



# Analysis of Aging of Foam

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# Objectives

Decorative geometric shapes on the left side of the slide, including a large light orange hexagon, a smaller red hexagon, a dark green hexagon, and a yellow hexagon.

## Characterize Foam Aging:

- understand the impact of physical aging on the visco-elastic behavior of foam.
- Measure and analyze the storage modulus to quantify the foam's elastic response to applied stress or strain.
- Measure and analyze the relaxation modulus to understand how quickly the foam dissipates energy and relaxes over time.



# Introduction

- Foam aging is a crucial aspect in material science, impacting various industries.
- Understanding the changes in foam properties over time is essential for product development and performance.
- Foam aging refers to the gradual transformation of foam properties over time.
- Factors such as temperature, humidity, and chemical composition influence this process.
- Studying foam aging provides insights into the material's long-term behavior and durability, making it invaluable for



# What is Foam ?

- Foam is a substance formed by trapping pockets of gas within a liquid or solid matrix, resulting in a material with a cellular structure.
- Foams can exhibit a range of properties, including low density, high porosity, and unique mechanical characteristics.
- Components:
  - Polymeric Matrix
  - Air or Other Gases
  - Stabilizers
  - Additives (Colorants, Fillers, and Flame Retardants)



# What is Physical Aging?

- Time-dependent changes in mechanical properties .
- This phenomenon involves a gradual structural rearrangement of polymer chains, even below the glass transition temperature, leading to an observable increase in material stiffness and a decrease in its ability to flow.
- The implications of physical aging extend across industries, particularly in plastics, adhesives, and coatings, where a nuanced understanding of these time-dependent changes is vital for effective material design and accurate performance evaluations.



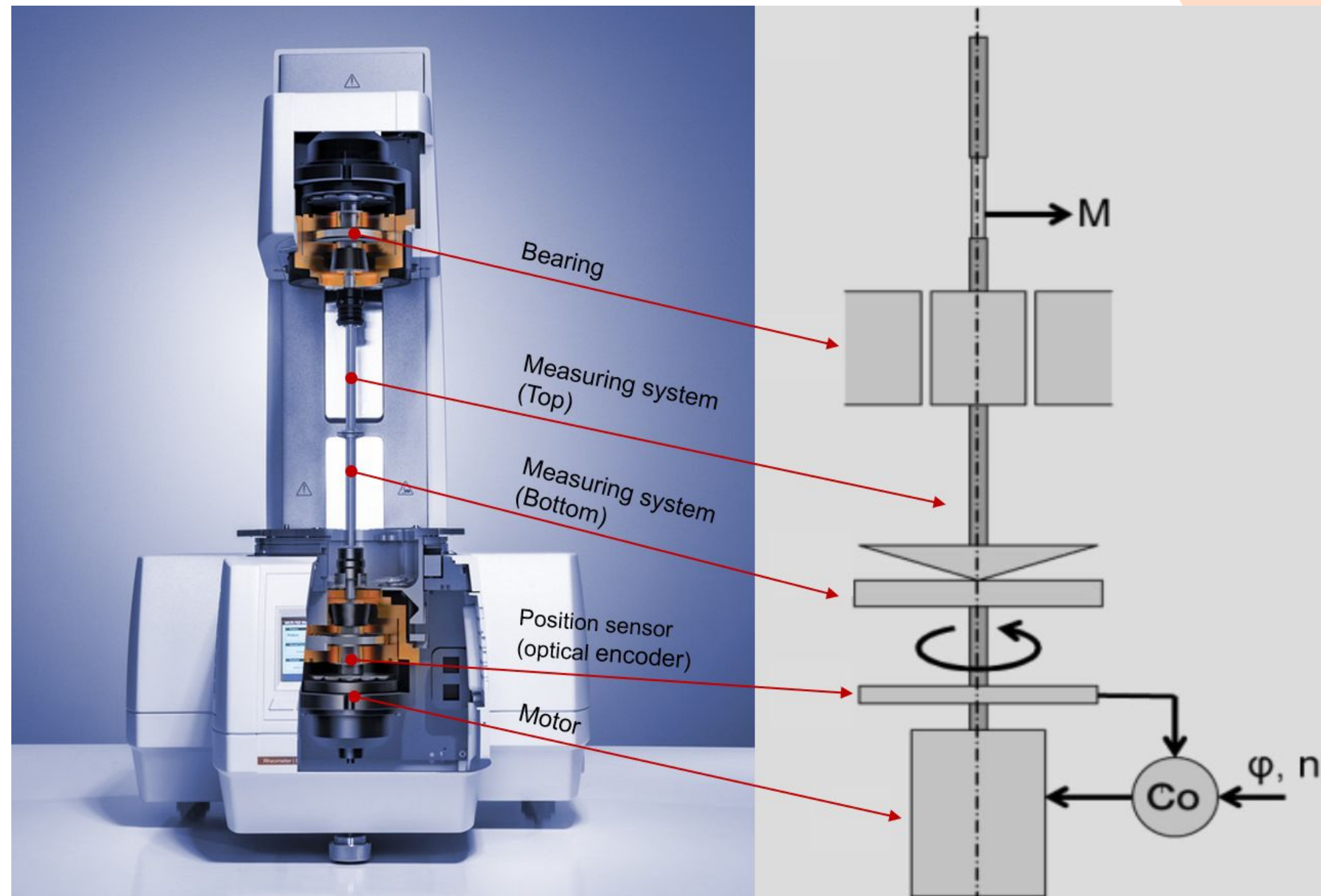
# What is Rheometer ?

- A rheometer is a precision instrument designed to measure the rheological properties of materials, including their flow and deformation characteristics.
- Purpose : to analyze the aging of foam by measuring parameters like storage modulus and relaxation modulus and evolving of viscoelastic behavior with time.





# Rheometer





# Theory

## Relaxation Modulus:

- The relaxation modulus,  $G(t)$ , is a measure of the time-dependent stress relaxation behavior of a viscoelastic material.
- It is defined as the ratio of the stress,  $\sigma(t)$ , to the constant strain,  $\epsilon$ , at time  $t$  following the application of a step strain.
- $G(t) = \sigma(t)/\epsilon$
- The relaxation modulus is a measure of the elastic energy stored in the material as a function of time.
- The relaxation modulus is typically measured in a stress relaxation test in which a constant strain is applied to a sample





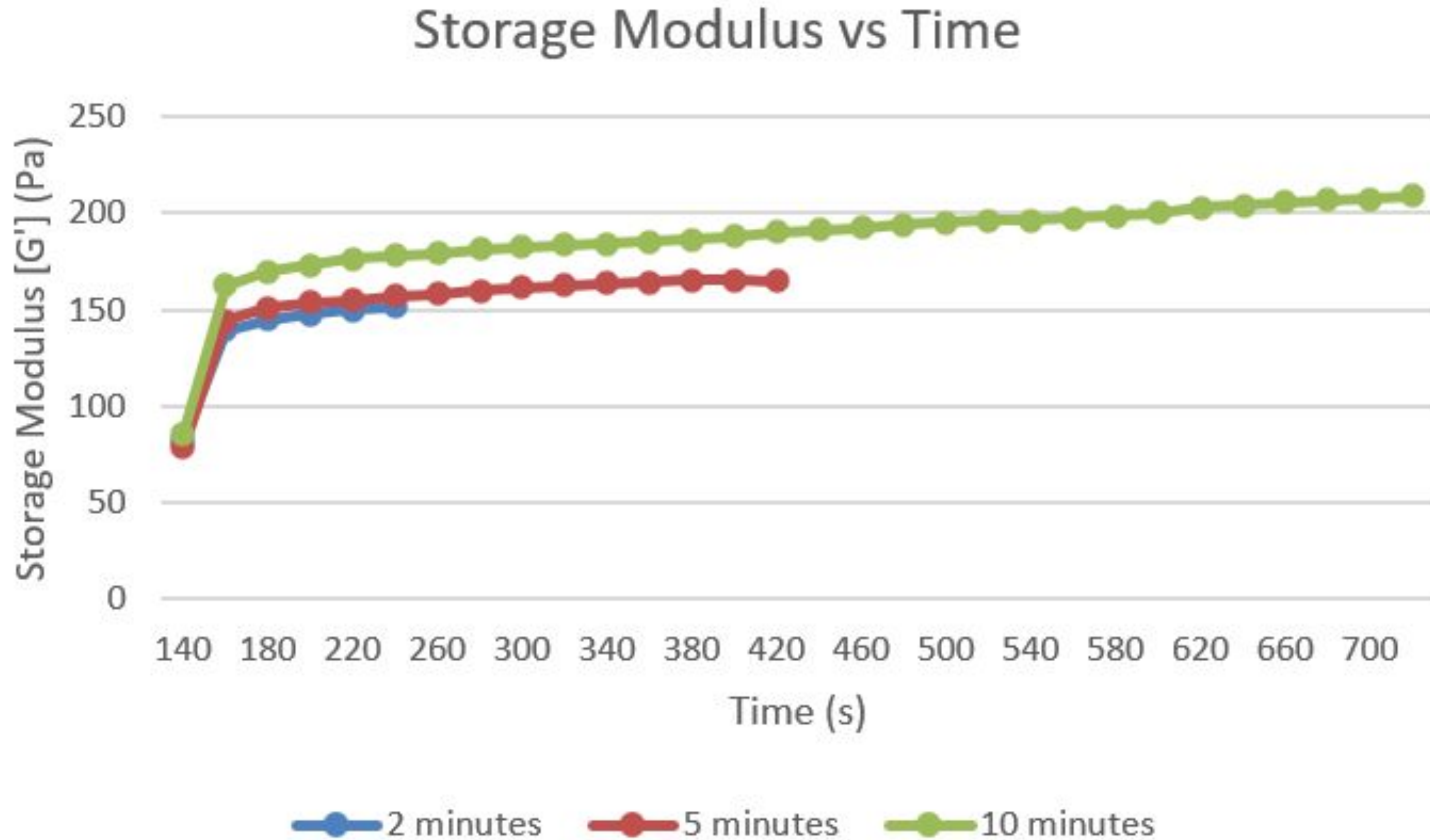
# Storage Modulus :

- The storage modulus,  $G'$ , is a measure of the elastic energy stored in a viscoelastic material under oscillating deformation.
- It is defined as the real part of the complex modulus,  $G^*$  which is the ratio of the stress,  $\sigma^*$  to the strain,  $\epsilon^*$ , in a viscoelastic material under oscillating deformation.
- $G' = \text{Re}(G^*)$
- The storage modulus is a measure of the stiffness of a viscoelastic material, and it is related to the elastic modulus of a purely elastic material.
- The higher the storage modulus, the stiffer the material.

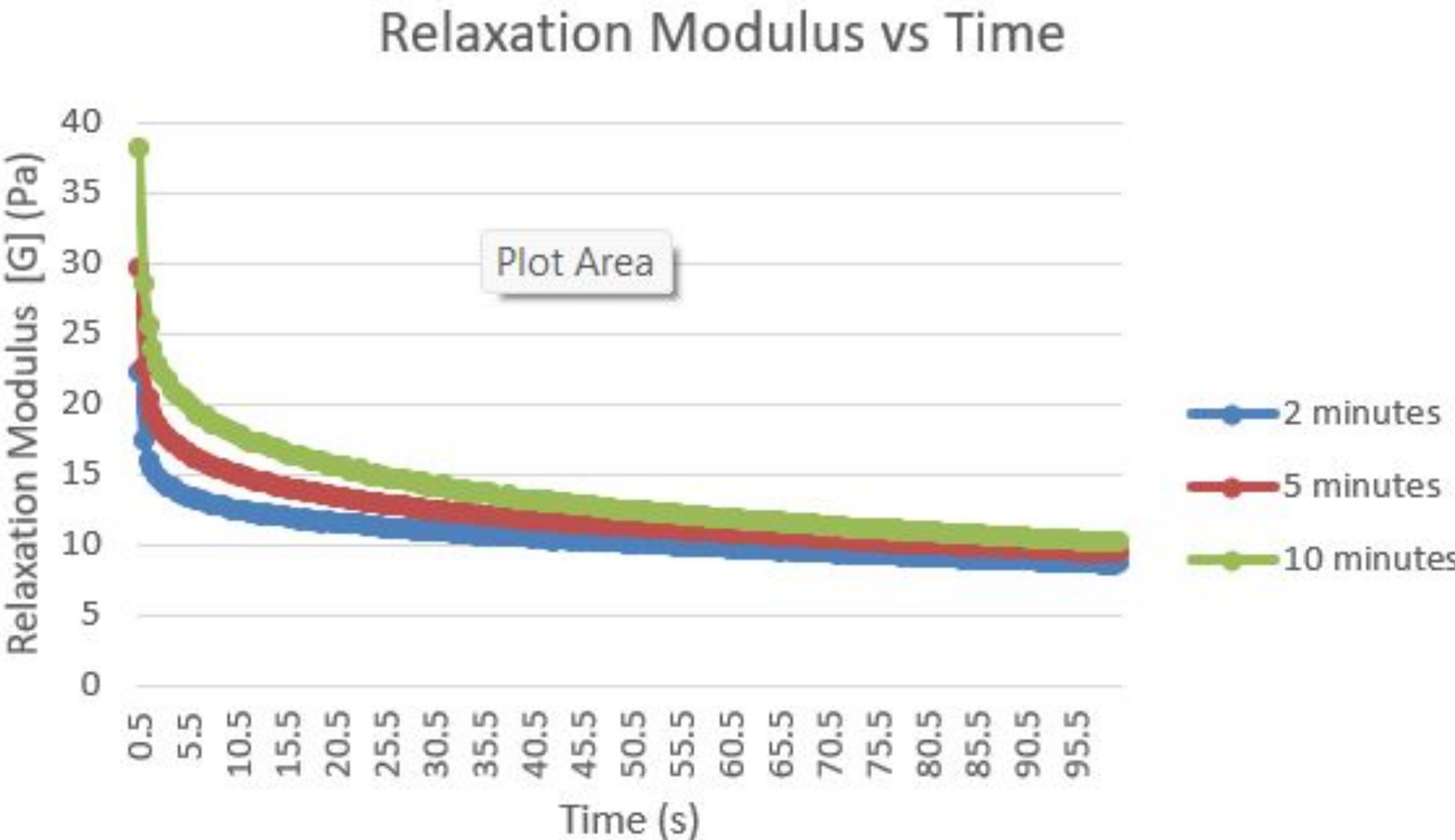
# PROCEDURE:

- Sample Preparation: Started with a well-characterized foam sample and spread it on the bottom plate of the rheometer
- Rejuvenation: Applied deformation to the material by rotating the upper plate for 120 sec applying a constant strain rate of 200/s. This leads to the realignment or rearrangement of molecular structures, restoring some of the original rheological properties
- Aging Time: After rejuvenation wait for 2 minutes in the first step, 5 minutes in the second step, and 10 minutes in the third step. Materials often exhibit a relaxation process where stress or deformation decreases over time after removing an applied force
- Collection of Data: Selected a suitable step time of 20 seconds and collected data for the storage modulus and relaxation modulus.

## G' vs Time Aging Foam Sample



# G vs Time Aging Foam Sample



# CONCLUSION:

- The relaxation modulus describes how the material's response to stress changes over time. Prolonged aging may cause a shift in the relaxation time, altering the rate at which the material relaxes. This shift can manifest as a change in the time scale over which the relaxation process occurs. The relaxation time increases, indicating a slower relaxation.
- With prolonged aging time, especially in polymers or viscoelastic materials, you might observe an increase in the storage modulus. This increase could be due to processes like cross-linking or molecular rearrangement that enhance the material's stiffness and elastic behavior. Aging processes can lead to the development of a more ordered or constrained molecular structure, contributing to an overall stiffening of the material and an increase in the storage modulus.





# APPLICATIONS:

- An understanding of the aging process is essential in various industries, such as in the design of materials for long-term use, in the formulation of cosmetics and pharmaceuticals, and in the development of durable goods. Researchers use rheological techniques to study and characterize the aging behavior of materials, helping to predict their performance over time and optimize their formulations for specific applications.
- Understanding how relaxation time affects these rheological parameters is crucial for characterizing and predicting the mechanical response of materials, which is valuable in various fields, including polymer science, materials engineering, and product development. Experimental techniques like dynamic mechanical analysis (DMA) and stress relaxation tests are commonly used to measure and analyze these rheological properties.





