DEVELOPMENT OF OPTIC SOLID LARGE CORE LIGHTING CABLE FROM KERATIN PROTEIN OF WASTE CHICKEN FEATHERS: AN INNOVATION IN FIBER OPTICS TECHNOLOGY

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ABSTRACT

Optic fiber lighting cables are installed on pools, fountains and lighted pathways for emergency routes and stairway steps. However, these lighting cables are very hard, expensive and not locally fabricated. Thus, the researchers were motivated to produce a cost effective lighting cable using the keratin of waste chicken feathers. The keratin was extracted from chicken feathers to develop an optic solid large core lighting cables using chemical reagents. Then, Biuret test was performed to confirm the presence of keratin protein. After which, the optic solid large core lighting cable was fabricated using the varying ratios of keratin solution (0.15 mL, 0.25 mL, 0.35 mL), hardener and resin in the different setups. Then, the qualities of the lighting cables were evaluated in terms of their absorbance, transmittance, flexibility, impact resistance, luminous emittance and water absorbance. Biuret test confirmed the presence of keratin from chicken feathers. Result showed that the amount of keratin in the optic solid large core lighting cables is directly proportional to its transmittance, impact resistance, and luminous emittance but inversely proportional to its absorbance, flexibility and water absorbance. This implies that the higher the amount of keratin, the higher is its ability to transmit and emit light and the lower is its chances of deteriorations and deformations which are very important characteristics of the optic solid large core lighting cable. Scheffe test also revealed that the keratin from chicken feathers significantly increased the transmittance and luminous emittance and significantly decreased the absorbance, flexibility and water absorbance of the lighting cable as compared to the control group (hardener and resin only).

Keywords: Chicken feathers; keratin; optic solid large core lighting cable.

INTRODUCTION

The Philippine architectural, commercial and landscaping industry have recently been investing on the installation of effective and dramatic lighting fixtures for the improvement and betterment of their own line of business, specifically on pools, fountains, lighted pathways for emergency routes, stairway steps and refrigerated display cases. As a result, they have put up multi-colored light bulbs to suffice this need for lightings. However, light bulbs are known to be fragile materials with less color rendition, on contrary to what entrepreneurs necessitate which are sturdy illuminations, a primary example would be the large core fiber optics.

According to Fiberoptics Technology, Inc. (2012), the large core fiber optics is used to allow light to travel from a source along the length of the plastic material. This plastic material is the refinement done by scientists to ensure the “leaking phenomena” of the light traveling the cable,

resembling a neon light tube during the process. These materials also transfer less heat while on consumption and have higher temperature resistance of 100°C. However, these commercial large core fiber optic cables also display disadvantages, such as higher chance of deterioration and corrosion because of too much exposure from water or moisture, making the fiber useless. Moreover, they also require special jacketing and protection when used outdoors to avoid deformations which brings inconvenience. Furthermore, these fiber optic cables are found to be very expensive and very hard to avail, one of the reasons is that our country do not manufacture large core fiber optics and to acquire such lightings, the entrepreneurs and consumers residing in Philippines, should pre- order them from manufacturing countries like China, Australia and Saudi Arabia.

Other components of the optic solid large core lighting cable are resin and hardener. Resin is commonly used in eye protection, as well as in other projectile resistant viewing in lighting, application that would normally indicate the use of glass and when it dries it transforms from a less viscous liquid to a semi-hard, transparent object while the hardener is mostly known because it hastens the solidification process of resin (Johnson, 2013).

On the other hand, chicken feathers are waste products of the poultry industry (Gerber and Steinfeld, 2002). An estimated 15 million tons of chicken feathers are available globally each year as a by-product of meat manufacture (Chinta et al., 2013). In the Philippines, poultry industry produced about 40 million broiler chickens annually (USDA FAS 2005). These chickens generate about six million kilograms of waste feathers annually when the birds are processed in commercial dressing plants. Traditional disposal strategies of chicken feathers are expensive and difficult. They are often burned in incineration plants, buried in landfills, or recycled into low quality animal feeds. However, these disposal methods are restricted or generate greenhouse gases that pose danger to the environment. To counteract this perceived difficulty, the researchers have been searching for a novel solution, one that concerns the lack of effective lighting fixtures in our country and the abundant population of non-biodegradable waste chicken feathers, and they have found out that nano fibrous mat made from keratin protein, was proved to have the ability to scatter and transmit light (Choi, 2014). Keratin protein is a hydrophobic molecule which is known to repel or doesn't combine with mass of water (Williams, 2012). Furthermore, in accordance to Frazer's (2012) statement, keratin protein is a major component of chicken feathers and these proteins supply the capability of feathers to be both light and tough enough to tolerate mechanical and thermal stresses. The aforementioned references gave the researchers the idea and motivation to utilize the keratin protein extracted from chicken feather wastes for the development and evaluation of innovative optic solid- large core lighting cable.

The quality of the innovative solid large core lighting cables were to be evaluated under these following parameters and analysis such as light spectroscopy analysis using the SB-3000 UV Vis Spectrometer at 410 nm for the absorbance and transmittance, luminous emittance, water absorbance, flexibility and impact resistance. These are necessary to supply answers for the following specific objectives: to determine if there is the presence of keratin protein in the extracted solution from the waste chicken feathers; to know if there is a significant difference between the different ratios of resin, hardener and keratin (R:H:K) in terms of the absorbance, light transmittance, luminous emittance, water absorbance, flexibility and impact resistance; to

determine if there is an interaction between the different weights applied on the cable and the varying ratios of R:H:K; to discern the specific pairs of ratios that possess significant differences, particularly in terms of absorbance, transmittance, luminous emittance, impact resistance and flexibility; and lastly, to discern if there is relationship between the weights applied on the cable and the different ratios of R:H:K.

METHODOLOGY

Research Design

Factorial research design was used in this study because there is more than one independent variable present in the flexibility testing. This design allows the researchers to measure the individual effect of each independent variable which are the varying R:H:K ratios and different weights applied on the cables on the dependent variable which is the flexibility response and also the interaction effects of independent variable between the different weights and the varying R:H:K ratios on the flexibility response of the cables.

Posttest only control group research design was also used in this study which involves both the experimental and the control group. This design allows the researcher to determine the effect of the intervention on the experimental group by comparing it to the control group. The researchers used this research design in obtaining the results of the absorbance, transmittance, luminous emittance and impact resistance.

Finally, the Pre-Test Posttest control group design was used in this study to determine the water absorbance of the lighting cable. In this design, the initial weight and the constant weight of the lighting cables were measured and recorded (Pre-test) then, the cables were submerged in the water and after an hour, the final weight (Posttest) of the lighting cables were then measured and recorded.

Location of the Study

The extraction of the keratin solution from the waste chicken feathers was conducted at DOST-Iloilo. The Buiret Test and Light Spectroscopy Analysis were conducted at Negros Prawn Analytical and Diagnostic Laboratory, Bacolod City. The fabrication of the solid optic lighting cable was performed at Colegio de San Agustin, Bacolod City while the flexibility test, impact resistance and luminous emittance were tested at STI-West Negros University College of Engineering, Bacolod City.

General Procedure

A. **Gathering of materials and chemicals**

The materials and equipment used in the experiment were: stirring rod, centrifuge, filter paper, magnetic stirrer, beaker, watch glass, funnel, Erlenmeyer flasks, analytical balance, volumetric flasks, hot plate, distilled water, test tube, rack stand, fume hood, cutter, cups, cutter, dropper, hardener, stopwatch, meter stick, lux meter, microfiber, pipette, UV-Vis SB 3000 Spectrometer, syringe, 3 m of 0.25-in-diameter poly tube and chicken feathers while the following chemicals that were used in this study are resin, ammonium sulphate, sodium sulfide, sodium hydroxide, copper sulfate and potassium hydroxide.

C. Collection and preparation of chicken feathers

Five (5) kg of chicken feathers were collected from Poultry Industry in Brgy. Cabug, Bacolod City. They were washed and soaked in ether for 24 hours. The main purpose of this is to free the feathers from stains, oil and grease before processing it. Then, the feathers were washed with soap water and sun-dried for 3 days. The dried feathers were then cut manually into smaller pieces and were kept carefully in a sealed plastic bag.

D. Production of keratin protein solution

The extraction of keratin protein from chicken feathers was based from the procedure of Gupta and Parumal (2012).

D.1 Dissolving of chicken feathers

Seventy-eight grams (78g) of sodium sulfide were placed in a beaker using a magnetic stirrer and 1L of distilled water was added in the beaker to dissolve the sodium sulfide. After dissolving the sodium sulphide reagents, another 1 Liter of distilled water was added and the solution was stirred continuously. While stirring, 50 g of cut chicken feathers were weighed using the analytical balance and gradually placing it afterwards in the 2L sodium sulfide solution. The solution was then heated at temperature of 30°C. The pH was also maintained within 10-13 and the solution was stirred continuously for 6 hours. After which, the solution was filtered using filter paper to make it particle free.

D.2 Preparation of ammonium sulfate solution

Three hundred fifty (350) g of ammonium sulfate were dissolved in 500 mL distilled water. Then, the solution was stirred using the magnetic stirrer until all the ammonium sulfate particles dissolved. The solution was then filtered to get rid of unwanted particles.

D.3 Protein precipitation

Five hundred (500) mL of feather filtrate solution were collected and were placed in a beaker and were stirred. Then, 250 mL of the feather filtrate solution was placed in an Erlenmeyer flask, and then the remaining solution was placed to another Erlenmeyer flask. Two hundred fifty (250) mL of ammonium sulfate solution were added drop wise in the first Erlenmeyer flask and the flask was shaken after every drop of the ammonium sulfate solution. The ratio of feather filtrate solution and ammonium sulfate solution that was added is 1:1. The same process was applied in the other flask. Then, both flasks were set aside for an hour for the solution to precipitate. After four hours, the solid particles floating on the surface of the solution was removed and the solution was then placed in a clean glass bottle. The remaining solution was then centrifuged at 2000 rpm for 5 minutes to collect the remaining solid particles which did not precipitate from the former process.

D.4 Protein purification

The solid particles that were collected were washed by adding it into a beaker which contained 100 mL distilled water and then the particles were stirred until they dissolved. After that, the solution was centrifuged at 2000 rpm for 5 minutes; the liquids obtained in the test tube were poured into a beaker. Using a small spatula, the solid particles were gently collected which can be found in the bottom part of the test tube and placed it into another clean glass bottle. After washing, the collected solid particles were then dissolved in 100 mL of 2M (8 g) sodium

hydroxide solution. The solution was then centrifuged again at 2000 rpm for 5 minutes and all the liquids were collected carefully and were sealed and stored in a clean glass bottle while the solids were discarded. The precipitating, washing and dissolving steps were repeated 3 times.

D.5 Performing the Biuret Test

Biuret test was performed to confirm the presence of keratin in the solution. One percent (1%) Copper sulphate solution and 1% Potassium hydroxide solution were prepared (both solutions contained 1 g of each stated chemical and 100 mL of distilled water). Five (5) mL of the protein solution was mixed with Potassium hydroxide solution following the 1:1 ratio. Then, three (3) drops of Copper sulphate solution were added to the mixture solution. Changes in the solution were observed and recorded. The solution was then analyzed using the UV-Vis SB-3000 spectrophotometer to obtain its absorbance and transmittance.

E. Fabrication of Optic Solid Large Core Lighting Cable

Fifty (50) mL of keratin protein solution from the waste chicken feathers were poured into a small bowl and was shaken to diminish the number of air bubbles until no more bubbles can be observed. Next, resin and hardener were mixed with the corresponding amount of keratin solution into three containers. The resin served as the base material in forming the lighting cable and the hardener aided the solidification process of the solution. The different set ups were as follows: Set-up 1 contains 30 mL of resin, 0.25 mL of hardener and 0.15 mL of keratin solution; Set-up 2 contains 30 mL of resin, 0.25 mL of hardener and 0.25 mL of keratin solution; Set-up 3 contains 30 mL, 0.25 mL, 0.35 mL of resin, hardener and keratin solution respectively; and Set-up 4 contains 30 mL resin and 0.25 mL of hardener. The resin and hardener were kept the same all throughout the experiment.

One end of a 12 inch poly tube was swiftly placed in the container with corresponding set-up. After which, the syringe was attached on the other free end of the poly tube to serve as the suction material, in order to transport the solution inside the poly tube. The solution was carefully drawn up in the poly tube by pulling up the syringe. This was then detached from the poly tube afterwards and the poly tube was set aside overnight to solidify. Finally, the poly tube was removed thoroughly and carefully using a cutter until the solidified mixture inside of it is obtained.

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F. Proper Disposal

The laboratory apparatuses used were washed thoroughly using diluted dishwashing liquid and were rinsed with ultrapure water and were eventually placed in a rack to dry. The remaining solutions were spilled into a drainage advised and recommended by the assisting scientist.

G. Data Gathering Procedure

The light transmittance and absorbance of the different ratios of R:H:K were determined using the SB-3000 UV Vis Spectrometer, and this was conducted through submitting 5 mL sample from each setup at a wavelength of 410 nm. The luminous emittance of the lighting cables were

also tested by putting the light source at the one end of the lighting cable and the other end was placed at the light sensor of the lux meter.

The water absorbance of the lighting cable was tested by measuring its initial weight. Then, it was immersed in water for one hour. After which, it was removed from the water, wiped out any traces of water and measured again for its final weight. On the other hand, the flexibility of the lighting cable was also tested by placing the cable in a plane surface of an improvised stand with the center of the stand having a hole, then, a coiled wire was hanged at the center of the stand, which looked like a hook wherein the weights can be attached (Long, n.d.). These weights tell the movement or the flexibility of the cable at a specific weight by measuring the distance of the cables from the surface which is caused by the weights and these weights progressed from 120g, 320g and lastly 520g. The impact resistance of the lighting cable was also measured by dropping 0.1 kg of weight at a height of 1 m to the lighting cables.

Impact Resistance Formula:

$$Mass\ (0.1kg) x\ Gravitational\ Force\ \left(9.8\ {}^{m}/_{s_2}\right)$$
$$x\ Height\ (1m) x\ time\ reached\ the\ object\ (s)$$
$$= Force\ needed\ to\ damage\ the\ lighting\ cable$$

Water Absorbance Formula:

$$\text{Water Absorbance} = \frac{\textit{Final Weight} - \textit{Initial Weight}}{\textit{Initial Weight}}$$

H. Statistical Analysis Tool

The Analysis Toolpak of Microsoft Excel 2007 was used to process and analyze the data gathered. Mean was used to compute the mean of the absorbance, transmittance, luminous emittance, water absorbance, impact resistance and flexibility of the different ratios of R:H:K. One-way ANOVA was used to determine if there was a significant difference and interaction between the varying ratio of R:H:K on the development and evaluation of optic solid-large core lighting cable in terms of the absorbance, light transmittance and impact resistance. Two-way ANOVA was used to determine the significant difference between the varying ratio of R:H:K in terms of the flexibility and to discern the interaction between the different applied weights on the cable and the varying ratios of R:H:K. Scheffe Pairwise Multiple Comparison was used to determine specific pairs of ratios that possess significant differences. Lastly, Regression Analysis was used to discern the relationship between the varying weights applied on the cable and flexibility.

RESULTS

Table 1 shows that after adding 1 % of Copper sulphate and 1% of Potassium hydroxide on the different trials, all of them turned purple confirming the presence of peptide bonds in the solutions. The absorbance obtained by trial 1 is 0.114 then, trial 2 got an absorbance of 0.122 and lastly, trial 3 obtained an absorbance of 0.114. The total absorbance was also computed and has a value of 0.41 and with an average mean of 0.1367.

Table 1. *The Absorbance of the Keratin Protein Solution Extracted from Waste Chicken Feathers*

Trial	Observation (Color of the solution)	Absorbance	Total	Mean
1	Purple	0.114		
2	Purple	0.122	0.41	0.1367
3	Purple	0.114		

Table 2. *Absorbance of the Different R:H:K ratios at 410 Nm Wavelength*

Set-ups	Mean*
1 R: 30 mL H: 0.25 mL K: 0.15 mL	1.064^{b}
2 R: 30 mL H: 0.25 mL K: 0.25 mL	0.862^{c}
3 R: 30 mL H: 0.25 mL K: 0.35 mL	0.721^{d}
4 R: 30 mL H: 0.25 mL	3.0^{a}

Note: means with the same letters are not significantly different

Scheffe Pairwise Multiple Analysis Comparison, as shown in Table 2, reveals that all set-ups are significantly different from each other in terms of their absorbance. Set-up 4 with resin and hardener only had significantly higher absorbance than the set-ups with the addition of the varying amount of keratin (0.15 mL, 0.25 mL and 0.35 mL). It was also observed that the higher the amount of keratin from chicken feathers, the lower is the recorded absorbance.

Table 3. *Percent Transmittance of the Different R:H:K ratios at 410 Nm Wavelength*

Set ups	Mean (%)
1 R: 30 mL H: 0.25 mL K: 0.15 mL	8.62[c]
2 R: 30 mL H: 0.25 mL K: 0.25 mL	13.74[b]
3 R: 30 mL H: 0.25 mL K: 0.35 mL	19.02[a]
4 R: 30 mL H: 0.25 mL	0.10[d]

Note: means with the same letters are not significantly different

Scheffe Pairwise Multiple Analysis Comparison, as shown in Table 3, reveals that all set-ups are significantly different from each other in terms of their transmittance. Set-up 4 with resin and hardener only had significantly lower absorbance than the set-ups with the addition of the varying amount of keratin (0.15 mL, 0.25 mL and 0.35 mL). It was also observed that the higher the amount of keratin from chicken feathers, the higher is the recorded transmittance of light.

Table 4. Flexibility Response *for the Varying Weights Applied and the Different R:H:K Ratios on the Cables*

Set-ups	Average of the Flexibility Response (cm)		
	120 g	**320 g**	**520 g**
1 R: 30 mL H: 0.25 mL K: 0.15 mL	5.5[b]	8.33[b]	14.67[b]
2 R: 30 mL H: 0.25 mL K: 0.25 mL	2.17[c]	5.67[c]	11.17[c]
3 R: 30 mL H: 0.25 mL K: 0.35 mL	1[d]	3.5[d]	8.17[d]
4 R: 30 mL H: 0.25 mL	9.5[a]	11.67[a]	17[a]

Note: means with the same letters are not significantly different

Scheffe Pairwise Multiple Analysis Comparison, as shown in Table 4, reveals that all set-ups are significantly different from each other in terms of their flexibility response using varying amount of weight (120g, 320g and 520g) and different R:H:K ratios. Set-up 4 with resin and hardener only had significantly higher flexibility response than the set-ups with the addition of the varying amount of keratin (0.15 mL, 0.25 mL and 0.35 mL). It was also observed that the higher the amount of keratin from chicken feathers, the lower is the recorded flexibility response.

Table 5. *Regression Analysis Between the Flexibility and Weights Applied on the Cables*

Regression Statistics	
Multiple R	0.987977635
R Square	**0.976099807**
Adjusted R Square	0.952199614
Standard Error	43.726599
Observations	3

Table 5 shows that the flexibility and weights applied on the cables are very highly correlated or a strong linear relationship was observed which was represented by the R square of 0.993636

Table 6. *Average Impact Resistance of the Different Ratios of R:H:K Cables*

Set-ups	**Mean (N)**
1	
R: 30 mL	0.4017
H: 0.25 mL	
K: 0.15 mL	
2	
R: 30 mL	0.4083
H: 0.25 mL	
K: 0.25 mL	
3	
R: 30 mL	0.4110
H: 0.25 mL	
K: 0.35 mL	0.3887
4	
R: 30 mL	
H: 0.25 mL	

Table 6 shows that set up 3 got the highest average impact resistance of 0.411 followed by set up 2, which got an average impact resistance of 0.4083 then by set-up 1 with an average impact resistance of 0.4017 and lastly, set up 4 got the lowest average impact resistance of 0.3887. However, there is no significant difference among the 4 set-ups as revealed by One-way ANOVA at 0.05α. Since lighting cables should be sturdy illuminations, the flexibility of lighting cables should be lower to avoid further deformations but the impact resistance should be higher.

Table 7. *Average Luminous Emittance of the Different Ratios of R:H:K Cables*

Set-ups	Mean (lx)
1 R: 30 mL H: 0.25 mL K: 0.15 mL	81.67[a]
2 R: 30 mL H: 0.25 mL K: 0.25 mL	121.67[b]
3 R: 30 mL H: 0.25 mL K: 0.35 mL	158.33[c]
4 R: 30 mL H: 0.25 mL	3.00[d]

Note: means with the same letters are not significantly different

Scheffe Pairwise Multiple Analysis Comparison, as shown in Table 7, reveals that all set-ups are significantly different from each other in terms of their luminous emittance. Set-up 4 with resin and hardener only had significantly lowered luminous emittance than the set-ups with the addition of the varying amount of keratin (0.15 mL, 0.25 mL and 0.35 mL). It was also observed that the higher the amount of keratin from chicken feathers, the higher is the recorded luminous emittance.

Table 8. *Average Water Absorbance of the Different Ratios of R:H:K Cables*

Set-ups	Mean (%)
1 R: 30 mL H: 0.25 mL K: 0.15 mL	0.1867[a]
2 R: 30 mL H: 0.25 mL K: 0.25 mL	0.1769[a]
3 R: 30 mL H: 0.25 mL K: 0.35 mL	0.1428[a]
4 R: 30 mL H: 0.25 mL	194.9[b]

Note: means with the same letters are not significantly different

Scheffe Pairwise Multiple Analysis Comparison, as shown in Table 8, reveals that all set-ups are not significant except for Set-up 4 (30 mL Resin and 0.25 mL Hardener) with water absorbance percentage of 194.9. It was also observed that the cables having keratin protein solution has lower water absorbance than the Set-up 4 without the Keratin Protein Solution.

DISCUSSION

The keratin from waste chicken feathers was successfully extracted using sodium sulfide as reducing agent. It was observed that the chicken feathers completely dissolved in sodium sulphide. The protein also precipitated using the ammonium sulphate as protein purifying agent. Buiret test confirmed the presence of keratin wherein the reagent changed to purple color in the presence of peptide bonds.

According to Frazer (2004), keratin makes the chicken feather both light and tough enough to tolerate mechanical and thermal stresses. It is also used in the fabrication of printed circuit board. Zhan, Wool and Xiao (2011) discovered that the chicken feather-based printed circuit board has lower dielectric constant and the electrons move at twice speed compared to circuit boards with conventional semiconductor insulator materials such as silicon dioxide. The same chemical component, silicon was melted and converted into a glass tube that under particular processes turns into optical fiber, a kind of fiber that is replacing metal wire as the transmission medium in high-speed, high-capacity communications systems that convert information into light, which is then transmitted via fiber optic cable. This characteristic of keratin made it a potential component in fabricating large core optic fibers.

The standard large core optic lighting cables have low absorbance and high transmittance and luminous emittance and these characteristics were able to meet by the innovative large core optic lighting cable using the keratin from waste chicken feathers. It was recorded in this study that the higher the amount of keratin used in the fabrication of the large core optic lighting cable, the higher its transmittance, luminous emittance and impact resistance. In contrast, the higher the amount of keratin used in the fabrication of the large core optic fiber cable, the lower is its absorbance and flexibility. Since the amount of keratin significantly improves the impact resistance of the optic solid large core lighting cable, therefore, it also contributes to the durability of the said cable.

A good quality lighting cable should have a ratio that possesses lesser absorbance and higher light transmittance. Through determining the absorbance, one would be able to know how much light is absorbed by the varying ratios and it should follow that the light transmittance which determines how much light is transmitted in the varying ratios will have an indirect relationship to the recorded absorbance. The flexibility of the varying R:H:K ratios is also important to measure since it will help one to determine what R:H:K ratio is not prone to deformations which is a vital characteristic of lighting cables. Moreover, by measuring the water absorbance, one would be able to know if the varying R:H:K ratios are able to repel water thus reducing the chances of deterioration of the lighting cables. As for the impact resistance, the maximum force that the lighting cables can tolerate before they undergo breakage can be determined.

Luminous emittance is the total amount of visible light leaving a point on a surface into all directions above the surface. In this study, the keratin from the waste chicken feathers allows the

light to travel faster through the tube because it is bioluminescent with high light remittance (Dorion, 2011). According to Driggers (2003), the important component of fluorescence (emission of light by a substance) in the body is the keratin found in the stratum granulosum.

The large core optic lighting cable with varying amount of keratin has also lower water absorbency than without the keratin. Water absorbency is very important since the large core optic lighting cable are also installed in pools, fountains, lighted pathways for emergency routes, stairway steps and refrigerated display cases, which make them exposed to water.

CONCLUSIONS

The keratin protein extracted from chicken feathers can be used as a component in the fabrication of optic solid large core lighting cables. The amount of keratin in the solid large core lighting cables is directly proportional to its transmittance, luminous emittance and impact resistance but inversely proportional to its absorbance and flexibility. Furthermore, the lighting cables with keratin protein are not prone to deteriorations since they have lower percentage water absorbance compared to the lighting cable without keratin. Therefore, the higher the amount of keratin, the higher is its ability to transmit and emit light and the lower its chances of deteriorations and deformations which are very important characteristics of the optic solid large core lighting cable.

RECOMMENDATIONS

Based on the results of the study, the gathering of data particularly of the time it takes for the light from a light source to travel the cable at a specific length and the power loss (light loss) of the light travelling in the cable at a certain length are highly recommended. Moreover, the keratin solution should be characterized further using the Fourier transform infrared (FTIR) spectroscopy to know its physical and chemical properties; provision of more replicates to further validate the results and improvisation of the length and diameter of the lighting cables are also suggested.

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REFERENCES

Chinta S.K ,Landage S.M., Yadav K. (2013). Application of Chicken Feathers inTechnical Textiles. *International Journal of Innovative Research in Science, Engineering and Technology*. 2 (4). 1158 – 1165.

Choi, J. (2014 Dec). Schematic illustration of light transmission through the transparent nano fibrous mat. Research Gate. Retrieved from https://www.researchgate.net/figure/270398041_fig8_Fig-10-Schematic-illustration-of-light-transmission-through-the-transparent-nano-fi on April 7, 2016.

Dorion, R. (2011). Bitemark Evidence: A Color Atlas and Text, 2nd Edition. USA: Taylor and Francis, Inc.

Driggers, R. (2003). Encyclopedia of Optical Engineering: Las-Pho. USA: CRC Press.

Frazer, L. (2004 Jul). Chicken Electronics: A Technology Plucked from Waste. Environmental Health Perspectives. Retrieved from http://www.ncbi.nlm.nih.gov/ pmc/articles/ PMC1247399/ on April 7, 2016.

Fiberoptics Technology Inc (2012). Large Core Fiber Optics.Retrieved from http://www.fiberopticstech.com/products/large_core_fiber_optics.php on August 1, 2016.

Gerber, P. and Steinfeld, H. (2002) Poultry production and the environment-a review.Retrieved from http://www.fao.org/ag/againfo/home/events/bangkok2007/docs/part2/2_2.pdf on April 7, 2016.

Gupta, A. and Parumal, R. (2012).Process for extracting keratin. Retrieved from http://www.google.com/patents/US20120130048 on April 7, 2016.

Johnson, B.P. (2013). Hydrophobic Property of Keratin. Retrieved fromhttps://google.com.ph/id=PSNIYKwC&pg=PA14&lpg=PA14&dq=hydrophobic+property+of+keratin&source=bl&ots=HsxYI2ViJ3&sig=LzlN6Quu3U6SryzFJQ5N_cIKh_Q&hl=fil&sa=X&ved=0ahUKEwjmyrGr7_7PAhUKbbwKHVldBk4Q6AEILDAB#v=onepage&q=hydrophobic%20property%20of%20keratin&f=false on October 7, 2016.

Long, S.D. (n.d) Flex life vs. Flexibility.Retrieved from http://www.cmcorporation.com/white-papers/FlexLife.pdf on August 17, 2016.

USDA Foreign Agricultural Service. (2005). Philippine Poultry and Products Annual 2005. Global Agriculture Information Network. Manila, October 2005. pp 10.

Williams, J. (2013). Retrieved from http://study.com/academy/lesson/what-is-hydrophobic-definition-interactions-quiz.html on October 29, 2016.

APPENDIX (A)

Figure 2. The gathered waste chicken feathers (Photo taken by :CJP ,Lijayan)

Figure 3. Washing the gathered waste chicken feathers (Photo taken by :CJP ,Lijayan)

Figure 4. Drying the waste chicken feather (Photo taken by :CJP ,LIjayan)

*Figure 5.*The chemicals used are: Sodium Sulfide to dissolve the chicken feathers and Ammonium Sulfate for the precipitation process (Photo taken by: TP, Advincula)

Figure 6. The shredded chicken feathers in a sealed plastic bag (Photo taken by: TP, Advincula)

Figure 7. Some of the apparatus used in dissolving processes (Photo taken by: TP, Advincula)

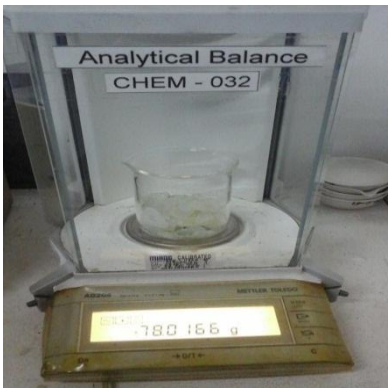


Figure 8. Weighing of the sodium sulfide using the analytical balance (Photo taken by :TP, Advincula)

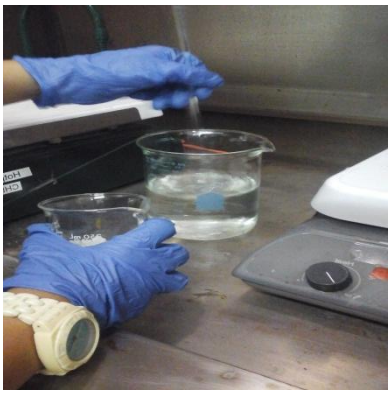


Figure 9. Dissolving of the sodium sulfide using the magnetic stirrer (Photo taken by :TP, Advincula)

Figure 10 .Weighing of the shredded chicken feathers (Photo taken by: TP, Advincula)

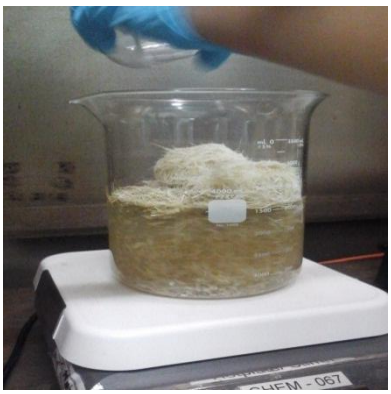


Figure 11 .Pouring the feathers onto the sodium sulfide solution (Photo taken by: TP, Advincula)

Figure 12 .Checking if the pH value still in the range between 10- 13

Figure 13. The chicken feather and sodium sulfide solution after 6 hours of stirring (Photo taken by: TP, Advincula)

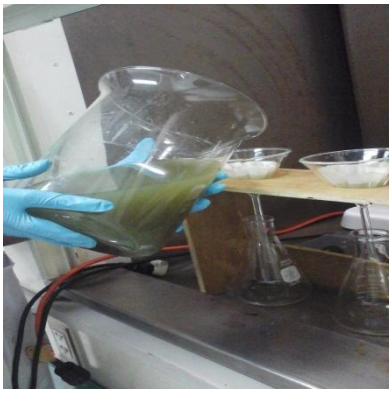


Figure 14. Filtering of the chicken feather mixed with sodium sulfide solution (Photo taken by: TP, Advincula)

Figure 15 The filtered chicken feather and sodium sulfide solution in the Erlenmeyer flask. (Photo taken by: TP, Advincula)

Figure 16 .Weighing of the Ammonium Sulfate (Photo taken by: TP, Advincula)

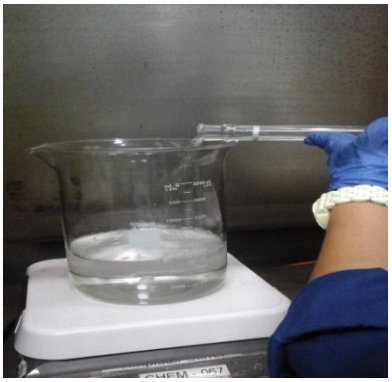


Figure 17. Dissolving the Ammonium Sulfate with the use of the magnetic stirrer. (Photo taken by: TP, Advincula)

Figure 18. Ammonium sulfate solution after dissolving and stirring processes. (Photo taken by: TP, Advincula)

Figure 19. Filtering the ammonium sulfate solution (Photo taken by: TP, Advincula)

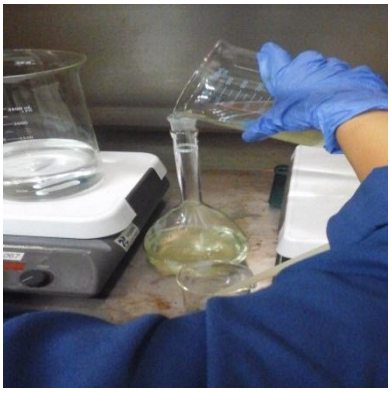


*Figure 20.*Transferring the filtered ammonium sulfate solution after stirring in the Erlenmeyer flask (Photo taken by: TP, Advincula)

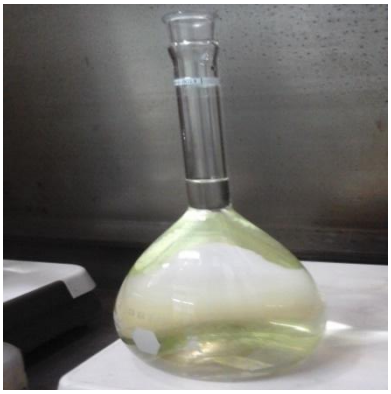


Figure 21.The ammonium sulfate solution (Photo taken by: TP, Advincula)

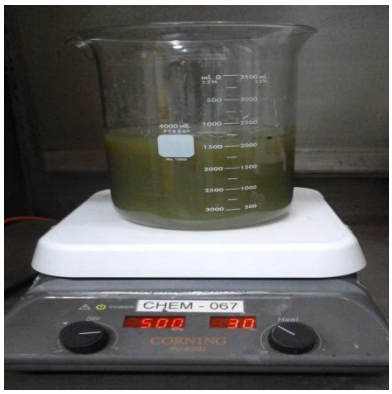


Figure 22. Preparing the feather-filtrate solution before mixing it with ammonium sulfate solution (Photo taken by :CJP ,Lijayan)

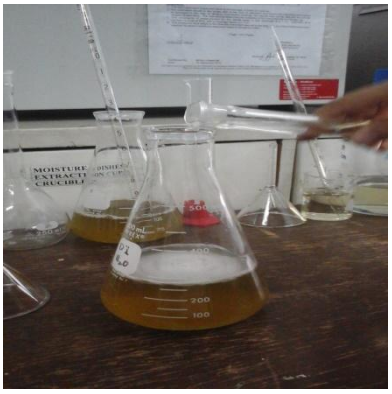


*Figure 23.*Ammonium sulfate was added drop wise and was shook after every drop (Photo taken by :CJP ,Lijayan)

*Figure 24.*The solution after four hours of precipitation (Photo taken by :CJP ,Lijayan)

Figure 25. The collected solids floating on the surface of the solution (Photo taken by :CJP ,Lijayan)

Figure 26 . The remaining solution was transferred into a test tube (Photo taken by: CJP ,Lijayan)

Figure 27. The gathered solution was then centrifuged to collect the remaining particles(Photo taken by :CJP ,Lijayan)

Figure 28 .The solid particles were washed by adding it into a 100 ml distilled water (Photo taken by :CJP ,Lijayan)

Figure 29 .The solid particles with 100 ml distilled water was stirred (Photo taken by :CJP ,Lijayan)

Figure 30. The mixed solution was transferred to the test tube (Photo taken by :CJP ,Lijayan)

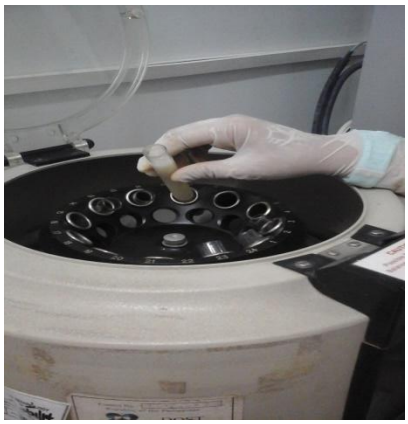


Figure 31. The mixture was then centrifuged (Photo taken by :CJP ,Lijayan)

Figure 32.The solid particles collected after the centrifuge (Photo taken by :CJP ,Lijayan)

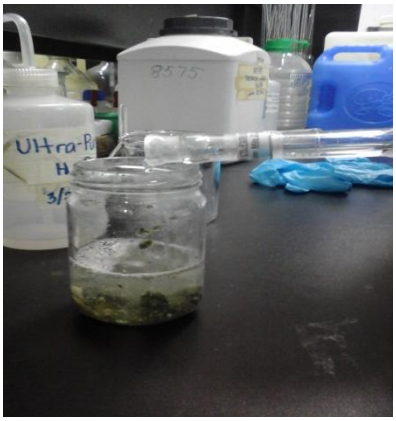


Figure 33. The solid particles was added with 100 mL sodium hydroxide for purification (Photo taken by :CJP ,Lijayan)

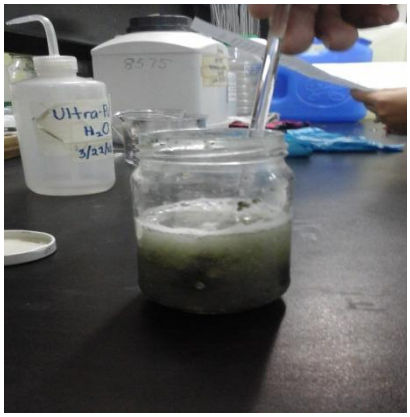


Figure 34. The solid particles were stirred for dissolving process (Photo taken by :CJP ,Lijayan)

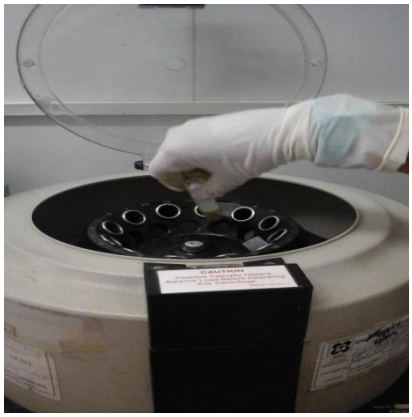


Figure 35. The solid particles mixed with sodium hydroxide was centrifuged (Photo taken by :CJP ,Lijayan)

Figure 36.Collecting the solid particles after the centrifuge process (Photo taken by :CJP ,Lijayan)

Figure 37 .Washing the laboratory apparatus that was used (Photo taken by :A, Panes)

Figure 38.Transferring of the keratin solution using the pipette (Photo taken by :A, Panes)

Figure 39 . Dropping the copper sulfate solution to the keratin solution (Photo taken by :A, Panes)

Figure 40 . Preparing the potassium hydroxide (Photo taken by :A, Panes)

Figure 41 .Observing the mixture of keratin and copper (Photo taken by :A, Panes)

Figure 42 .Putting the potassium hydroxide (Photo taken by :A, Panes)

Figure 43 Shaking the solution (Photo taken by :A, Panes)

Figure 44. Preparing the microfiber (Photo taken by :A, Panes)

Figure 45 .Analyzing the solution under uv-vis using a device called spectrophotometer (Photo taken by :A, Panes)

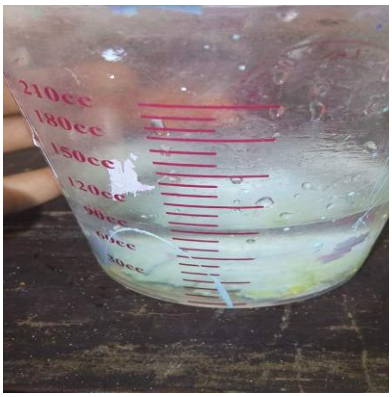


Figure 46. Measuring the resin (Photo taken by :A, Panes)

Figure 47. Pouring the measured resin into a small container (Photo taken by :A, Panes)

Figure 48.Obtaining keratin using a dropper (Photo taken by :A, Panes)

*Figure 49.*Dropping corresponding amount of keratin solution into containers (Photo taken by : TP , Advincula)

*Figure 50.*Dropping the 0.25ml hardener on the container (Photo taken by : TP , Advincula)

Figure 51 .Mixing the solution (Photo taken by : TP , Advincula)

Figure 52. Inserting the of the syringre to the polytube (Photo taken by : TP , Advincula)

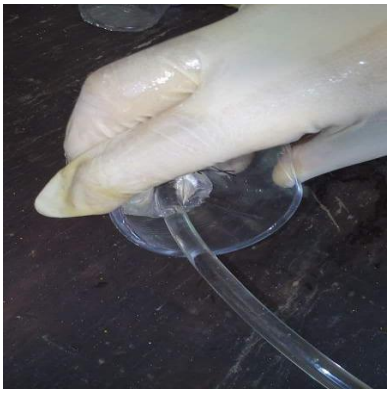


*Figure 53.*Drawing up the solution using the syringe and polytube (Photo taken by : TP , Advincula)

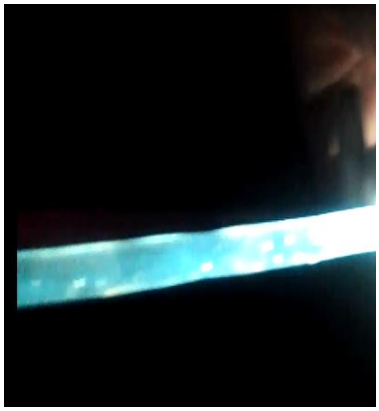
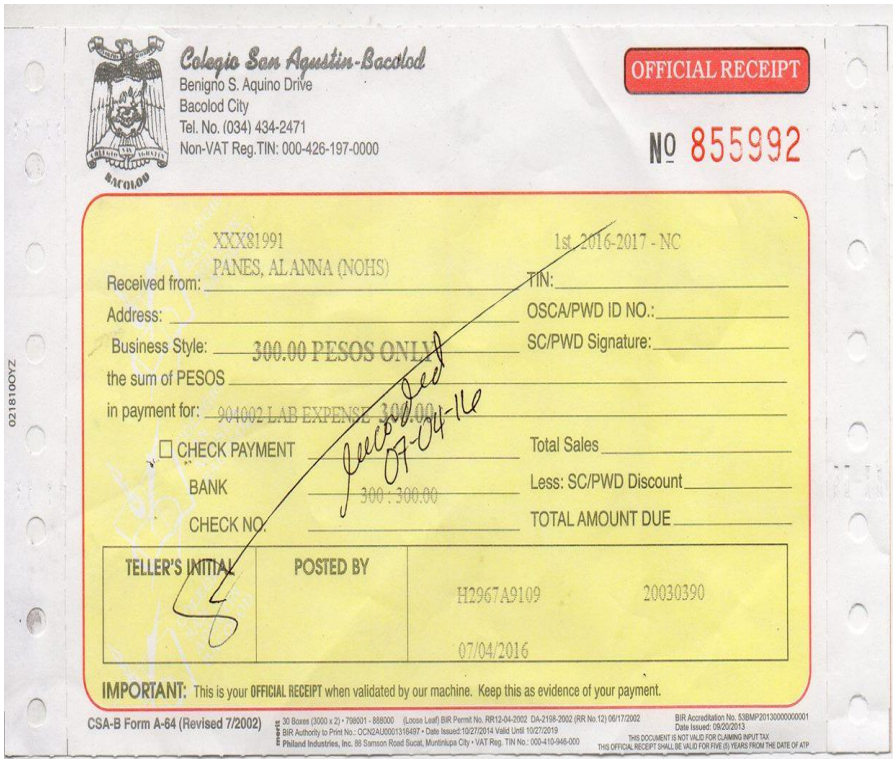


*Figure 54.*The final product (Photo taken by: TP , Advincula)

APPENDIX (B)


Colegio San Agustin-Bacolod
Benigno S. Aquino Drive
Bacolod City
Tel. No. (034) 434-2471
Non-VAT Reg.TIN: 000-426-197-0000

OFFICIAL RECEIPT
No 855992

XXX81991
PANES, ALANNA (NOHS)
1st, 2016-2017 - NC

Received from:
Address:
Business Style: 300.00 PESOS ONLY
the sum of PESOS
in payment for: 904002 LAB EXPENSE 300.00
☐ CHECK PAYMENT
BANK 300 : 300.00
CHECK NO.

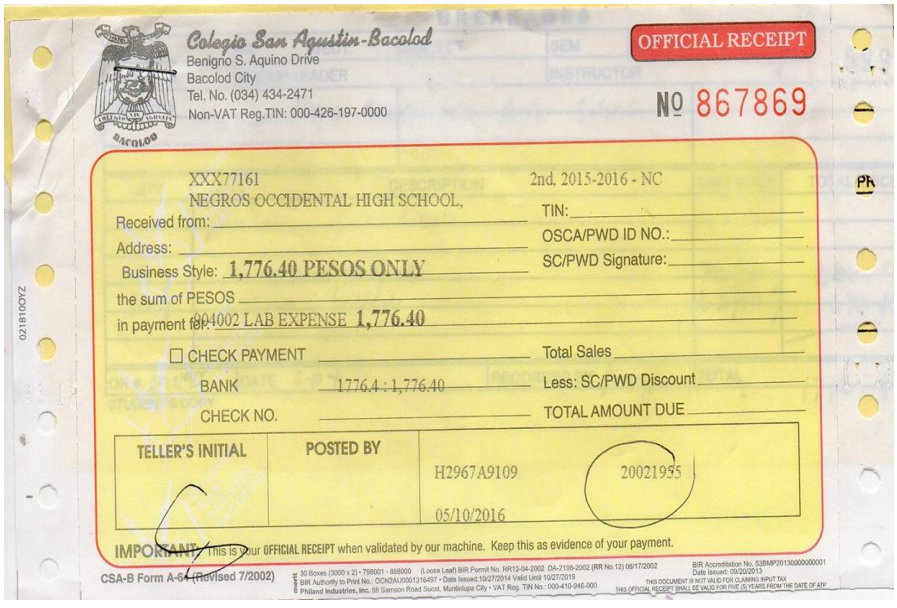
TIN:
OSCA/PWD ID NO.:
SC/PWD Signature:
Total Sales
Less: SC/PWD Discount
TOTAL AMOUNT DUE

TELLER'S INITIAL	POSTED BY	
		H2967A9109 20030390 07/04/2016

IMPORTANT: This is your OFFICIAL RECEIPT when validated by our machine. Keep this as evidence of your payment.

CSA-B Form A-64 (Revised 7/2002)

Figure 88. The official receipt of lab expenses in performing the experiment in Colegio San Agustin-Bacolod


Colegio San Agustin-Bacolod
Benigno S. Aquino Drive
Bacolod City
Tel. No. (034) 434-2471
Non-VAT Reg.TIN: 000-426-197-0000

OFFICIAL RECEIPT
No 867869

XXX77161
NEGROS OCCIDENTAL HIGH SCHOOL,
2nd, 2015-2016 - NC

Received from:
Address:
Business Style: 1,776.40 PESOS ONLY
the sum of PESOS
in payment for: 904002 LAB EXPENSE 1,776.40
☐ CHECK PAYMENT
BANK 1776.4 : 1,776.40
CHECK NO.

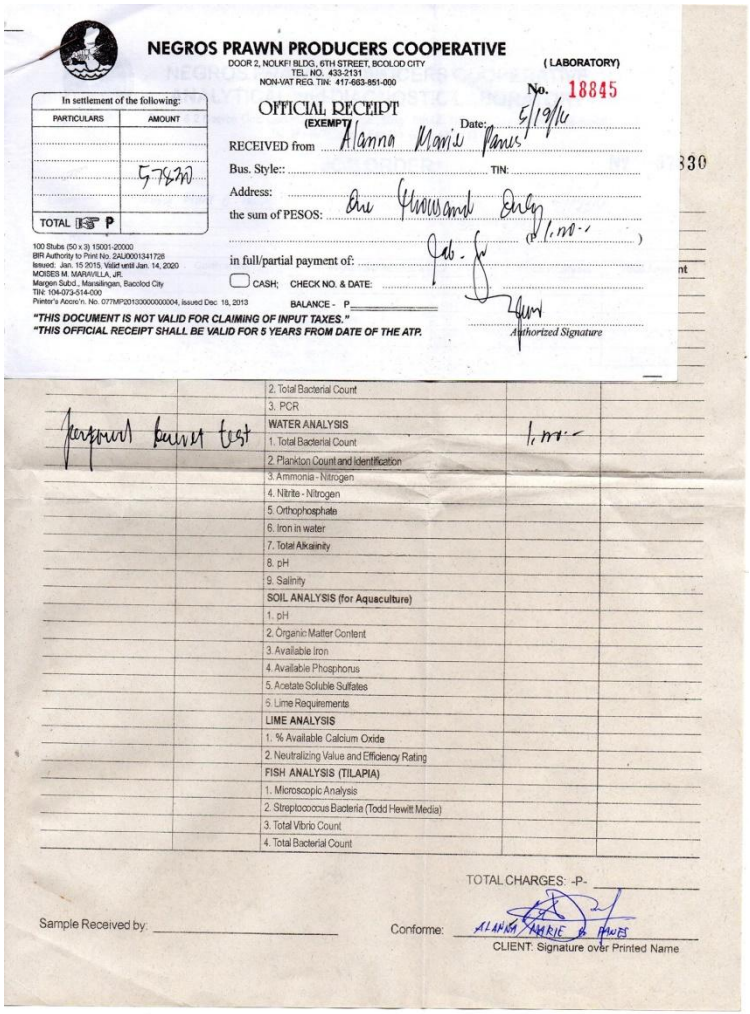
TIN:
OSCA/PWD ID NO.:
SC/PWD Signature:
Total Sales
Less: SC/PWD Discount
TOTAL AMOUNT DUE

TELLER'S INITIAL	POSTED BY	
		H2967A9109 20021955 05/10/2016

IMPORTANT: This is your OFFICIAL RECEIPT when validated by our machine. Keep this as evidence of your payment.

CSA-B Form A-64 (Revised 7/2002)

Figure 59. Receipt of the purchased chemical that was used in the experiment on Colegio San Agustin-Bacolod



NEGROS PRAWN PRODUCERS COOPERATIVE
DOOR 2, NOLKFI BLDG., 6TH STREET, BCOLOD CITY
TEL. NO. 433-2131
NON-VAT REG. TIN: 417-663-851-000
(LABORATORY)

In settlement of the following:

PARTICULARS	AMOUNT
	57830
TOTAL P	

No. 18845

OFFICIAL RECEIPT
(EXEMPT)
Date: 5/19/16

RECEIVED from Alanna Marie Panes
Bus. Style:: TIN:
Address:
the sum of PESOS: One Thousand Only (P 1,000.-)
in full/partial payment of:
CASH; CHECK NO. & DATE:
BALANCE - P

100 Stubs (50 x 3) 15001-20000
BIR Authority to Print No. 24UD0013417128
Issued: Jan. 15 2015, Valid until Jan. 14, 2020
MOISES M. MARAVILLA, JR.
Margen Subd., Maraligan, Bacolod City
TIN: 104-073-514-000
Printer's Accre'n. No. 077MP20130000000004, Issued Dec. 18, 2013

"THIS DOCUMENT IS NOT VALID FOR CLAIMING OF INPUT TAXES."
"THIS OFFICIAL RECEIPT SHALL BE VALID FOR 5 YEARS FROM DATE OF THE ATP."

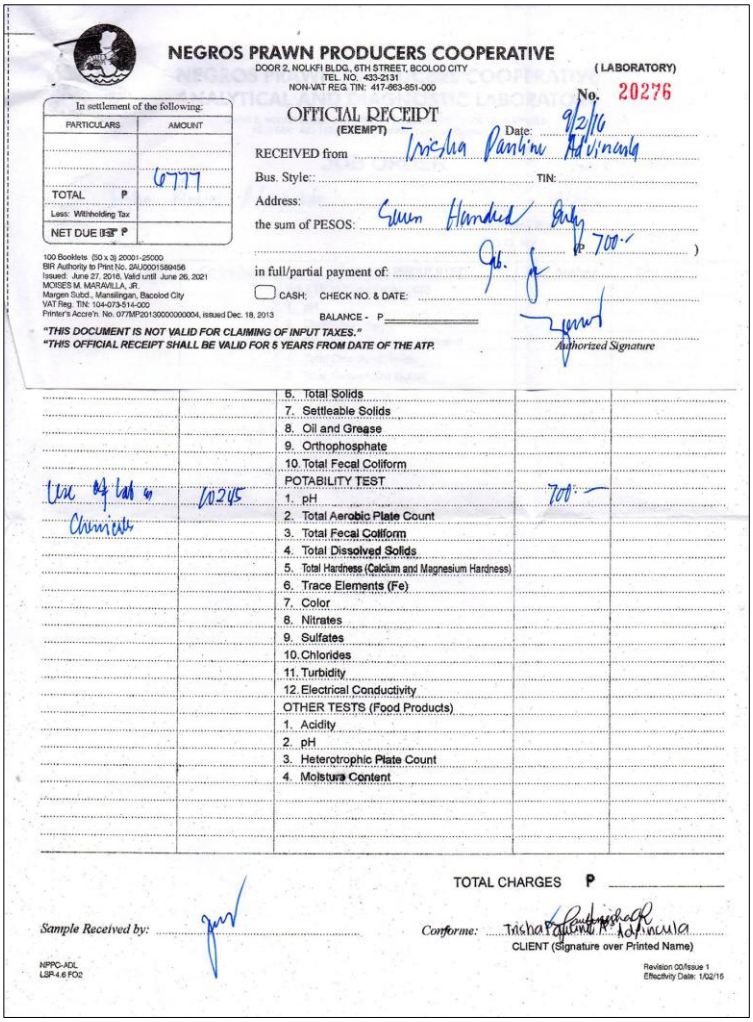
Authorized Signature

	2. Total Bacterial Count	
	3. PCR	
Jerspoint Biuret test	WATER ANALYSIS	1,000.-
	1. Total Bacterial Count	
	2. Plankton Count and Identification	
	3. Ammonia - Nitrogen	
	4. Nitrite - Nitrogen	
	5. Orthophosphate	
	6. Iron in water	
	7. Total Alkalinity	
	8. pH	
	9. Salinity	
	SOIL ANALYSIS (for Aquaculture)	
	1. pH	
	2. Organic Matter Content	
	3. Available Iron	
	4. Available Phosphorus	
	5. Acetate Soluble Sulfates	
	6. Lime Requirements	
	LIME ANALYSIS	
	1. % Available Calcium Oxide	
	2. Neutralizing Value and Efficiency Rating	
	FISH ANALYSIS (TILAPIA)	
	1. Microscopic Analysis	
	2. Streptococcus Bacteria (Todd Hewitt Media)	
	3. Total Vibrio Count	
	4. Total Bacterial Count	

TOTAL CHARGES: -P-

Sample Received by: _____
Conforme: ALANNA MARIE B. PANES
CLIENT: Signature over Printed Name

Figure 60. Biuret test receipt, the biuret test was used to determine the amount of keratin protein on the solution



NEGROS PRAWN PRODUCERS COOPERATIVE
DOOR 2, NOLKFI BLDG., 6TH STREET, BCOLOD CITY
TEL. NO. 433-2131
NON-VAT REG. TIN: 417-663-851-000
(LABORATORY)

In settlement of the following:

PARTICULARS	AMOUNT
	6777
TOTAL P	
Less: Withholding Tax	
NET DUE P	

No. 20276

OFFICIAL RECEIPT
(EXEMPT)
Date: 9/2/16

RECEIVED from Trisha Pauline Advincula
Bus. Style:: TIN:
Address:
the sum of PESOS: Seven Hundred Only (P 700.-)
in full/partial payment of:
CASH; CHECK NO. & DATE:
BALANCE - P

100 Booklets (50 x 2) 20001-25000
BIR Authority to Print No. 24UD0013894S6
Issued: June 27, 2016, Valid until June 26, 2021
MOISES M. MARAVILLA, JR.
Margen Subd., Maraligan, Bacolod City
VAT Reg. TIN: 104-073-514-000
Printer's Accre'n. No. 077MP20130000000004, issued Dec. 18, 2013

"THIS DOCUMENT IS NOT VALID FOR CLAIMING OF INPUT TAXES."
"THIS OFFICIAL RECEIPT SHALL BE VALID FOR 5 YEARS FROM DATE OF THE ATP."

Authorized Signature

	5. Total Solids	
	7. Settleable Solids	
	8. Oil and Grease	
	9. Orthophosphate	
	10. Total Fecal Coliform	
Use of last 4 digits of Clinic's ID	POTABILITY TEST	700.-
	1. pH	
	2. Total Aerobic Plate Count	
	3. Total Fecal Coliform	
	4. Total Dissolved Solids	
	5. Total Hardness (Calcium and Magnesium Hardness)	
	6. Trace Elements (Fe)	
	7. Color	
	8. Nitrates	
	9. Sulfates	
	10. Chlorides	
	11. Turbidity	
	12. Electrical Conductivity	
	OTHER TESTS (Food Products)	
	1. Acidity	
	2. pH	
	3. Heterotrophic Plate Count	
	4. Moisture Content	

TOTAL CHARGES P

Sample Received by:
Conforme: Trisha Pauline M. Advincula
CLIENT (Signature over Printed Name)

NPPC-JDL
LSP4.6 FO2
Revision 00/Issue 1
Effectivity Date: 1/02/16

Figure 61 . The Receipt in testing the absorbance and transmittance of the different set-ups with varying ratio of keratin and with constant amount of resin and hardener

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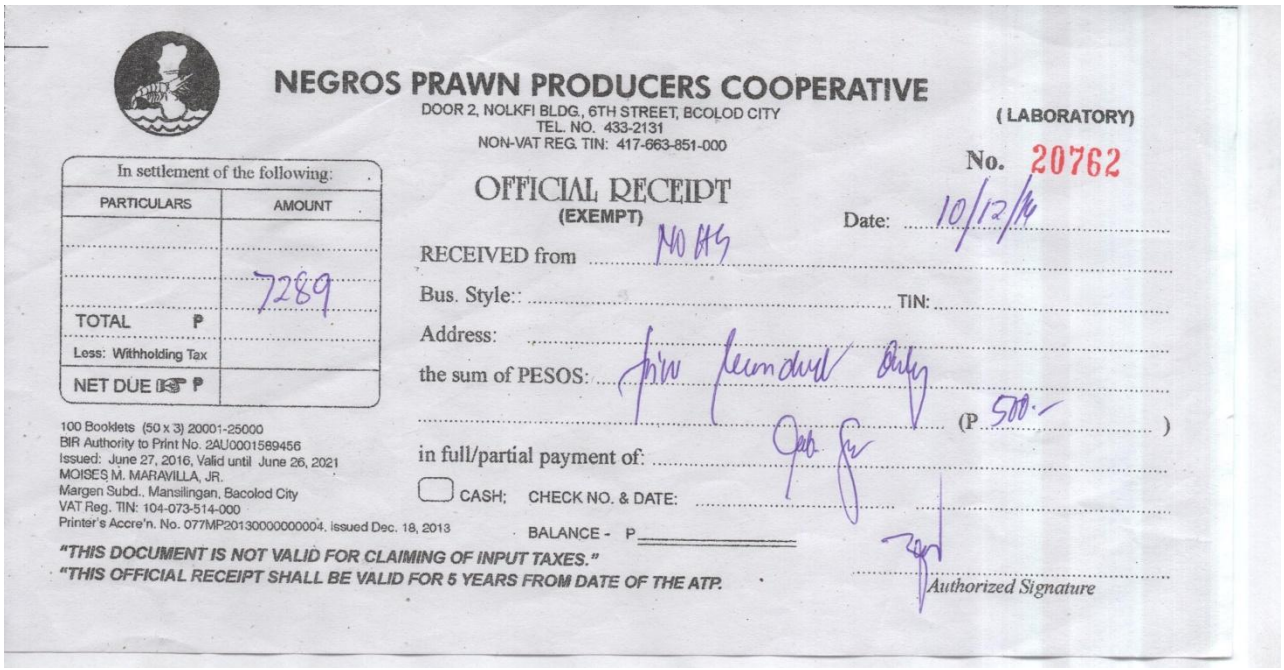


NEGROS PRAWN PRODUCERS COOPERATIVE
DOOR 2, NOLKFI BLDG., 6TH STREET, BCOLOD CITY
TEL. NO. 433-2131
NON-VAT REG. TIN: 417-663-851-000

(LABORATORY)

No. 20762

OFFICIAL RECEIPT
(EXEMPT)

Date: 10/12/14

RECEIVED from NO NAME

Bus. Style:: TIN:

Address:

the sum of PESOS: five hundred only (P 500.-)

in full/partial payment of:

CASH; CHECK NO. & DATE:

BALANCE - P

Authorized Signature

In settlement of the following:

PARTICULARS	AMOUNT
	7289
TOTAL P	
Less: Withholding Tax	
NET DUE ☞ P	

100 Booklets (50 x 3) 20001-25000
BIR Authority to Print No. 2AU0001589456
Issued: June 27, 2016, Valid until June 26, 2021
MOISES M. MARAVILLA, JR.
Margen Subd., Mansilingan, Bacolod City
VAT Reg. TIN: 104-073-514-000
Printer's Accre'n. No. 077MP20130000000004, issued Dec. 18, 2013

"THIS DOCUMENT IS NOT VALID FOR CLAIMING OF INPUT TAXES."
"THIS OFFICIAL RECEIPT SHALL BE VALID FOR 5 YEARS FROM DATE OF THE ATP.

Figure 62. The official receipt in testing the water absorbance having the different set-up of the lighting cable

APPENDIX (C)

NEGROS PRAWN PRODUCERS COOPERATIVE
Door No.1 & 2., NOLKFI Bldg., 6th Street., Bacolod City
Tele/Fax 034-4332131 email address nppc_adl@yahoo.com.ph

CLIENT	:	ALANNA MARIE G. PANES
ADDRESS OF CLIENT	:	BACOLODCITY
SAMPLE DESCRIPTION	:	KERATIN EXTRACT
SAMPLING SITE	:	BACOLODCITY
DATE REPORTED	:	MAY 20, 2016
DATE OF SAMPLE RECEIVED	:	MAY 19, 2016
DATE OF SAMPLING	:	MAY 19, 2016
DATE OF ANALYSIS	:	MAY 19, 2016
SAMPLE COLLECTED BY	:	ALANNA MARIE G. PANES
REFERENCE NO.	:	57830

LABORATORY TEST RESULTS:

TRIAL	ABSORBANCE
1	0.114
2	0.122
3	0.114

Note: 1. **Result of Examination specifically related to samples as received.**
2. **Test results shall not be reproduced without the approval of the Laboratory Head.**
3. **Measurement uncertainty is available upon request.**

Analyzed by:
Sharmine Chavez
Chemical Analyst

Certified by:
Roselyn D. Usero, RChem, MEE
Laboratory Head
Registered Chemist, Lic.#6460

NPPC-ADL
LSP 5.10 FO1
Rev. 00/Issue 1
Effectivity Date 1/02/15

- Page 1/1 -

Figure 63. Result of the examination in testing the absorbance in every set-up

NEGROS PRAWN PRODUCERS COOPERATIVE
ANALYTICAL AND DIAGNOSTIC LABORATORY
Door No.1 & 2., NOLKFI Bldg., 6th Street., Bacolod City
Tele/Fax 034-4332131 email address nppc_adl@yahoo.com.ph

Client : Negros Occidental High School
Address: Bacolod City
LSO No.: 16-6777
Specimen: Keratin
Test Requested: Absorbance at 410 nm

Date Submitted: 9/2/16
Date Reported: 9/2/16
Control Number: 10246

Laboratory Test Results:

Sample Description	Absorbance	Transmittance (%0)
Set-up 1 (30 mL Resin, 0.25 mL Hardener and 0.15 mL Keratin Solution)	0.721	19.02
Set-up 2(30 mL Resin, 0.25 mL Hardener and 0.25 mL Keratin Solution)	0.862	13.74
Set- up 3 (30 mL Resin, 0.25 mL Hardener and 0.35 mL Keratin Solution)	1.064	8.62

NOTE:
1. Result of examination specifically related to samples as received.
2. Test results shall not be reproduced without the approval of the Laboratory Head.

Analyzed by:

ROSELYN D. USERO, RChem, MEE
Laboratory Head
PRC License No. 6460

Form #: 006

Figure 64. Result of the examination in testing the absorbance and the transmittance (%) of the sample in different trial with varying ratio of keratin with constant amount of resin and hardener

STI WEST NEGROS UNIVERSITY
Burgos street, Bacolod City
Negros Occidental, Philippine 6100
Tel. (034) 434 4561 local 118

CERTIFICATION OF OFFICIAL RESULTS

This is to certify that the results below were garnered and computed during the performance of the impact resistance method and flexibility testing.

Impact Resistance Method Results

Set-ups	Impact Resistance			Observed Damage
	R1	R2	R3	
1	0.546	0.529	0.556	×
2	0.846	0.840	0.857	×
3	0.910	0.916	0.912	×
4	0.532	0.550	0.630	×

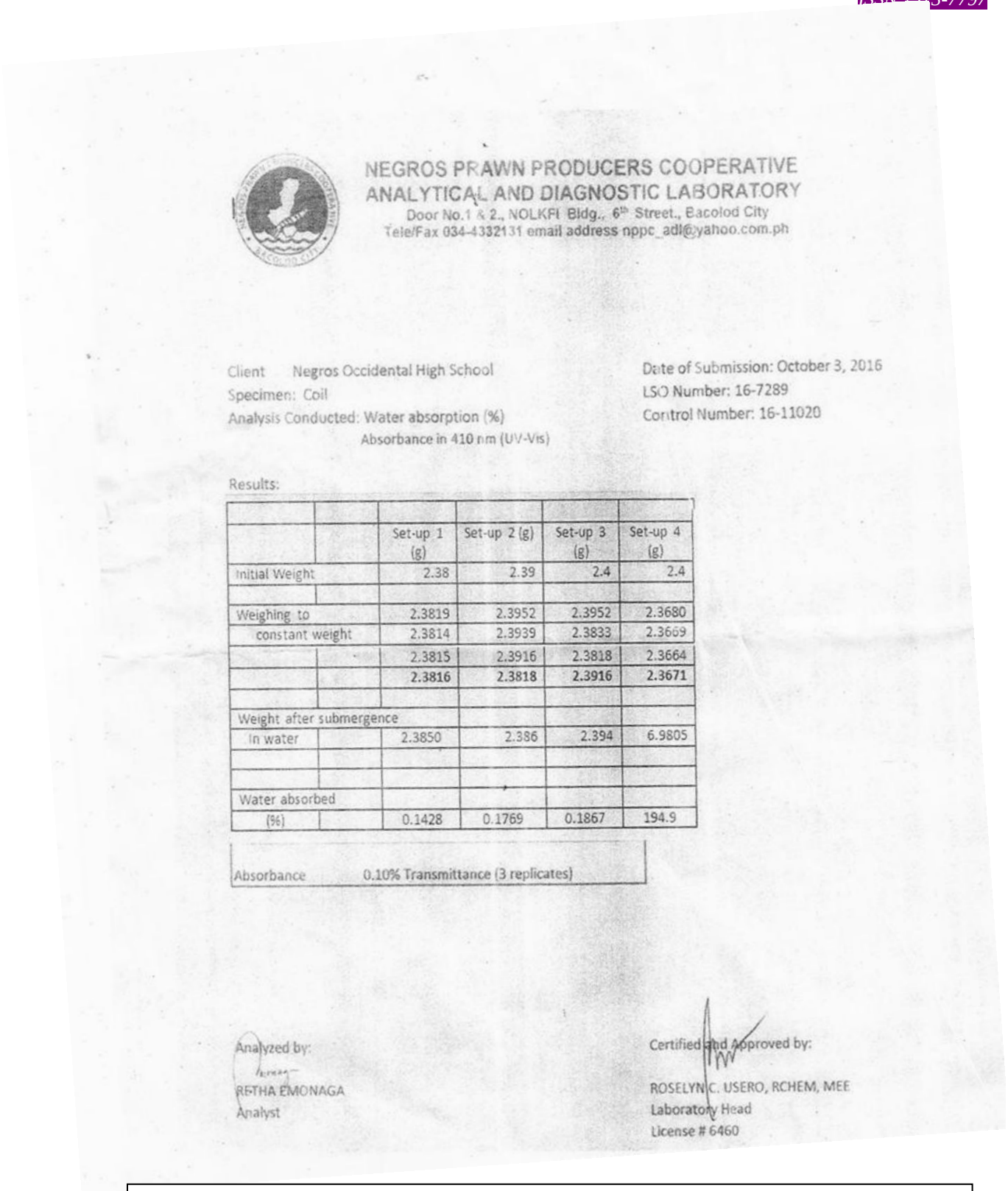
Flexibility Testing Results

Set-ups	Flexibility (cm)								
	120 g			320 g			520 g		
	R1	R2	R3	R1	R2	R3	R1	R2	R3
1	5	6.5	5	8	9	8	15	14	15
2	2	2	2.5	6	5	6	11	11	11.5
3	1	0.5	1.5	4	3	3.5	8	8.5	8
4	8.5	10.5	9.5	11.5	11.5	11	17.5	16	17.5

Certified by:

Engr. Lalaine Rufin
Testing Consultant
STI West Negros University

Figure 65. Shows the result of impact resistance and flexibility of the cables in different set-ups



NEGROS PRAWN PRODUCERS COOPERATIVE
ANALYTICAL AND DIAGNOSTIC LABORATORY
Door No.1 & 2., NOLKFI Bldg., 6th Street., Bacolod City
Tele/Fax 034-4332131 email address nppc_adl@yahoo.com.ph

Client Negros Occidental High School
Specimen: Coil
Analysis Conducted: Water absorption (%)
Absorbance in 410 nm (UV-Vis)

Date of Submission: October 3, 2016
LSO Number: 16-7289
Control Number: 16-11020

Results:

	Set-up 1 (g)	Set-up 2 (g)	Set-up 3 (g)	Set-up 4 (g)
Initial Weight	2.38	2.39	2.4	2.4
Weighing to	2.3819	2.3952	2.3952	2.3680
constant weight	2.3814	2.3939	2.3833	2.3669
	2.3815	2.3916	2.3818	2.3664
	2.3816	**2.3818**	**2.3916**	**2.3671**
Weight after submergence				
In water	2.3850	2.386	2.394	6.9805
Water absorbed				
(%)	0.1428	0.1769	0.1867	194.9

Absorbance	0.10% Transmittance (3 replicates)

Analyzed by:
RETHA EMONAGA
Analyst

Certified and Approved by:
ROSELYN C. USERO, RCHEM, MEE
Laboratory Head
License # 6460

Figure 66. This shows the result of the water absorbance and absorbance of the optic solid large core lighting cable in different set-ups

APPENDIX (D)

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Row 1	3	1.205	0.40167	0.00067
Row 2	3	1.225	0.40833	0.00022
Row 3	3	1.234	0.41133	8.1E-05
Row 4	3	1.166	0.38867	0.00043

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Setup 1	3	1.205	0.40167	0.00067
Setup 2	3	1.225	0.40833	0.00022
Setup 3	3	1.206	0.402	1E-04
Setup 4	3	1.166	0.38867	0.00043

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Column 1	4	1.618	0.4045	9.2E-05
Column 2	4	1.626	0.4065	0.00054
Column 3	4	1.558	0.3895	0.00029

Figure 67. Computation of Anova: single factor summary on impact resistance

Anova: Two-Factor With Replication					
SUMMARY	Setup1	Setup2	Setup 3	Setup 4	Total
120 g					
Count	4	4	4	4	16
Sum	23.5	10.5	5	17.5	56.5
Average	5.875	2.625	1.25	4.375	3.53125
Variance	1.0625	0.89583	0.25	0.22917	3.74896
Count	4	4	4	4	16
Sum	32	17	9.5	28	86.5
Average	8	4.25	2.375	7	5.40625
Variance	0.66667	2.41667	1.89583	1.5	6.57396
Count	4	4	4	4	16
Sum	52	39.5	28	52.5	172
Average	13	9.875	7	13.125	10.75
Variance	11.3333	6.72917	5.5	7.72917	13.0667
Total					
Count	12	12	12	12	
Sum	107.5	67	42.5	98	
Average	8.95833	5.58333	3.54167	8.16667	
Variance	13.2936	13.2652	8.83902	17.2424	

Figure 68. The computation of Anova: two factor with replicates summary on flexibility

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
1	3	3.192	1.064	4E-06
2	3	2.856	0.952	7E-06
3	3	2.163	0.721	7E-06

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	0.183554	2	0.091777	15296.17	7.54E-12	5.143253
Within Groups	3.6E-05	6	6E-06			
Total	0.18359	8				

Figure 69. Summary of computation of Anova: single factor in terms of absorbance

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
1	3	25.86	8.62	0.0004
2	3	41.22	13.74	0.0196
3	3	57.06	19.02	0.0004

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	162.2528	2	81.1264	11930.35	1.59E-11	5.143253
Within Groups	0.0408	6	0.0068			
Total	162.2936	8				

Figure 70. The summary of computing the Anova: single factor of the parameter transmittance

Water Absorbance (%)
0.1867
0.1769
0.1428
194.9

	1	2	3
1	0.1862	0.1879	0.186
2	0.1771	0.1767	0.1769
3	0.1425	0.1429	0.143
4	198.2	191.4	195.1

Initial Weight	Constant	Final Weight
2.4	2.3916	2.394
2.39	2.3818	2.386
2.38	2.3816	1.985
2.4	2.3671	6.9805

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Row 1	3	0.4284	0.1428	7E-08
Row 2	3	0.5307	0.1769	4E-08
Row 3	3	0.5601	0.1867	1E-06
Row 4	3	584.7	194.9	11.59

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	85321	3	28440	9815.4	1E-14	4.0662
Within Groups	23.18	8	2.8975			
Total	85344	11				

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Column 1	4	198.71	49.676	9804.1
Column 2	4	191.91	47.977	9142.3
Column 3	4	195.61	48.901	9499.6

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	5.792	2	2.896	0.0003	0.9997	4.2565
Within Groups	85338	9	9482			
Total	85344	11				

Figure 71. Summary computation of Anova: single factor in terms of the water absorbance of the cable

Anova: Single Factor

SUMMARY

Groups	Count	Sum	Average	Variance
Row 1	3	30	10	25
Row 2	3	245	81.66667	58.33333
Row 3	3	365	121.6667	58.33333
Row 4	3	475	158.3333	58.33333

ANOVA

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	36322.9	3	12107.6	242.153	3.44898E-08	4.06618
Within Groups	400	8	50			
Total	36722.9	11				

Figure 71. The computation of Anova: single factor in terms of the luminous emittance of the optic solid large lighting cable

Table 21

Scheffe Pairwise Multiple Analysis Comparison for the Absorbance

Pairs	Comparison Values	Remarks
A& B A- R: 30 mL, H: 0.25 mL, K: 0.15 mL B- R: 30 mL H: 0.25 mL K: 0.25 ml	0.202 ≥ 0.01784	Significant
A & C A- R: 30 mL, H: 0.25 mL, K: 0.15 mL C- R: 30 mL H: 0.25 mL K: 0.35 mL	0.343 ≥ 0.01784	Significant
A & D A- R: 30 mL H: 0.25 mL K: 0.15 mL D- R: 30 mL H: 0.25 mL	1.936 ≥ 0.01784	Significant
B & C B- R: 30 mL H: 0.25 mL K: 0.25 ml C- R: 30 mL H: 0.25 mL K: 0.35 mL	0.141≥ 0.01784	Significant
B & D B- R: 30 mL H: 0.25 mL K: 0.25 ml D- R: 30 mL H: 0.25 mL	2.138≥ 0.01784	Significant
C & D C- R: 30 mL H: 0.25 mL K: 0.35 mL D- R: 30 mL H: 0.25 mL	2.279 ≥ 0.01784	Significant

Figure 72. Shows scheffe pairwise multiple analysis comparison for the absorbance in finding pairs having significant difference

Table 22

Scheffe Pairwise Multiple Analysis Comparison for the Transmittance

Pairs	Comparison Values	Remarks
A& B A- R: 30 mL, H: 0.25 mL, K: 0.15 mL B- R: 30 mL H: 0.25 mL K: 0.25 ml	5.05 ≥ 0.2046	Significant
A & C A- R: 30 mL, H: 0.25 mL, K: 0.15 mL C- R: 30 mL H: 0.25 mL K: 0.35 mL	10.4 ≥ 0.2046	Significant
A & D A- R: 30 mL H: 0.25 mL K: 0.15 mL D- R: 30 mL H: 0.25 mL	8.52 ≥ 0.2046	Significant
B & C B- R: 30 mL H: 0.25 mL K: 0.25 ml C- R: 30 mL H: 0.25 mL K: 0.35 mL	5.35≥0.2046	Significant
B & D B- R: 30 mL H: 0.25 mL K: 0.25 ml D- R: 30 mL H: 0.25 mL	13.57 ≥ 0.2046	Significant
C & D C- R: 30 mL H: 0.25 mL K: 0.35 mL D- R: 30 mL H: 0.25 mL	18.92≥ 0.2046	Significant

*Figure 73.*This table show pairs having significant difference in terms of transmittance using the scheffe pairwise multiple analysis comparison

Table 23

Scheffe Pairwise Multiple Analysis Comparison for the Varying Weights Applied on the Cables on the Flexibility Response

Pairs	Comparison Values	Remarks
A& B A- R: 30 mL, H: 0.25 mL, K: 0.15 mL B- R: 30 mL H: 0.25 mL K: 0.25 ml	3.16 ≥ 1.5254	Significant
A & C A- R: 30 mL, H: 0.25 mL, K: 0.15 mL C- R: 30 mL H: 0.25 mL K: 0.35 mL	5.28 ≥1.5254	Significant
A & D A- R: 30 mL H: 0.25 mL K: 0.15 mL D- R: 30 mL H: 0.25 mL	3.22 ≥1.5254	Significant
B & C B- R: 30 mL H: 0.25 mL K: 0.25 ml C- R: 30 mL H: 0.25 mL K: 0.35 mL	2.12 ≥1.5254	Significant
B & D B- R: 30 mL H: 0.25 mL K: 0.25 ml D- R: 30 mL H: 0.25 mL	6.39≥1.5254	Significant
C & D C- R: 30 mL H: 0.25 mL K: 0.35 mL D- R: 30 mL H: 0.25 mL	8.5 ≥1.5254	Significant

Figure 74. Shows scheffe pairwise multiple analysis comparison for the varying weights applied on the cables in finding pairs having significant difference

Table 24

Scheffe Pairwise Multiple Analysis Comparison for the Varying Weights Applied on the Cables on the Flexibility Response

Pairs	Comparison Values	Remarks
A& B A- R: 30 mL, H: 0.25 mL, K: 0.15 mL B- R: 30 mL H: 0.25 mL K: 0.25 ml	3.16 ≥ 1.5254	Significant
A & C A- R: 30 mL, H: 0.25 mL, K: 0.15 mL C- R: 30 mL H: 0.25 mL K: 0.35 mL	5.28 ≥1.5254	Significant
A & D A- R: 30 mL H: 0.25 mL K: 0.15 mL D- R: 30 mL H: 0.25 mL	3.22 ≥1.5254	Significant
B & C B- R: 30 mL H: 0.25 mL K: 0.25 ml C- R: 30 mL H: 0.25 mL K: 0.35 mL	2.12 ≥1.5254	Significant
B & D B- R: 30 mL H: 0.25 mL K: 0.25 ml D- R: 30 mL H: 0.25 mL	6.39≥1.5254	Significant
C & D C- R: 30 mL H: 0.25 mL K: 0.35 mL D- R: 30 mL H: 0.25 mL	8.5 ≥1.5254	Significant

*Figure 754.*This shows the scheffe pairwise multiple analysis comparison for the varying weights applied on the cable and determine pairs with significant difference

Table 26

Scheffe Pairwise Multiple Analysis Comparison for the Luminous Emittance of the Lighting Cables

Pairs	Comparison Values	Remarks
A & B A- R: 30 mL, H: 0.25 mL, K: 0.15 mL B- R: 30 mL H: 0.25 mL K: 0.25 ml	40 ≥20.2148	Significant
A & C A- R: 30 mL, H: 0.25 mL, K: 0.15 mL C- R: 30 mL H: 0.25 mL K: 0.35 mL	76.66 ≥20.2148	Significant
A & D A- R: 30 mL H: 0.25 mL K: 0.15 mL D- R: 30 mL H: 0.25 mL	78.67 ≥20.2148	Significant
B & C B- R: 30 mL H: 0.25 mL K: 0.25 ml C- R: 30 mL H: 0.25 Ml K: 0.35 mL	36.66 ≥20.2148	Significant
B & D B- R: 30 mL H: 0.25 mL K: 0.25 ml D- R: 30 mL H: 0.25 mL	118.67≥20.2148	Significant
C & D C- R: 30 mL H: 0.25 mL K: 0.35 mL D- R: 30 mL H: 0.25 mL	155.33 ≥20.2148	Significant

*Figure 76.*Shows scheffe pairwise multiple analysis comparison for the varying ratios of R:H:K cables on the flexibility response in finding significant pair

Table 26

Scheffe Pairwise Multiple Analysis Comparison for the Luminous Emittance of the Lighting Cables

Pairs	Comparison Values	Remarks
A& B A- R: 30 mL, H: 0.25 mL, K: 0.15 mL B- R: 30 mL H: 0.25 mL K: 0.25 ml	40 ≥20.2148	Significant
A & C A- R: 30 mL, H: 0.25 mL, K: 0.15 mL C- R: 30 mL H: 0.25 mL K: 0.35 mL	76.66 ≥20.2148	Significant
A & D A- R: 30 mL H: 0.25 mL K: 0.15 mL D- R: 30 mL H: 0.25 mL	78.67 ≥20.2148	Significant
B & C B- R: 30 mL H: 0.25 mL K: 0.25 ml C- R: 30 mL H: 0.25 Ml K: 0.35 mL	36.66 ≥20.2148	Significant
B & D B- R: 30 mL H: 0.25 mL K: 0.25 ml D- R: 30 mL H: 0.25 mL	118.67≥20.2148	Significant
C & D C- R: 30 mL H: 0.25 mL K: 0.35 mL D- R: 30 mL H: 0.25 mL	155.33 ≥20.2148	Significant

*Figure 77.*Shows scheffe pairwise multiple analysis comparison for the luminous emittance of the lighting cables in finding significant pair

Table 27

Scheffe Pairwise Multiple Analysis Comparison for the Water Absorbance of the Lighting Cables

Pairs	Comparison Values	Remarks
A & B E- R: 30 mL, H: 0.25 mL, K: 0.15 mL F- R: 30 mL H: 0.25 mL K: 0.25 ml	0.0341 ≥4.8862	Not Significant
A & C E- R: 30 mL, H: 0.25 mL, K: 0.15 mL G- R: 30 mL H: 0.25 mL K: 0.35 mL	0.0439 ≥4.8862	Not Significant
A & D E- R: 30 mL H: 0.25 mL K: 0.15 mL H- R: 30 mL H: 0.25 mL	194.7572 ≥4.8862	Significant
B & C F- R: 30 mL H: 0.25 mL K: 0.25 ml G- R: 30 mL H: 0.25 Ml K: 0.35 mL	0.0098 ≥4.8862	Not Significant
B & D F- R: 30 mL H: 0.25 mL K: 0.25 ml H- R: 30 mL H: 0.25 mL	194.7231≥4.8862	Significant
C & D G- R: 30 mL H: 0.25 mL K: 0.35 mL H- R: 30 mL H: 0.25 mL	194.7133 ≥4.8862	Significant

Figure 78. This table shows scheffe pairwise multiple analysis comparison for the luminous emittance of the lighting cables and determine pairs having significant difference