ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 8| Issue: 12| December 2022|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2022: 8.205 || ISI Value: 1.188

EXPLORING THE ELASTIC BEHAVIOR OF RUBBER BANDS AT DIFFERENT TEMPERATURES

Oyor David Ifeanyichukwu[1], Ezike Fidelis Ikechukwu[1]
Odoala Chukwuemeka Emmanuel[2]

[1]*Department of Science Laboratory Technology, Akanu Ibiam Federal Polytechnic Unwana-Afikpo, Ebonyi State, Nigeria.*
[2]*Department of Metallurgical Engineering Technology, Akanu Ibiam Federal Polytechnic Unwana-Afikpo, Ebonyi State, Nigeria.*

ABSTRACT

The chains of molecules in rubber (Hevea Braziliensis) have a natural elasticity: they can stretch when pulled but when the pulling force is removed, the elastic polymers in rubber spring back to their original length. This work demonstrates that rubber bands obey Hooke's law. It also reveals that rubber bands become more elastic when heated to a higher temperature especially when weight is added. The result of our work reveals that, at lower temperatures (say, 0°C to 40°C) the different in extension between 100g weight and 500g weight was significantly less than the difference in extension between the same amounts of weight at higher temperatures. The heated rubber bands were the most elastic; stretching to the farthest extends of 21.40+/-0.05cm at 100°C. Thus, an experimental proven of the fact that, increase in temperature increases the elasticity of the rubber band.

KEYWORDS: ***Elasticity – Rubber bands – Temperature – Weight***

1. INTRODUCTION

All matter is made up of atoms, such as carbon, hydrogen or oxygen. Atoms are linked together to form larger compounds called molecules. Some molecules are made by stringing together repeated subunits, such as molecules called polymers. Rubber is an example of natural polymers, the chains of molecules in rubber have a natural elasticity, they can stretch when pulled but when the pulling force is removed, and the elastic polymers in rubber spring back to their original length (Punmanee et al., 2011).

Natural rubber is obtained as latex from tree called “Hevea Braziliensis”. It has a long chain-like molecule containing repeating subunits. It is also called polyisoprene (elastomer). Natural rubber is a polymer of isoprene meaning it is built of repeating isoprene units derived from conjugated diene monomers. It is from the monomer isoprene (2-methyl-1,3-butadiene) (Anonymous, 2022). Natural rubber is used extensively in many applications and products either alone or in combination with other materials. In most of its forms, it has large stretch ratio and high resilience and is extremely water proof (Marisa, 2021).

A rubber band (also known as an elastic band, gum band or lacky band) is a loop of rubber, usually ring or oval shaped, and commonly used to hold multiple objects together. The rubber band was patented in England on March 17, 1845 by Stephen Perry (Loadman and James, 2009). Most rubber bands are manufactured out of natural rubber or, especially at larger sizes, an elastomer, and are sold in a variety of sizes. Rubber bands are made by extending the rubber into long tube to provide its general shape, putting the tube on mandrels, curing the rubber with heat and then slicing it across the width of the tube into little bands (Karen, 2018). A rubber band is usually measured in three basic dimensions: length, width, and thickness. Its length is defined as half its circumference while thickness is the distance from the inner surface to the outer surface, and its width is the distance from one cut edge to the other (Bonnie, 2020)

Elasticity is the ability of a body to resist a distorting force or influence and return to its original size and shape when the force or influence is removed. Solid objects are capable of deforming when adequate forces are applied to them. If a material is elastic, the object will return to its original shape and size when these forces are removed (Sadd, 2004). At room temperature, a rubber band snaps back due to its elastic molecular properties. The stands that make up the rubber band pull them back to their original shape (Legner et. al., 2010).

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 8| Issue: 12| December 2022|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2022: 8.205 || ISI Value: 1.188

Temperature affects the elasticity of a rubber band in unusual way. Heating causes the band to contract and cooling causes its expansion (Brown, 1963).

2. AIM OF THE STUDY

The aim of this work is to study the elasticity of rubber bands and its restoring force or elastic force as they vary with temperature.

3. MATERIALS AND METHODS

3.1MATERIALS

The following are the list of materials used in the carrying out this study: Bunsen burner, hot plate, water, ice blocks, retort stand with double clamp, thermometer, meter rule, rubber bands, 100g weight hook / hanger, tongs, wire gauze, metal hook, medium rubber container, carbon sheet, sharp knife, and 100g weights.

3.2METHOD

The first action was to create a contraption with the aid of the medium container and the carbon sheets were used to lag the container. Afterwards, the container was opened at one end and perforated at the other end. The contraption was hanged on the left hand clamp of the retort stand, which helped in determining the elasticity of the rubber bands and the amount of weight placed on them.

On the top of the contraption, we fastened a metal hook that extended downward from the middle of the apparatus, at the down end of the metal hook, the rubber was anchored and 100g weight hook to hold the weights was hanged on the rubber band. We fastened a meter rule to the second clamp of the retort stand, in order to measure how much the rubber band stretched.

After the contraption was built, we heated the rubber bands to achieve the desired temperature of the rubber ban. We dipped a different set of rubber bands in a container containing ice, so as to get the temperature of rubber band to 0°C. The first rubber band was picked from the ice container with the aid of the tong, anchored on the metal hook and 100g weight hook, the ground state was measured, the elasticity of the rubber band at 100g, 200g 300g, 400g, and 500g were measured respectively. The procedure for different temperatures (0°C, 20°C, 40°C, 60°C, 80°C and 100°C) were repeated using different rubber band. Then, we measured the extension made by rubber bands after adding weights to the initial of 100g to the hook. The extension made by varying the different masses and different temperature were calculated by subtracting their values from the initial value of the extension made by the rubber bands at that temperature with the 100g weight hook, that is, without any added mass on the hook.

4. RESULTS AND ANALYSIS

The data gotten from the experiment proved that the effect temperature had on the elasticity of rubber bands was amplified under more weight. From our result, at lower temperatures (say, 0°C to 40°C) the difference in extension between 100g weight and 500g weight was significantly less than the difference in extension between the same amounts of weight at higher temperatures. The tables below gives the summary of results obtained from the experiment.

Table 1. Extensions made by rubber bands with 100g at different temperatures

Temperature ±1(°C)	0	20	40	60	80	100
Weight(g)	100	100	100	100	100	100
Extension$\pm$0.05(cm)	1.6	1.7	2.0	2.3	1.9	2.3

Table 2. Extensions made by rubber bands with 200g at different temperatures

Temperature ±1(°C)	0	20	40	60	80	100
Weight(g)	200	200	200	200	200	200
Extension$\pm$0.05(cm)	4.3	4.2	5.4	6.6	4.9	6.6

Table 3. Extensions made by rubber bands with 300g at different temperatures

Temperature ±1(°C)	0	20	40	60	80	100
Weight(g)	300	300	300	300	300	300
Extension$\pm$0.05(cm)	8.2	8.0	9.4	11.7	9.2	12.3

Table 4. Extensions made by rubber bands with 400g at different temperatures

Temperature ±1(°C)	0	20	40	60	80	100
Weight(g)	400	400	400	400	400	400
Extension$\pm$0.05(cm)	12.2	11.7	13.5	14.1	13.3	17.2

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 8| Issue: 12| December 2022|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2022: 8.205 || ISI Value: 1.188

Table 5. Extensions made by rubber bands with 500g at different temperatures

Temperature ±1(°C)	0	20	40	60	80	100
Weight(g)	500	500	500	500	500	500
Extension±0.05(cm)	15.2	14.7	16.8	19.4	17.0	21.4

In the table above, it was observed that increase in temperature increases the elasticity of the rubber band. However, the extensions of the rubber band keep fluctuating due to the fact that the rubber bands vary in thickness and width and some unavoidable errors that occurred.

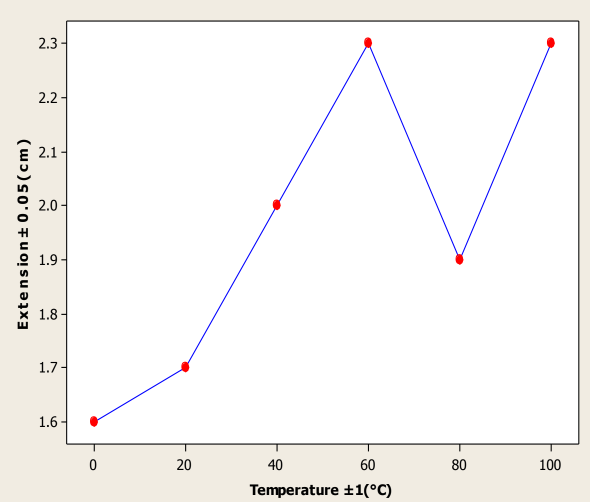

Fig. 1 Graph of Extension vs Temperature for 100g weight

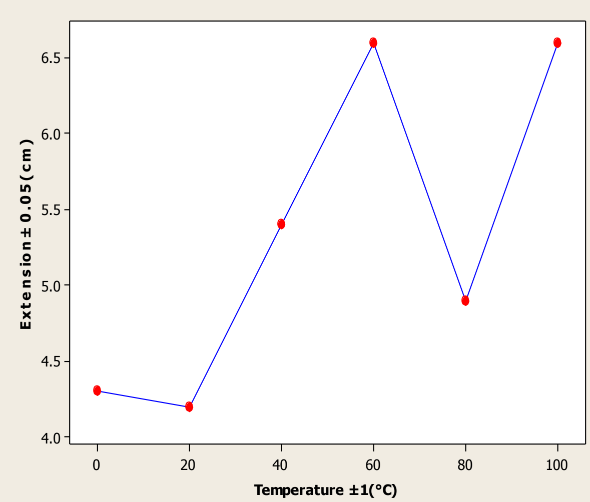

Fig. 2 Graph of Extension vs Temperature for 200g weight

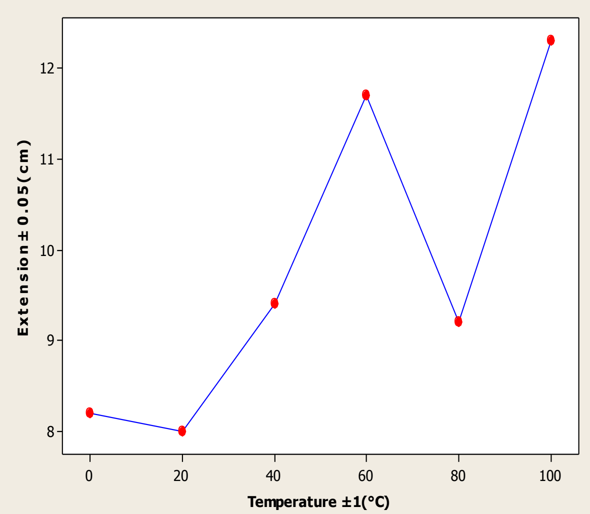

Fig. 3 Graph of Extension vs Temperature for 300g weight

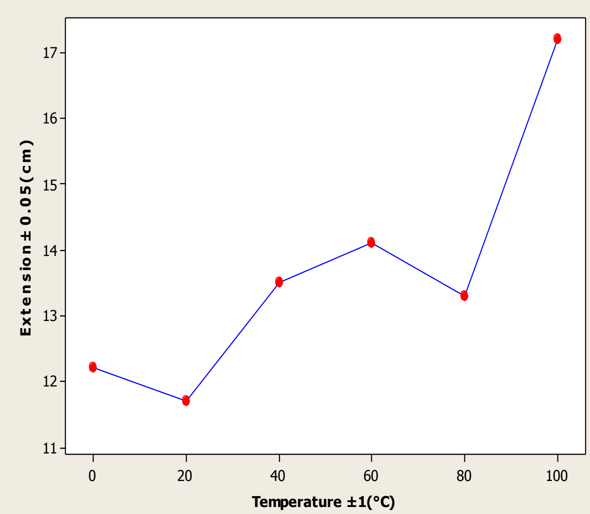

Fig. 4 Graph of Extension vs Temperature for 400g weight

ISSN (Online): 2455-3662
EPRA International Journal of Multidisciplinary Research (IJMR) - Peer Reviewed Journal
Volume: 8| Issue: 12| December 2022|| Journal DOI: 10.36713/epra2013 || SJIF Impact Factor 2022: 8.205 || ISI Value: 1.188

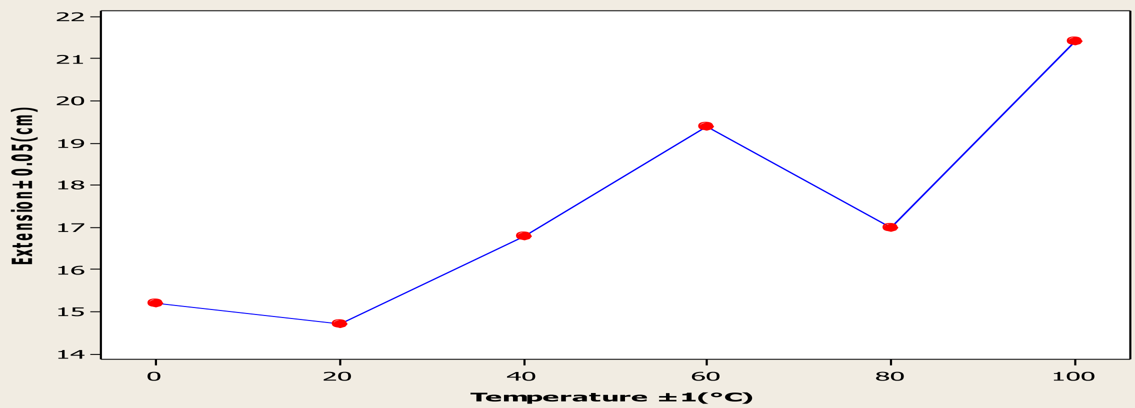

Fig. 5 Graph of Extension vs Temperature for 500g weight

At a cursory look on the graphs above, it is observed that they have similar shape with a unique drop in the extension at about 80°C for all the weights and a maximum extension at about 100°C. In all, this study conforms to the fact that rubber bands pass through a glass transition at a temperature below their melting point. Hence, this goes with the fact that, when a rubber band is stretched out, there are not as many ways the individual molecules can arrange themselves as they are when the rubber band is not stretched. For there to be more ways to arrange the molecules, the entropy will be higher. When a rubber band is stretched, entropy dictates that the rubber band will want to contract again. When the temperature is higher, the molecules are more excited, and want even more to be in a random state thereby making the rubber band easier to stretch out.

5.2 CONCLUSION

The experiment conducted gave a clear prove that temperature has an inevitable effect on rubber band. The heated rubber bands were the most elastic; stretching to the farthest extends of 21.40$\pm$0.05 at 100°C. The rubber bands in freezing water were the consistent, providing a reliable conclusion to the project. Thermal expansion caused the rubber bands to react as they did. When the rubber bands were heated, the particles stretched out, making them more elastic and able to withstand greater force. When frozen, the particles contracted, adding strength and increasing resistance to force. Our results showed that the effect temperature had on the elasticity of the rubber bands was amplified under more weight. At lower temperatures the difference between light and heavy weights was significantly less than the difference between the same amounts of weight at higher temperatures.

REFERENCES

1. *Anonymous (2022). https://byjus.com/jee-questions/is-rubber-a-polymer/Retrieved, August 2022.*
2. *Bonnie, S. S. (2020). Rubber Band Basics; https://en.wikipedia.org/wiki/Rubber_band#Size_numbers, Retrieved, May 2022.*
3. *Brown, J. B. (1963). "Thermodynamics of a Rubber Band"; American Journal of Physics, 31 (5): 397*
4. *Karen, G. B. (2018). The Manufacturing process of rubber; https://sciencing.com/harden-rubber8760550.html, Retrieved, September2022.*
5. *Loadman, J. and James, F. (2009). The Hancocks of Marlborough: Rubber, Art and the Industrial Revolution – A Family of Inventive Genius; p. 89, Oxford, England, United Kingdom.*
6. *Legner, l. A., Fred, O. A., and Erich, F. I. (2010). Rubber and Other Latex Products, University of California, Irvine, United States of America.*
7. *Marisa, A. A. (2021). Rubber and Other Elastomers; Libre Texts Chemistry, Sacramento City College, California, United States of America.*
8. *Punmanee, J., Chaiwat, R., Praneee. C., and Yupaporn, R. (2011). "Glycidylmethacrylate grafted natural rubber: Synthesis, characterization, and mechanical property"; Journal of Applied Polymer Science, https://doi.org/10.1002/app.34324, Retrieved, August 2022.*
9. *Sadd, M. H. (2004). "Elasticity: Theory, Applications and Numerics". Academic Press, Oxford, United Kingdom; ISBN: 978-012-605-8116.*