



## Production and Evaluation of Biodegradable Plastic Films and their Resistance to Organic solvents

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**ABSTRACT:** The character of gelatinized cassava starch was studied with a view to deciphering its rate of organic solvent absorption. Solution casting method was employed in fabricating the cast films. Cassava starch (CS) was initially modified to produce thermoplastic starch (TPS) and Polyvinyl alcohol (PVA) added to the matrix. Absorption test was also carried out by introducing glycerol into the mixture to completely gelatinize the blend. Each blended sample was dried in a closed vessel for 12 hours and then cured in the oven for half an hour at 80°C. Finally, the film was peeled off from the glass plate and sealed for experimental use. Results revealed that increase in polyvinyl alcohol content produced a corresponding increase in organic solvent uptake rate. However, this result implies that the cast films could absorb more water (hydrophilic) and microorganisms in a soil water environment increasingly over time with an increasing starch content, thus leading to a greater biodegradation.

DOI: <https://dx.doi.org/10.4314/jasem.v23i11.18>

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**Dates:** Received: 07 October 2019; Revised: 11 November 2019; 24 November 2019

**Keywords:** Biodegradable, resistance, gelatinization, thermoplastic.

Starch is a polymeric hydrocarbon made up of anhydroglucose units, and used to form biodegradable starch coatings. Such production is characterized by low cost and good mechanical properties (Xu *et al.*, 2005). Jolanta *et al.* (2018) described corn starch has been a good source for creating films, and that it consists of 25% amylose and 75% amylopectin. They also reported that starch is a very promising material that occurs in many plants, completely degradable in soil and water, and supports the process of biodegradation of biodegradable mixed plastics. Starch has been treated in an extruder by the use of mechanical thermal energy to be converted into the thermoplastic material (Mitrus *et al.*, 2016). In the manufacturing of thermoplastic starch plasticizers, it reduces the hydrogen bonds within the molecular level to ensure the stability of properties of the product (Jolanta *et al.*, 2018). Earlier works carried out on the synthesis of biodegradable plastics in solving the plastic waste disposal problem that have been reported in different parts of the world (Idris, 2012; Shen & Burgess, 2012; Potarniche, 2012; Dufresne and Thomas, 2013; Thakur *et al.*, 2014; Cinelli, 2014; Frone, 2014). Adriana *et al.* (2015) reported that despite the low price and high availability of starch, important drawbacks related to poor mechanical and thermal properties, brittleness and high moisture sensitivity have to be overcome to increase starch attractiveness for large-scale application. With this aim, starch was modified or blended with other

materials (Kumar & Singh, 2008; Müller *et al.*, 2009; Rahman *et al.*, 2010; Campos *et al.*, 2012; Noushirvani *et al.*, 2012; Priya *et al.*, 2014; Panaitescu *et al.*, 2015), moreover, due to its biodegradability, high polar character, good mechanical properties and easy processing, polyvinyl alcohol (PVA) is suitable for starch modification and many studies on starch/PVA have been reported (Sin *et al.*, 2010; Chaléat *et al.*, 2012). They further reported that strong hydrogen bonding between starch and PVA and the formation of a network structure were observed in starch – PVA blends with more than 30 % PVA. According to them, although biodegradation is mandatory for environmental purposes, the lifetime as well as thermal and water stability of starch based materials has to be improved for covering more application fields. It is believed that when starch is blended with polyvinyl alcohol, it acts as a weak link between the polyvinyl alcohol matrix and this becomes a point of attack by microorganisms which leads to disintegration of the plastic composite. This work is therefore aimed at producing biodegradable plastic films and evaluating their resistance to organic solvents.

### MATERIALS AND METHOD

**Materials:** Materials used for this study include Polyvinyl alcohol (PVA), which was obtained from Roosevelt Chemical Limited, Benin-City. Other materials used include Acetone, Methyl chloride,

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Toluene, Glycerol, Distilled water and Granulated Cassava starch.

*Methods:* Films were fabricated by solution casting method. Polyvinyl alcohol (PVA) and cassava starch (CS) were weighed into 2-sets of five different petri-dishes in the following grams ; 10g, 8g, 6g, 4g, 0, 2g, 4g, 6g, 10g, respectively. The calculated amount of PVA and CS were mixed and the mixture was slowly added to 40ml distilled water at room temperature with stirring.

When completely suspended, the temperature of the mixture was slowly raised to 80°C, maintaining the stirring but avoiding frothing. Glycerol was then added to the mixture and the stirring maintained for an hour and thirty minutes to completely gelatinize the starch. The volume of the slurry was maintained by adding a little distilled water during this period. After that, the mixture was removed from the heat and casted onto a glass plate which was placed on a flat surface. The blended sample was dried in a closed place for almost 12hours and then cured in the oven for half an hour at 80°C. Finally, the film was peeled off from the glass plate and sealed for experimental use. The step above was repeated for the rest of the samples. Polyvinyl chloride (PVA)/Thermoplastic starch (TPS) composition are shown in Table 1 below

**Table 1:** Formulation for PVA/CS Blend

Blend ratio (g)	PVA (%)	TPS (%)	Glycerol (%)
10:0	100	0	20
8:2	80	20	20
6:4	60	40	20
4:6	40	80	30
0:10	0	100	40

*Solvent absorption test:* Three pieces per test samples of the different composites were cut and dried in oven for 2 hours at 85 °C, followed by cooling, and was immediately weighed. The samples were entirely immersed in air-tight bottles containing the respective solvents: Toluene, Methyl Chloride and Acetone. The samples were removed from the bottles containing the various solvents after twenty minutes, wiped dry with a soft, clean dry cloth, to remove excess solvent from the surface of the samples and re-weighed immediately. This procedure was carried out for: 40, 60 and 80 minutes time intervals. The change in weight was calculated as solvent uptake.

$$\% \text{ Swelling} = \frac{(W_2 - W_1)}{W_1} \times (100)$$

Where  $W_1$  and  $W_2$  are the initial weight and final weight of the samples, respectively.

## RESULT AND DISCUSSION

Results of % Sorption in Toluene, Methyl Chloride and Acetone of Thermoplastic starch (TPS)/Polyvinyl Alcohol (PVA) Blends (Cast Films) at different time intervals.

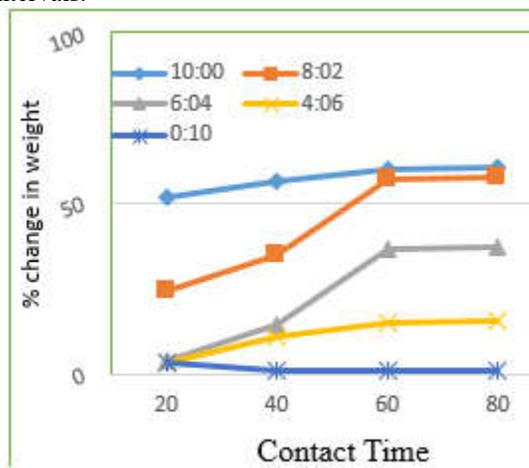


Fig 1: Graph of PVA/TPS Cast Film Absorption Rate in Toluene

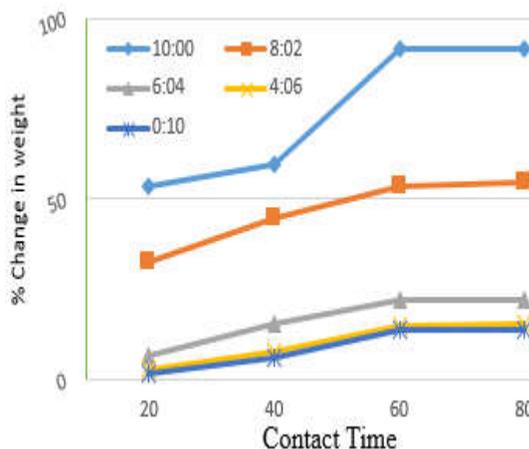


Fig 2: Graph of PVA/TPS Cast Film Absorption Rate in Methyl Chloride

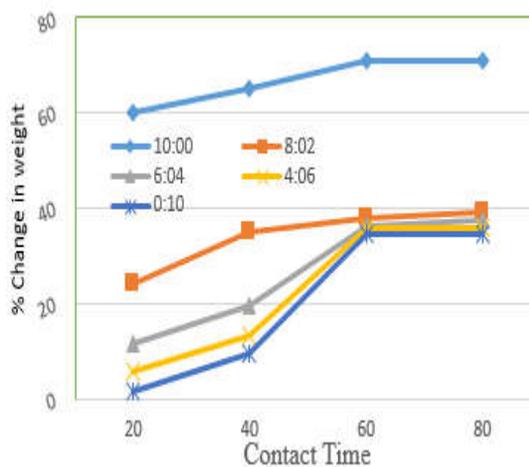


Fig 3: Graph of PVA/TPS Cast Film Absorption Rate in Acetone

The results obtained from this study revealed generally, that solvent uptake increases with time, except for that of PVA/TPS Cast Film Absorption Rate in Toluene (in proportion of 0:10) where the film was completely thermoplastic starch, and showed an initial down trend direction (indicating a decrease in solvent uptake) and then became constant. Moreover, there was a general decrease in the rate of organic solvent uptake as the polyvinyl alcohol content decreases, as against increase in water (hydrophilic) uptake by the blend reported by Azahari *et al.* (2011). Their findings revealed said that PVA films that contained starch demonstrated higher water uptake than the pure PVA films. Water uptake increased with increasing immersion time and starch content. This finding is due to the hydrophilic character of natural starch, which is responsible for the water absorption in the composites, therefore, a higher starch content led to a higher amount of water being absorbed (Kale *et al.*, 2007). The gelatinised starch favoured degradation of the blends when immersed in water; this was likely due to the rupture of the grains during starch gelatinization (Rosa *et al.*, 2004).

**Conclusion:** Conclusively, it could be generalized that natural starch decreases the tensile strength of the blend as it can permit the increased action of microorganisms to bring about biodegradation, and which could help in curbing the environmental consequences of employing the petroleum-based plastics counterpart.

**Acknowledgement:** The author wish to acknowledge Dr. P. O. Okonji, the Chief Technologist of Chemistry Department, University of Benin, for granting us access to the laboratory facilities in carrying out this research.

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