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PRODUCTION OF STARCH-BASED ADHESIVE FOR LIGHT LEATHER BONDING AND OTHER APPLICATIONS

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ABSTRACT

Potato peels were obtained from bean cake (akara) sellers at Sabon Gari metropolis of Zaria LGA, Kaduna State, Nigeria. Starch was extracted from the peels and the starch was used for the production of the adhesive. The adhesive produced was characterized based on the following physical properties: pH, density, viscosity, curing time, bond strength, and shelf life. Commercial synthetic adhesive was used as a control to compared with the produced starch-based adhesive. The result revealed the pH of the starch-based and commercial synthetic adhesives were the same (7.00), their densities were 1.09 and 1.19 g/ml respectively. The viscosity of the starch-based and commercial synthetic adhesives are 10.9 pa.s and 10.1 pa.s, their curing time was 20 and 15mins respectively, their bond strength was 26.72 and 27.09Nmm-2 respectively. Both adhesives showed no signs of deterioration after 4weeks of storage. The findings from the result of this research suggests that the working properties of the starch-based adhesive produced compared favourably with the synthetic adhesive sold commercially. This however, indicates that starch-based adhesive can to some extent be a good replacement for synthetic adhesives in bonding of footwear upper components such as light leather, fabrics, etc. and other articles such as paper and fiberboard. Furthermore, it is recommended that further research should be carried on starch-based adhesive to improve its working properties and shelf life in order to replace the synthetic adhesives and thus prevent the environmental and health hazard posse by the synthetic adhesives sold commercially.

Keywords: Adhesives, starch, potato peel, leather, synthetic

INTRODUCTION

Adhesive is any material that is applied to one or both surfaces of two separate articles to join them together and prevent their separation by an adhesive bonding process (Ebnesajjad, 2008). An adhesive can also be referred to as a substance capable of forming bonds to each of the two parts when the final object consists of two sections that are bonded together. It is a substance that has the capability to hold material together (Leonard, 2015). The manner by which adhesives are able to serve this function is due to a surface attachment that is resistant to separation (Pike, 2021). A bond occurs when the adhesive molecules adsorb into a solid surface and react chemically with it, causing the two surfaces to stick together.

Most times, an adhesive behaves as a liquid in the bonding process, to easily move over and produce close contact with the adherents (Ratkowsky, et al., 1982). Through the development of intermolecular forces, they form surface attachment (Dattoma, et al., 2006). They are chosen for their bonding property and holding capacity. The common structural adhesives are thermosetting acrylic, epoxy and urethane (Dunn, 2004).

Starch is an abundant, less expensive, renewable and biodegradable polymer (Meshram, et al., 2009). It is the second in abundant natural polymer after cellulose, and it is mainly obtained from the stalks, roots, and seeds of staple crops like corn, potato, rice, etc. (Gadhave, et al., 2017). A study of starch and its derivatives shows that starch is the principal water dispersible natural polymer used industrially as adhesives (De Bussy, 1972).

Starch-based adhesives are produced as a result of the ability of starch to gelatinize at a certain temperature. This gelatinization process involves hydrolyzing of the starch to from gel, paste or solution (Goswami, et al., 2004). Starch based adhesive also include the degraded or converted starch such as dextrin (De Bussy, 1972).

MATERIALS AND METHODS

Starch Preparation

The potato peels were washed with tap water to remove dirt, and then dried. The dried peels were grinded and sieved into fine powder, then it was soaked in water and the water was decanted. The washing and decanting were repeated for about four times, it was dried and then re-sieved again to obtain the starch.

Preparation of Adhesive

About 30g of the dried starch from the potato peel was dissolved in 100ml of 0.2M of HCl until there was complete dissolution. The solution was heated up at 60OC for 20mins, then it was allowed to cool at room temperature. 2g of NaOH was dissolved in 200ml distilled water, of which 40ml was added to the gel and then thoroughly stirred until perfect mixture was obtained. 6g of borax was dissolved in water and the solution was gently added with continuous stirring. The mixture was gently cooked at 80OC for 10mins then it was allowed to cool at room temperature. 2ml glycerin and 1ml formaldehyde were gently added and the mixture was thoroughly stirred to produce the final adhesive. The adhesive was transferred into a clean container and labelled. The adhesive produced was then subject to some physical analysis.

Physical characterization of the adhesives

pH: A digital pH meter was used to carry out this test. The sample was put into a beaker and the pH electrode was dipped into the sample and the value read on the digital display was recorded.

Density: The density of the adhesive was measured by using the pycnometer test method as described by ASTM.

Viscosity: The viscosity was measured by the falling ball method.

Curing Time: The curing time was determined by using the adhesive on a piece of leather and spreading it evenly, the time it takes to dry was recorded using a stop watch.

Bond Strength: The bond strength was determined by using a bond adhesive testing machine by measuring the force required to separate two surfaces attached together with the adhesive.

Shelf life: The adhesive produced was put in an air-tight container and stored at room temperature for over 4weeks, signs for deterioration was physically examined and its efficiency was determined afterwards.

RESULT AND DISCUSSION

Table 1: Result of the physical analysis on the starch-based adhesive

S/N	Parameter	Value
1.	pH	7.00
2.	Density	1.09 g/ml
3.	Viscosity	10.9 pa.s
4.	Drying time	20 minutes
5.	Bond Strength	26.72 Nmm^{-2}
6.	Shelf life (after 4weeks)	No sign of deterioration

Table 2: Result of the physical analysis on the commercial synthetic adhesive

S/N	Parameter	Value
1.	pH	7.00
2.	Density	1.19 g/ml
3.	Viscosity	10.1 pa.s
4.	Drying time	15 minutes
5.	Bond Strength	27.09 Nmm^{-2}
6.	Shelf life (after 4weeks)	No sign of deterioration

DISCUSSION

pH is the measure of hydrogen ion concentration of a substance. The pH of the produced starch-based adhesive and the commercial synthetic adhesive were found to be the same, with both have a neutral pH of 7.00. Franco, et al., (2005), in his study on the influence of pH on different adhesive systems, demonstrated that the pH of adhesive system influences the polymerization and bond strength of chemically cured resin materials, the higher the pH the higher the bond strength.

Density represents the degree of compactness of a material measured in mass per unit of volume. A higher density means the end product is heavier. Density is important because it helps to understand the volume or thickness of the adhesive to be applied. The densities of the starch-based and commercial synthetic adhesives were 1.09 g/ml and 1.19 g/ml respectively. The result shows a slight difference in their densities, and thus implies that the commercial synthetic adhesive is heavier that the starch-based adhesive produced.

Viscosity is the measure of a substance resistance to motion under an applied force. Low viscous adhesives flow more readily than high viscous adhesives. From the result of the viscosity test, the starch-based adhesive has a viscosity of 10.9 pa.s, this was found to be a bit higher than the viscosity of the commercial synthetic adhesive (10.1pa.s). This difference could be attributed to the quantity of borax added to the starch-based adhesive, because the higher the amount of borax added, the higher the viscosity of an adhesive.

Curing/drying time is the time taken for an adhesive to set or cure after it is applied on a surface. The result of the curing time of the starch-based and the commercial synthetic adhesives were found to be 20mins and 15mins respectively. The longer curing time of the starch-based adhesive is as a result of the water used as solvent, compared to the organic solvents which are volatile used in the case of synthetic adhesives which causes it to cure faster.

Bond strength generally involves determining the stress required to rupture a bond formed by an adhesive between two surfaces. The bond strengths of the starch-based and commercial synthetic adhesives were observed to be 26.72Nmm-2 and 27.09Nmm-2 respectively. The result shows that there was no significant difference in the bond strength of the starch-based adhesive and the commercial synthetic adhesive. This however, implies that the starch-based adhesive could serve as a suitable replacement for the synthetic adhesive in bonding light leather and other articles such as fibreboard, paper, etc.

The shelf life of an adhesive is the length of time that the adhesive may be stored without becoming unfit for use. The shelf life of the starch-based adhesive exceeded more than 4weeks and was found to be still suitable for used without any sign of spoilage or deterioration. Although, its shelf life may not be as long as the synthetic adhesives because starch being an organic substance is prone to microbial attack after a longtime. The commercial synthetic adhesive remained intact without any changes in its properties.

CONCLUSION

The use of adhesive offers many advantages over binding techniques such as sewing, mechanical fastening, thermal bonding, etc. stabilized adhesive has been produced from starch with the aim of contributing towards solving most of the problems encountered in fastening or holding articles together by surface attachment and also reduce the environmental hazard load caused by synthetic adhesive. The findings from the result of this research suggests that the working properties of the starch-based adhesive produced compared favourably with the synthetic adhesive sold commercially. This however, indicates that starch-based adhesive can to some extent be a good replacement for synthetic adhesives in bonding of footwear upper components such as light leather, fabrics, etc. and other articles such as paper and fibreboard. Furthermore, it is recommended that further research should be carried on starch-based adhesive to improve its working properties and shelf life in order to replace the synthetic adhesives and thus prevent the environmental and health hazard posse by the synthetic adhesives sold commercially.

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