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Surface Toughness Analyzer for Rubber Cuplumps

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Abstract: The Philippines has been known in the past to be one of the top producing countries of rubber- one of the most important global commodities. Unfortunately, the Philippine rubber industry is beleaguered with unfair trade practices resulting to poor quality of rubber. Good quality rubbers use formic acid for latex coagulation. The preference guarantees a consistent high-quality rubber product with good color, as is the demand of the global market. Thus, formic acid is one of the best coagulants for natural rubber latex in dry rubber production. Meanwhile, the use of sulfuric acid from batteries by local manufacturers has attracted considerable attention amongst rubber manufacturers. The use of the said agent has raised alarm since the excessive use of sulfuric acid has been reported to affect the durability of raw rubbers. Any residue of the acid in the dry rubber may also be harmful and may influence the cure characteristics. The production of this low quality rubber has almost blacklisted the country in the world rubber industry as a source of raw material. However, the Philippines has no facile field-testing protocol in detecting and consequently eliminating sulfuric acid-coagulated rubber for quality control. We reported herein the newly developed field testing sensor device, which can differentiate cuplumps coagulated using formic acid against sufuric acid. This developed sensor works by piercing through the rubber sample and determining the force/pressure applied on the surface of the rubber samples. By virtue of their structural differences due to different coagulating agents used, different amount of force are observed during piercing through the rubber sample. The developed force sensor has been successfully field-tested for immediate quality assessment, right after primary processing and harvesting, and could potentially help in boosting competitiveness of the Philippine rubber industry by promoting quality assessment and assurance.

Key Words: coagulation; cuplumps; sulfuric acid; formic acid

1. INTRODUCTION

Rubber is one of the most important global commodities. Natural rubber has a whole range of application markets, such as for automobile tires and tubes. The Philippines has been known in the past to be one of the top producing countries of rubber. Having its production in Mindanao, amid endemic insurgency in the sub-region, the Philippines have expanded rapidly over decades, wherein 222,600 hectares were devoted to rubber in 2015 (Philippine Statistics Authority, 2016). In addition, the Philiipine rubber industry produced rubber products worth P 8,181,800 in 2015 (Philippine Statistics Authority, 2016). Unfortunately, the Philippine rubber industry is beleaguered with unfair trade practices resulting to poor quality of rubber. Good quality rubbers use formic acid for latex coagulation. The preference guarantees a consistent high-quality rubber product with good color, as is the demand of the global market. Thus, formic acid is one of the best coagulants for natural rubber latex in dry rubber production (BASF – The Chemical Company, n.d.). Meanwhile, the use of sulfuric acid from batteries by

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local manufacturers has attracted considerable attention amongst rubber manufacturers. The utilization of battery – derived sulfuric acid has been attributed to its lower price and availability as compared with formic acid. The use of the said agent has raised alarm since the excessive use of sulfuric acid has been reported to affect the durability of raw rubbers. Any residue of the acid in the dry rubber may also be harmful and may influence the cure characteristics (Othman & Lye, 1980; Martin & Davey, 1935). The production of this low quality rubber has almost blacklisted the country in the world rubber industry as a source of raw material. Rubber companies are now exerting efforts to carefully choose their raw material supplier and even choosing tyre and tube competitors from abroad to avoid these low quality raw material rubbers. In this light, the study aims to develop a field testing device which can differentiate cuplumps coagulated using formic acid against battery acid. The development of a sensor is herein described.

2. METHODOLOGY

2.1 Sensor Fabrication

A modified load cell set-up was assembled consisting of a handle and an output reader. A correlation factor was programmed to the device for accurate measurements. A probe was connected to the end of the load cell for the purpose of puncturing the rubber sample to a certain height. This method was done to check the rubber surface toughness in order to determine if the acid coagulant used is a battery solution or not. Battery solution is not a good coagulant in post rubber processing and causes deterioration of rubber quality. This designed force sensor will determine rubber quality by piercing the rubber samples and measuring the amount of force applied to puncture the rubber surface.

2.2 Sensor Operation

The device must be turned on before using. Randomly selected rubber samples were tested by puncturing the different parts of the rubber sample using the probe on the load cell. Upon puncturing, the LED light (green or red) illuminates and the readout will display the force value in an arbitrary unit (A.U). This value is the amount of force required to puncture the rubber surface. If the value is greater than 45 A.U, the red LED light illuminates indicating battery solution was used to coagulate the rubber. If the value is less than 45 A.U, the green LED light illuminates indicating absence of battery solution during coagulation of the rubber.

2.3 Sensor testing

2.3.1 Using laboratory prepared rubber samples

Carefully prepared rubber samples, prepared using battery acid (Type A) and formic acid (Type B) from the Department of Agriculture, were tested using the fabricated force sensor following the standardized protocol above.

2.3.2 Using actual rubber samples

Pre-determined project sites were visited to check the quality of rubber produced using the fabricated force sensor. The field testing was conducted in Zamboanga specifically in Ipil, Titay, and STANDECO, a rubber processing plant. Rubbers sold in their respective "Bagsakan" were tested following the protocol above.

3. RESULTS AND DISCUSSION

3.1 Sensor Fabrication and Description

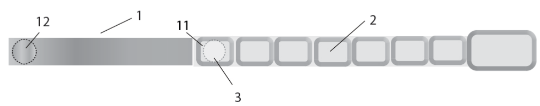

Figure 1. Top View of the sensor. The sensor is composed of a shear-beam (1), which has a handle-connecting end (11) and a probe-connecting end (12). The handle-connecting end is extended into a tubular handle (2) and is secured to the handle by a screw element (3).

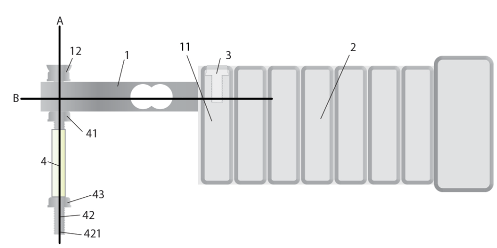

Figure 2. Side View of the sensor. In this view, the probe (4) is connected to the probe-connecting end (12) of the load cell (1) in a manner that the probe axis (A) is normal to the load cell axis (B). One end of the probe is a securing section (41), and the other end is a puncturing section (42). The securing section (41) is connected to the probe-connecting end (12) of the load cell (1). The puncture section has a length ranging from 7 mm to 11 mm, preferable from 8 mm to 10 mm, and a circular flat end face (421) with a diameter ranging from 3 mm to 5 mm, preferably from 3.5 mm to 4.5 mm. The puncturing section (42) has a length of 9.32 mm and the flat end face (421) has a diameter of 3.84 mm. The probe further

has a radial outward stop section (43) adjacent to the puncturing section (42). Sections 42 and 43 may be provided with an anti-corrosion coating.

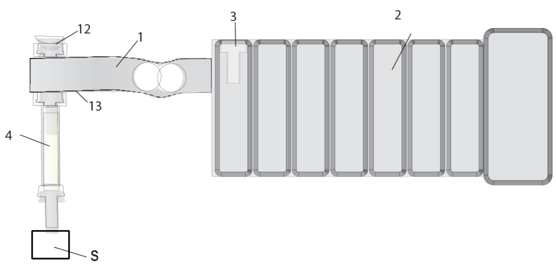

Figure 3. Sensor in its state of use. Side View of the sensor showing the probe puncturing a sample and configuration of the load cell as the sample is being punctured. The sensor is held by the handle (2), with the puncturing section of the probe above a sample (S), which is a rubber cup lump, in this figure. The sensor is lowered such that the puncturing section of the probe punctures the surface of the sample until the radial outward stop section touches the surface of the sample. The puncturing action applies a load to the probe-connecting end of the shear-beam load cell, causing a displacement of the probe-connecting end from the load cell axis as shown by the phantom lines (13). The load cell generates an output corresponding to the load in a conventional manner. Because the load is associated with the surface toughness of the sample, the output generated by the load cell also corresponds to the surface toughness of the sample. The output from the load cell is processed by a processor to obtain a digital value.

3.2 Characterization of actual and laboratory-prepared samples using pressure/force sensor

3.2.1 Sensor testing using laboratory prepared rubber samples

Laboratory prepared samples were used to test the capability of the sensor to differentiate between the rubber cup lumps prepared using sulfuric acid in battery solution (Type A) and the one coagulated using (Type B) formic acid. The rubber cup lump samples were tested by puncturing the different parts of the rubber sample using the probe on the load cell. Upon puncturing, values displayed in the readout (force value in arbitrary unit (A.U) or a Digital Output) were recorded. This value is, arbitrarily, the amount of force required to puncture the rubber surface. The average of the values was shown in Figure 4. From the results obtained, it is evident that the developed sensor was able to distinguish formic acid coagulated rubber cup lumps (Type B) from those that were formed using battery acid (Type A). The disparity in the sensor digital output based from surface toughness between type A and type B cup lumps was significant.

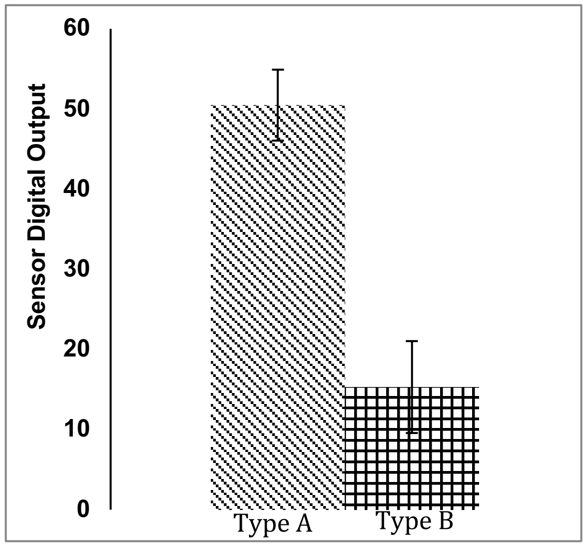

Figure 4. Mean sensor digital output for Type A rubber (sulfuric acid in battery solution) and Type B rubber (formic acid) prepared in the laboratory. Error bars denote standard deviation.

3.2.2 Sensor testing using actual rubber samples

The performance of the device was also tested in actual samples obtained from rubber traders and processors. The field testing was conducted in Zamboanga specifically in Ipil, Titay, and STANDECO. Rubbers sold in their respective “Bagsakan” including the ones already bought and stored in STANDECO were tested following the protocol above. Samples known to have been coagulated with formic acid (Type B) and sulfuric acid (Type A) in battery solution were analyzed using the fabricated force sensor. As shown in Figure 5, the measured force values indicated the distinct property of the rubber samples. The force readings, as digital output, in rubber samples coagulated with sulfuric acid in battery solution were distinctively higher in magnitude compared to the samples coagulated using formic acid solution. It turns out that, generally, battery solution containing rubber samples have force values greater than 45 A.U, while rubber samples containing formic acid solution have force values less than 45 A.U. From the data in Figure 7, it is evident that the device was still successful in differentiating type A and type B rubber cup lumps. It is still evident from these results that the developed device can easily and accurately differentiate type A from type B rubber cup lumps.

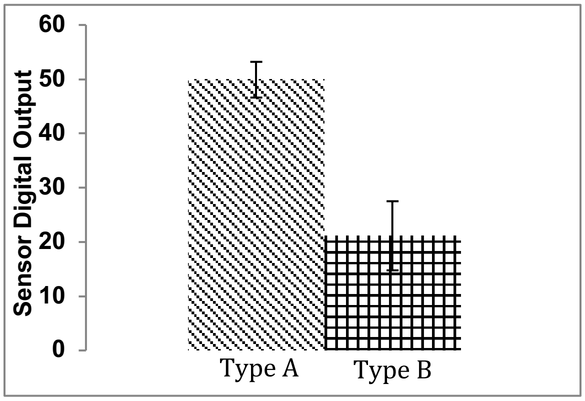

Figure 5. Mean sensor digital output for Type A rubber (sulfuric acid in battery solution) and Type B rubber (formic acid) sourced from rubber traders and processors. Error bars denote standard deviation.

4. CONCLUSIONS

Distinction between rubber samples coagulated with formic acid and sulfuric acid-containing battery solutions were established using a fabricated force sensor, which measures the force required to puncture the surface of the rubber samples. The force sensor could aid efficiently in assessing good quality of rubber in the Philippines, which could potentially result to restoring the Philippine rubber industry's image in the world market. Patent for this fabricated sensor has been applied and awaiting for approval. Future research activity will focus on the design of the sensor within the context of ergonomics.

5. ACKNOWLEDGMENTS

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