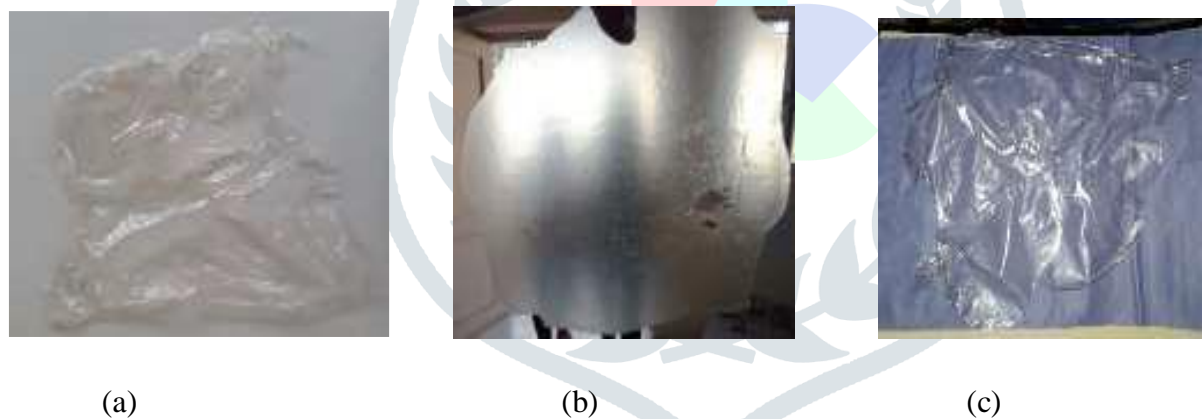
The physical and electrical properties of plastics are influenced by temperature and relative humidity in a manner that materially affects test results. In order to take reliable comparisons between different materials and different laboratories, It is very necessary to standardize the humidity conditions, as well as temperature, to which specimens of these materials are subjected prior to and during testing. Therefore, all films of plastics were conditioned prior to subject them to permeability and mechanical tests according to standard method. Films used for testing Tensile strength(TS) and Elongation break(%E) were conditioned at relative humidity(75%) and 25C by placing them in desiccators over a saturated solution of  $Mg(NO_3)_2 \cdot 6H_2O$  for 24 hours or more. For other tests film samples were transferred to plastic bags after peeling and placed in

desiccators. The tensile strength and elongation break of the films were cast in a collapsible aluminum mold in based on ASTM standard D638 for tensile tests and creep specimen was prepared as dumbbells by compression molding based on ASTM D2990 for tensile creep tests.

#### *Fourier transforms infrared analysis of bio plastic films (FT-IR)*

The infrared analysis was carried out using Fourier transform infrared spectroscopy (FT-IR) model mattson-Gensis, made by unicam, England, over the range  $400\text{-}4000\text{cm}^{-1}$ . FT-IR spectroscopic analysis can give useful information about chemical change occurring in polymer analysis due to blending process, casting process. However, the detection of such changes may be restricted because often different polymer compounds in the polymer blends are chemically similar so, their absorption peaks are masked. To facilitate the detection of changes, a comparison between the characteristics bands of the compound is investigated. FT-IR spectroscopic analysis can give useful information about chemical changes may be restricted because often different polymeric compounds in the polymer blends are chemically similar, so their absorption peaks are masked. To facilitate the detection of changes, a comparison between characteristics bands of the compounds is investigated.

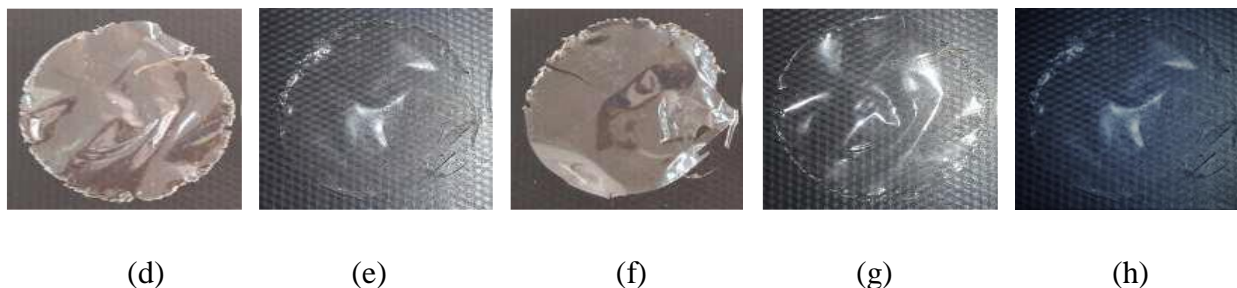
#### RESULT AND DISCUSSION



**Figure 1 Result of three different biopolymer. In figure(a) Starch and Salt based biopolymer. In figure(b) Gelatin based biopolymer. In figure(c) Agar-Agar based biopolymer.**

Above three results of biopolymer indicated that there were variations in their structural characteristics. In the Starch and Salt base biopolymer it is found that its structure was brittle and appearance was crystalline and there was no elasticity in its structure. Whereas, in Gelatin based biopolymer and Agar-Agar based biopolymer were having many similarities but the agar-agar based biopolymer had high elasticity and strength in comparison with gelatin based biopolymer structure. Gelatin based biopolymer also had brittleness. So, it was found that Agar-Agar biopolymer is good for further optimization purpose.

*Results of optimization.*



**Figure 2 variations in Agar-Agar and Glycerol.**

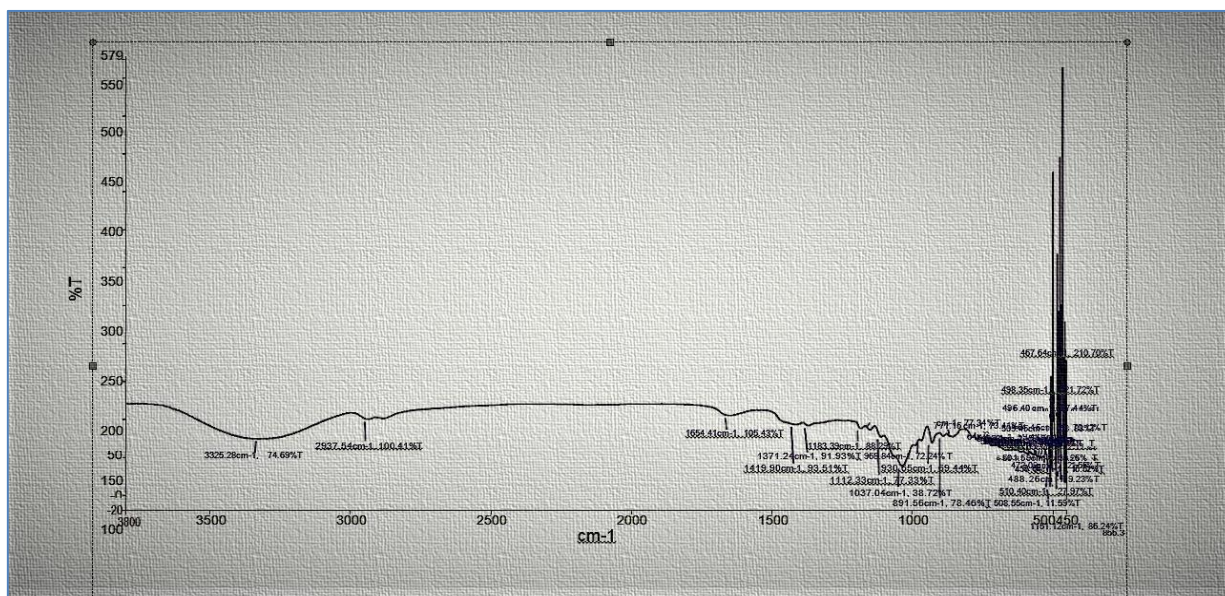
The above figure indicates five different combinations (d, e, f, and g, h) of Agar-Agar and glycerol (plasticizer).

**Result of characterization of Agar-Agar combinations**

Sample No.	Width	Thickness	Load	Tensile strength(TS)	Elongation break(%E)
Combination 1 (d)	1 cm	0.0020 cm	0.225 kg	112.5 kg/cm <sup>2</sup>	12.5%
Combination 2 (e)	1 cm	0.0020 cm	0.670 kg	335.0 kg/cm <sup>2</sup>	17.5%
Combination 3 (f)	1 cm	0.0020 cm	0.175 kg	87.50 kg/cm <sup>2</sup>	12.5%
Combination 4 (g)	1 cm	0.0015 cm	0.330 kg	220.0 kg/cm <sup>2</sup>	12.5%
Combination 5 (h)	1 cm	0.0020 cm	0.390 kg	195.0 kg/cm <sup>2</sup>	5%
Reference	1 cm	0.0080 cm	2.000 kg	250.0 kg/cm <sup>2</sup>	500%

**Table: Tensile strength and elongation break values**

From the above results tensile strength(TS) and elongation break(%E) values indicated that combination 2(blue font) is having a good values of tensile strength and elongation break in comparison with other combinations.



**Figure 3 FT-IR spectra of Agar-Agar combination 2**

From the above result of FT-IR analysis of agar-agar combination 2 revealed that the absorption band occurred  $3325\text{cm}^{-1}$  which represents OH bend and also strong band spectra occurred at  $1037.04\text{cm}^{-1}$  with long stretch which represents C-H stretch.

## CONCLUSION

From the above result it can be concluded that the use of biopolymer in the establishment of healthy environment perspective and it would be very useful. Biopolymer has the ability and characteristics which can replace the conventional plastic in the field of their applications. The biopolymers can be used in different sectors such as food packaging, plastic bags, plastic cups, plastic plates, cutlery plastic storage bags, storage containers or other plastic or composite materials and therefore can help in making environment clean.

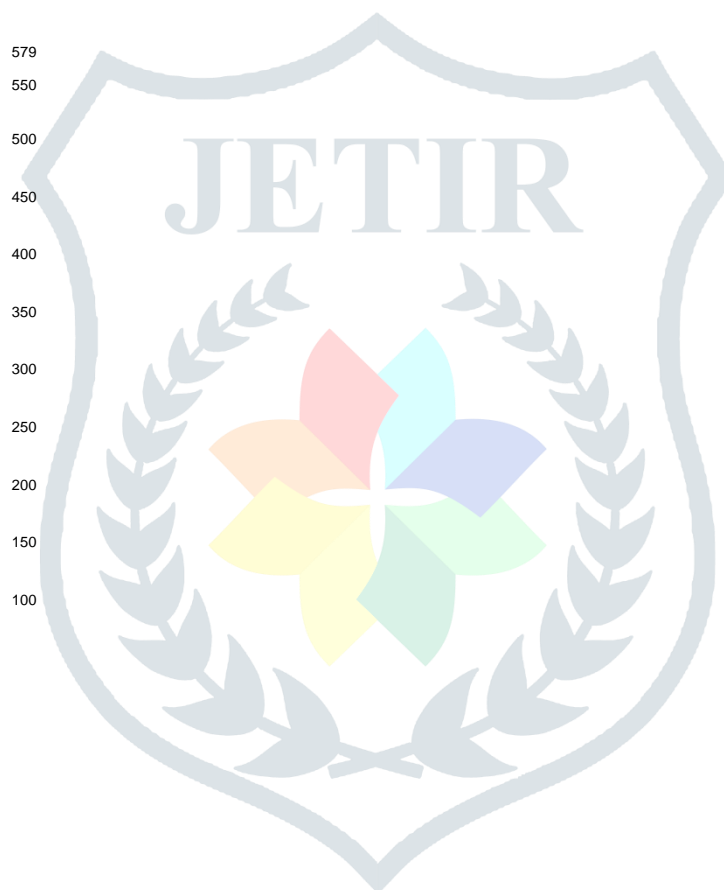
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1151.12cm-1, 86.24%T, 356.3,

579  
550  
500  
450