

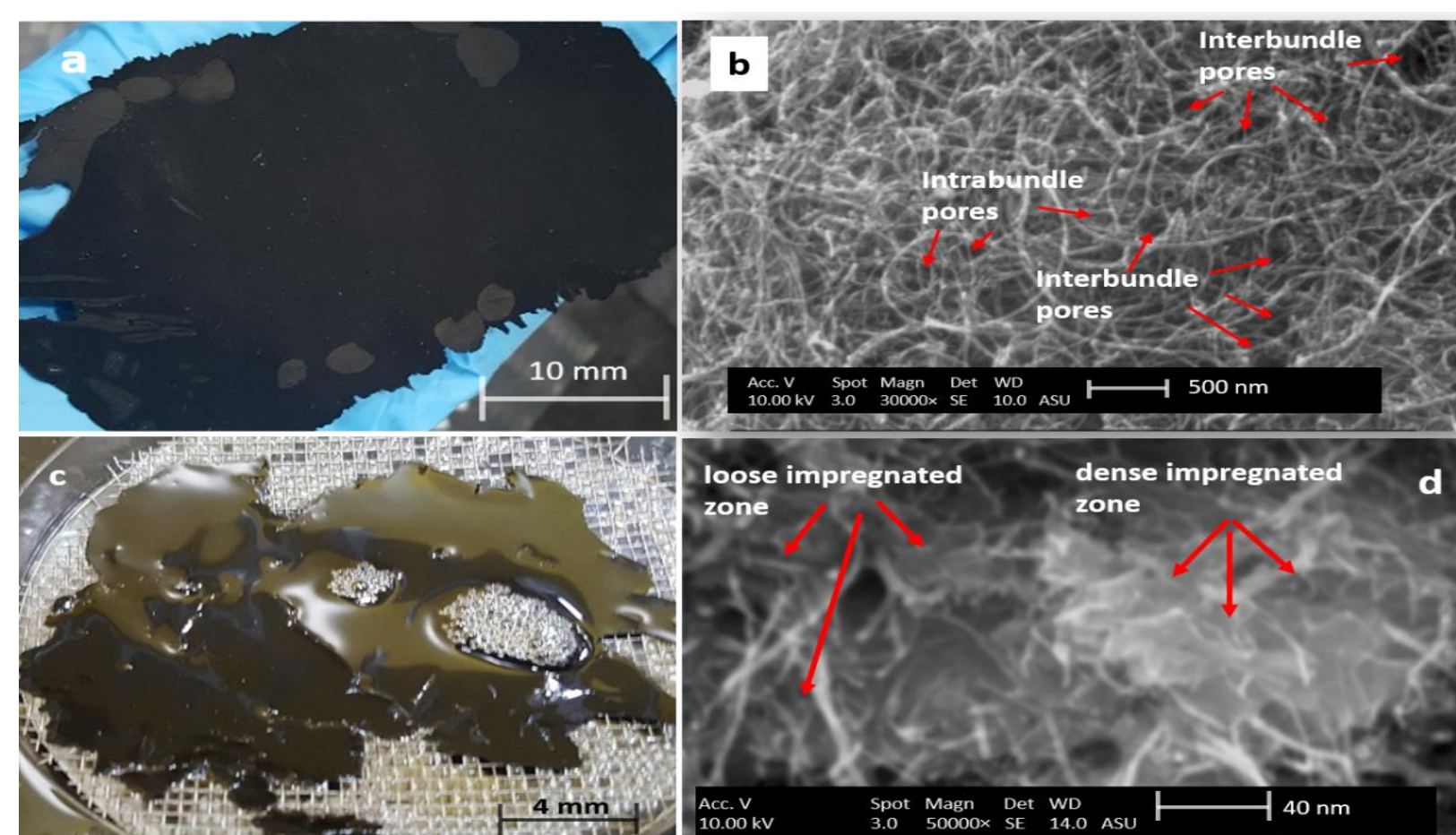
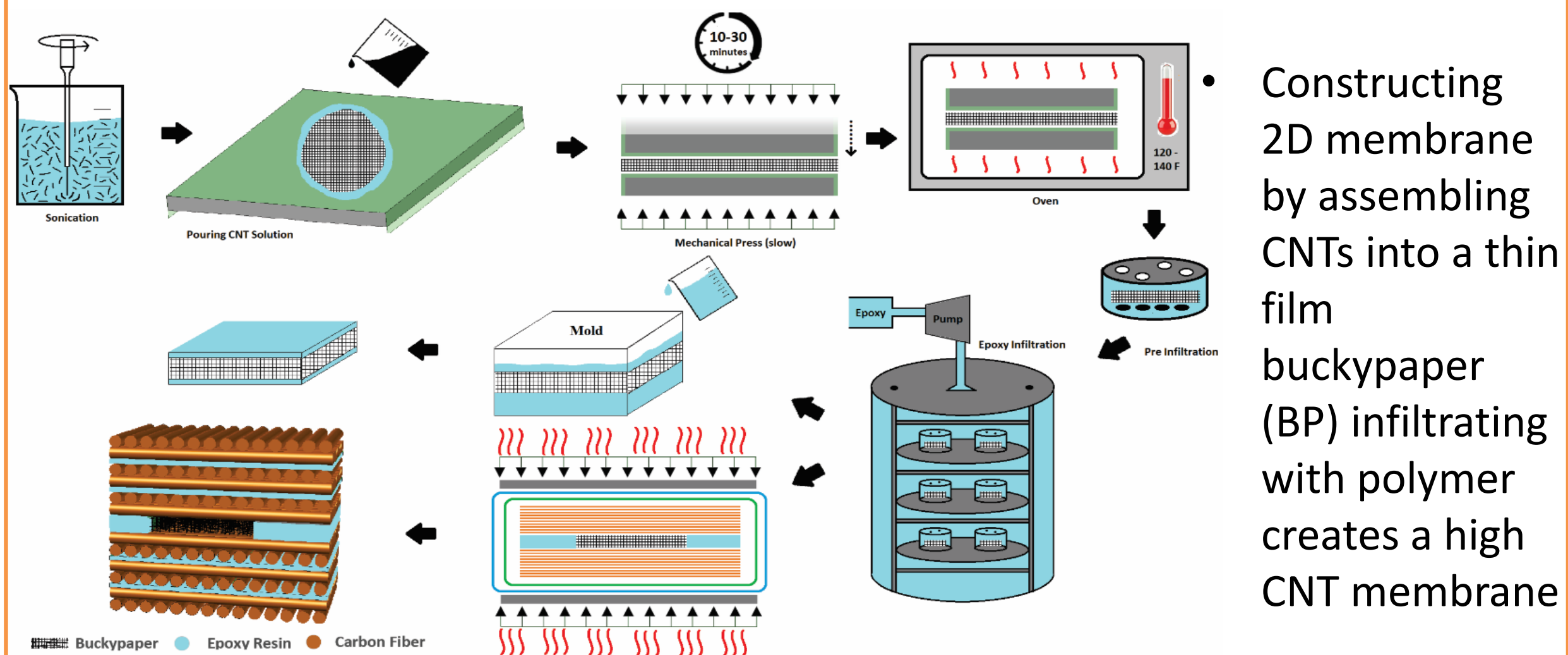
Assessment of Quali and Takayanagi models for evaluation of 2D membrane mechanical properties.

Samuel Perrino, Mechanical Engineering
Mentor: Masoud Yekani Fard, Assistant Research Professor
School for Engineering of Matter, Transport & Energy

Abstract

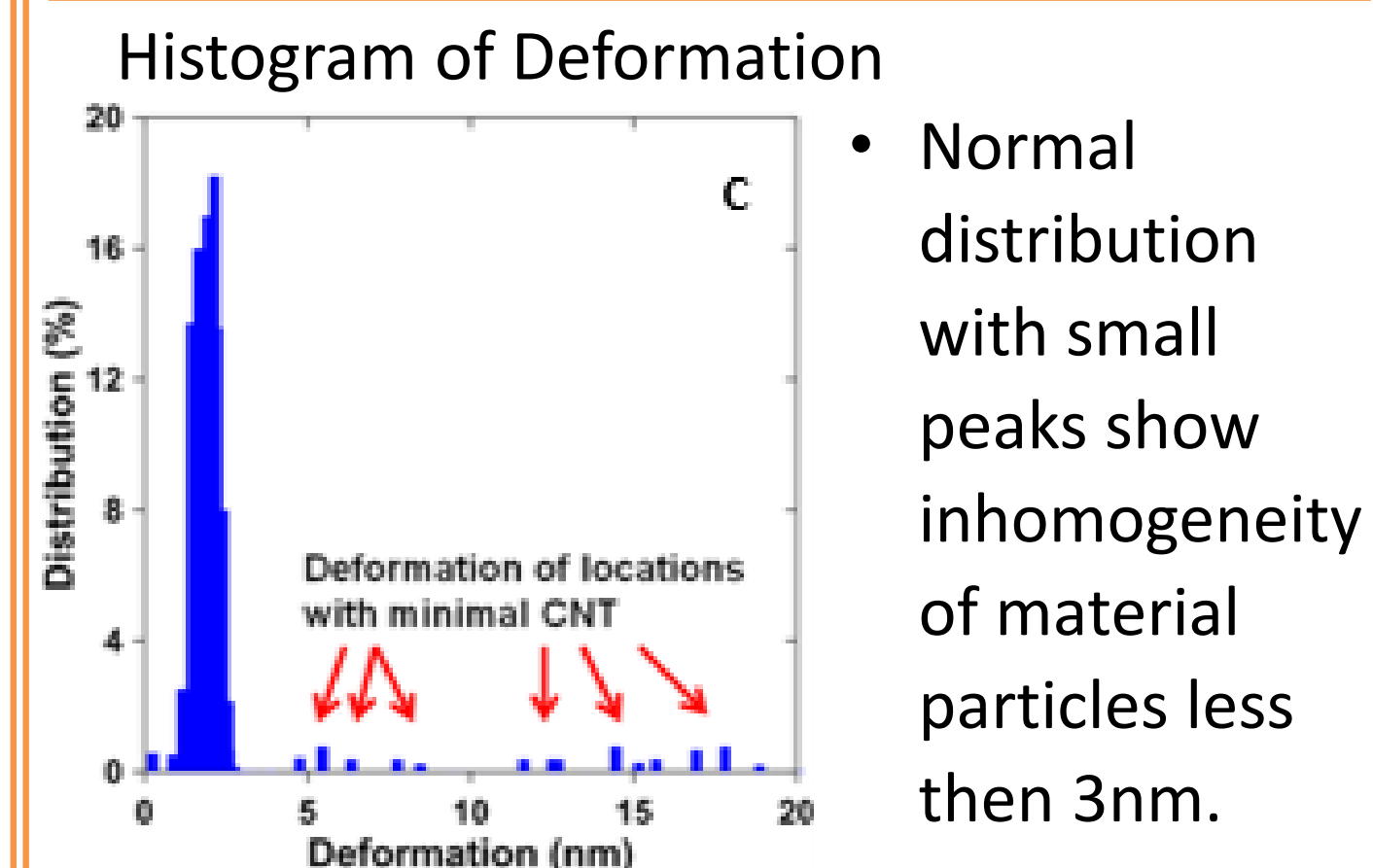
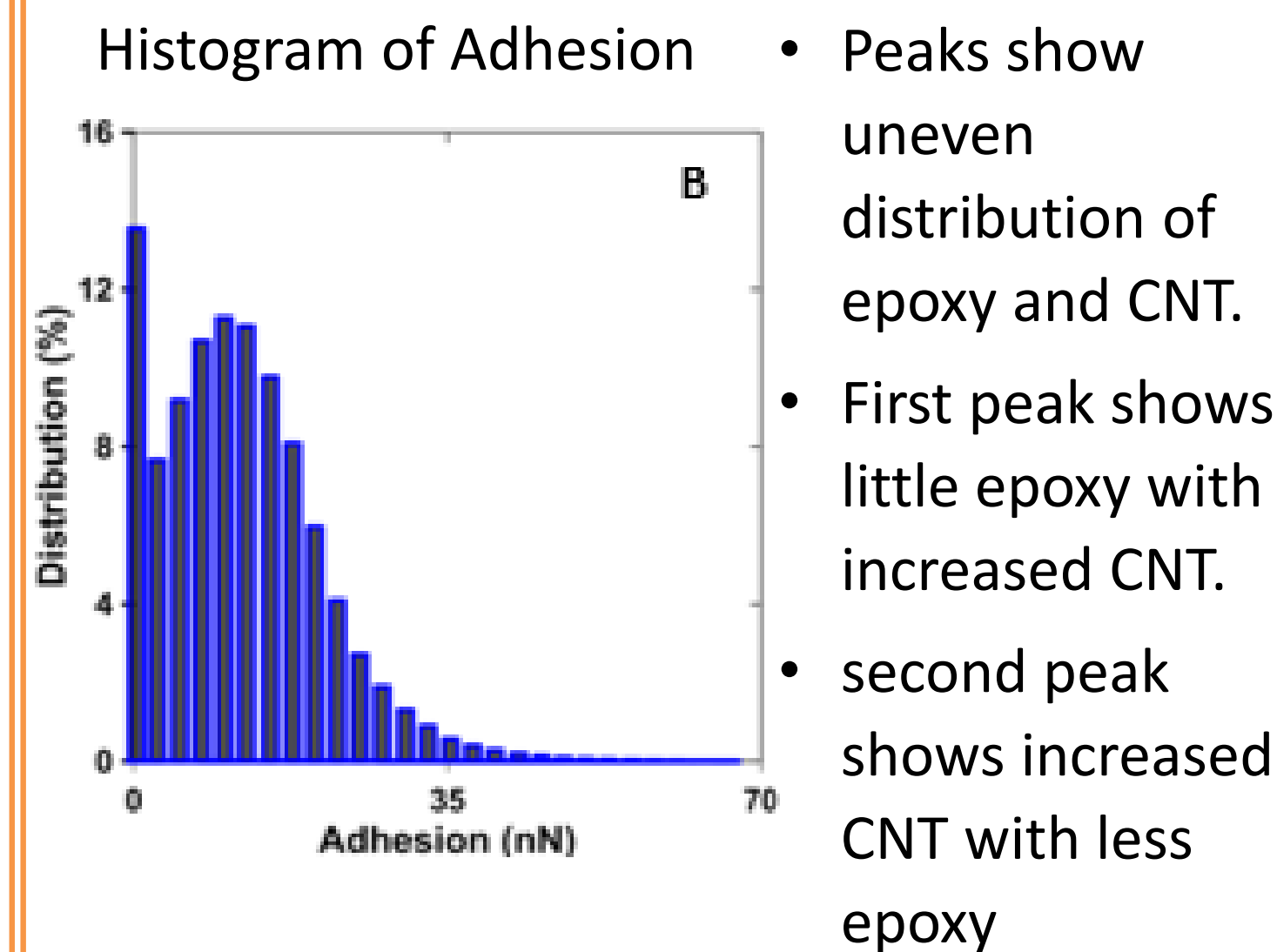
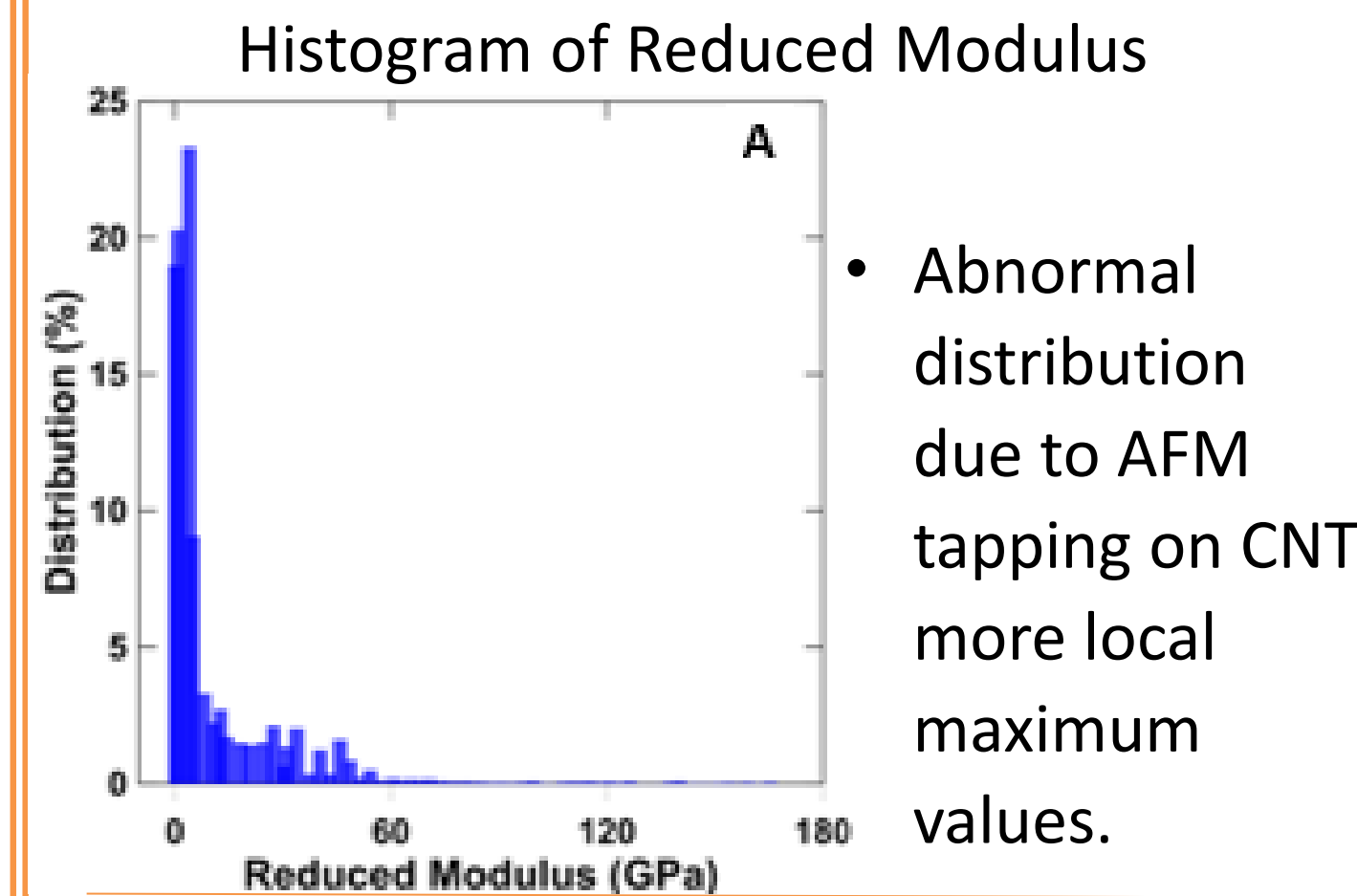
The purpose of this research is to assess the Quali and Takayanagi models for calculation of elastic modulus on 2D Buckypaper membranes and comparison of elastic modulus to values found using Atomic Force Microscopy. With the interphase between the CNT network and the surrounding polymer is categorized by Atomic Force Microscopy.

Manufacturing



- A. Dry Buckypaper
- B. Dry bp under scanning electron micro
- C. Infiltrated Buckypaper.
- D. Infused Buckypaper scanning electron micro

Data



Results

Quali model

$$E = \frac{\varphi_N(1-\varphi_f)E_dE_N + \varphi_N(\varphi_f - \varphi_N)E_mE_N + (1-\varphi_N)^2E_dE_m}{(1-\varphi_f)E_d + (\varphi_f - \varphi_N)E_m}$$

- φ_N is ~3.28% assuming φ_f and φ_p as 10% and 0.022% for BP PNC. with $E_d = 3.9\text{GPa}$, $E_N = 15.2\text{GPa}$, $E_m = 5\text{GPa}$, from AFM PFQNM.
- The elastic modulus (E) obtained from Quali model is 5.23GPa which is less than the reduced modulus obtained from PFQNM (6.2~8.2GPa).
- The Quali model ignores the effects of the interphase.

Takayanagi model

$$E = \frac{g(\varphi_f + \varphi_i)(1 - \varphi_f - \varphi_i)E_dE_N + g(\varphi_f + \varphi_i)(\varphi_f + \varphi_i - g\varphi_f - g\varphi_i)E_mE_N + (1 - g\varphi_f - g\varphi_i)^2E_dE_m}{(1 - \varphi_f - \varphi_i)E_d + (1 - g)(\varphi_f + \varphi_i)E_m}$$

- $\varphi_f = 0.1$, $\varphi_i = 0.3$, $E_d = 3.9\text{GPa}$, $E_N = 15.2\text{GPa}$, $E_m = 5\text{GPa}$, and $g = 0.305$,
- Elastic modulus of BP PNC is ~5.87GPa. It is larger than the elastic modulus obtained from BP PNC films, ~5.5GPa.
- The average reduced modulus of BP PNC 6.2~8.2GPa is higher than the values from the Quali model.
- The Takayanagi model is more accurate at calculating modulus than Quali model and AFM

References

Masoud Yekani Fard, Carbon nanotube network and interphase in buckypaper nanocomposites using atomic force microscopy, International Journal of Mechanical Sciences, Volume 212, 2021, 106811, ISSN 0020-7403, <https://doi.org/10.1016/j.ijmecsci.2021.106811>