Nylon humidity aging with and without Kevlar

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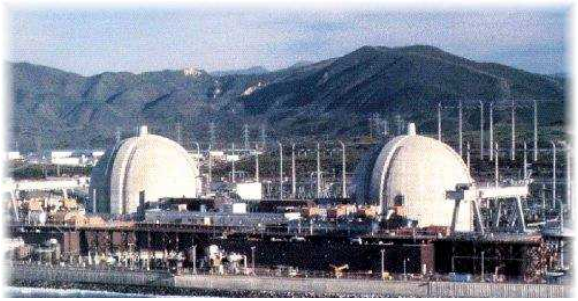
National Nuclear Security Administration

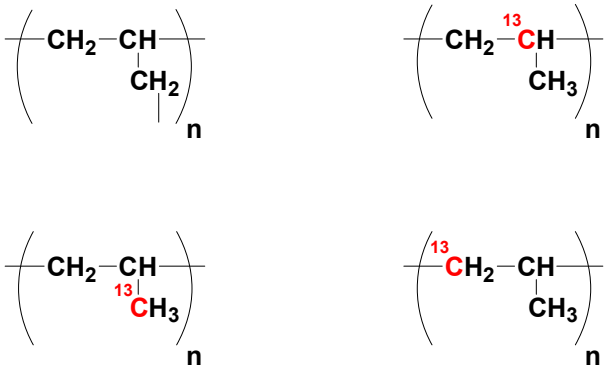
Organic Materials
Aging and Degradation

O-rings

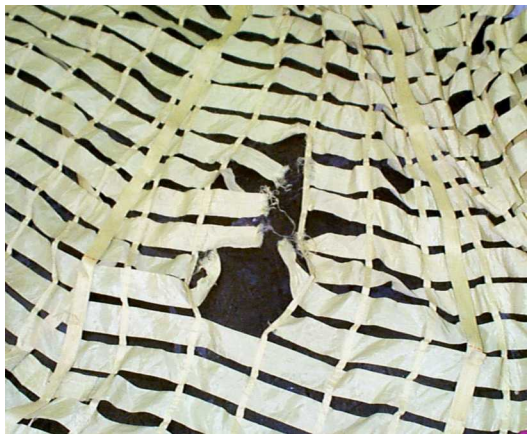


Nuclear Power Plant Cable Insulation

Aircraft Wire Insulation



Labeled Polypropylene



Textiles

Approach/Goals

Macroscopic level

Physical property

Tensile Property

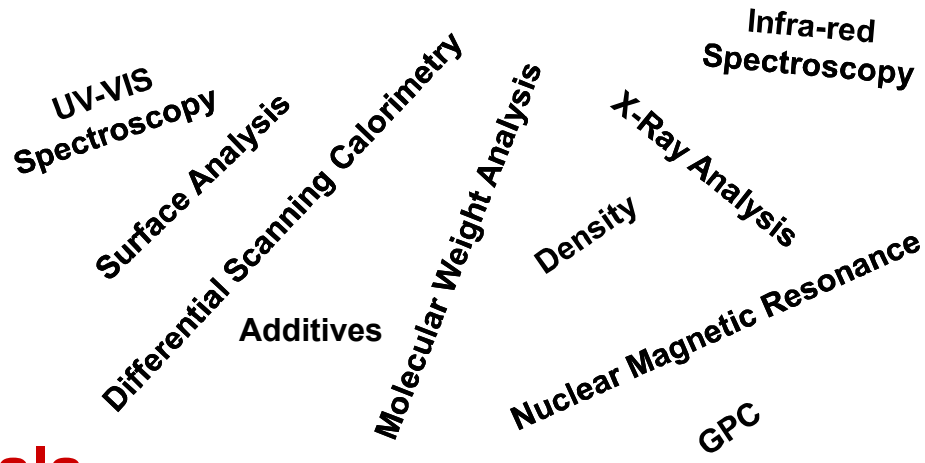
Permeation

Elongation

Dimensional changes

Molecular Level

Chemical Property

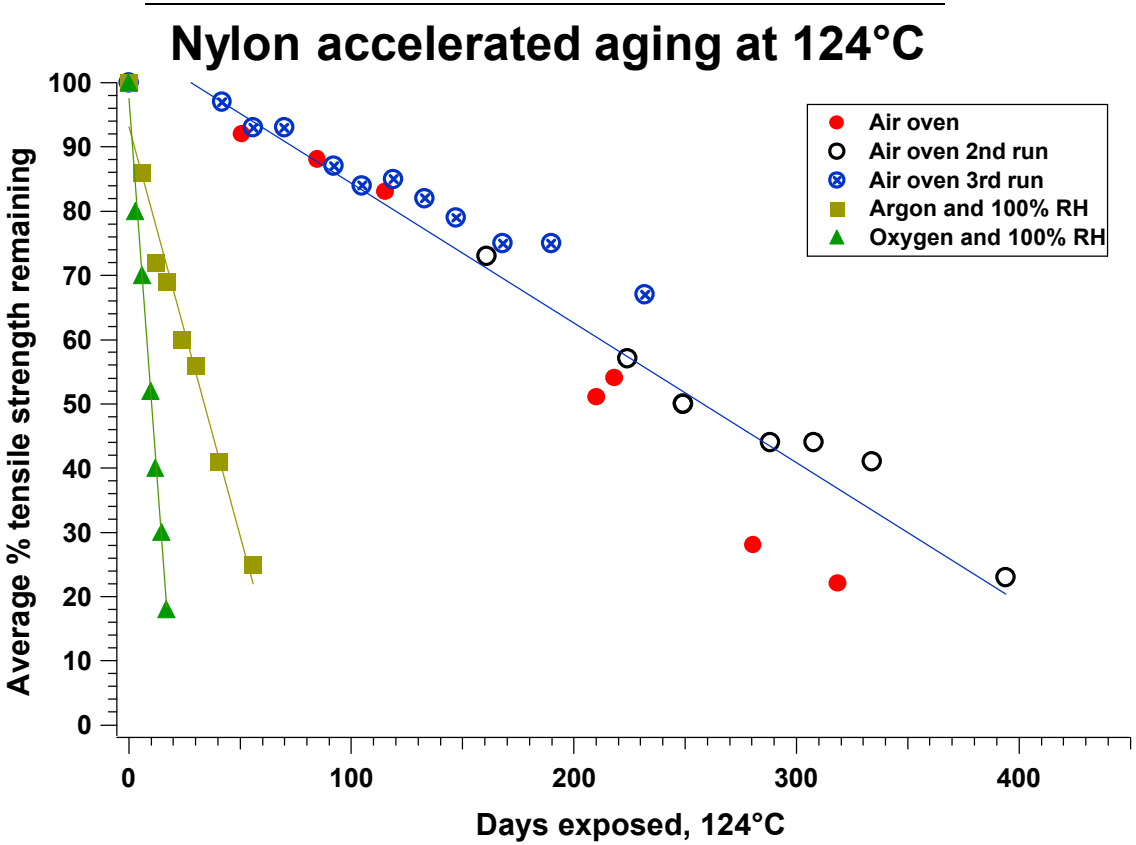


Goals

- Prediction of physical properties vs. time
  - Predict remaining lifetime of field materials
- Develop condition monitoring method

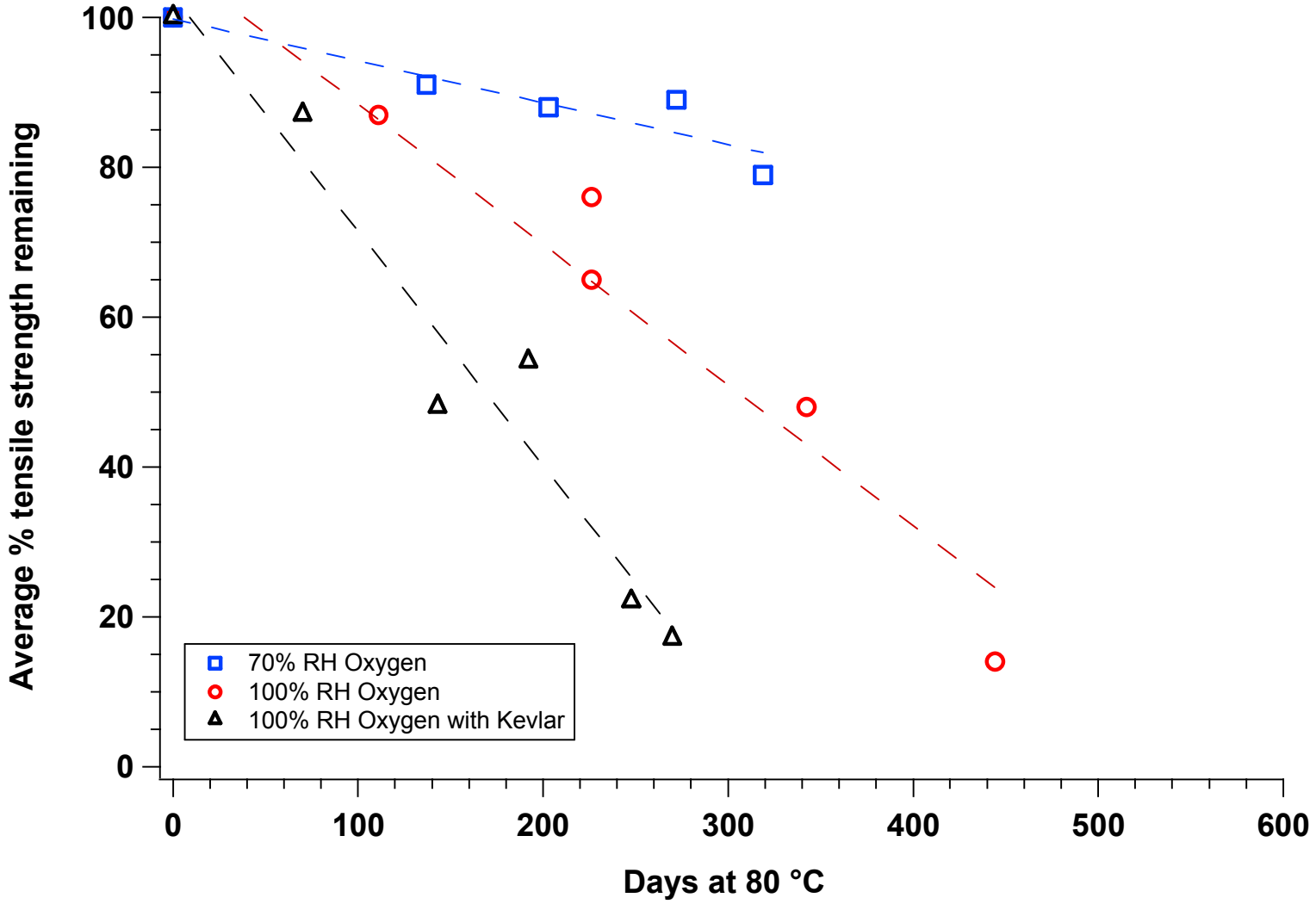
Background:
Materials of interest are Nylon 6.6 and Kevlar 29

Previous work entailed examination of Nylon and Kevlar and demonstrated humidity as the main contributing factor to degradation, however the presence of an oxygen atmosphere has been shown to make a difference for Nylon



(1) Bernstein, R.; Derzon, D. K.; Gillen, K. T. Polymer Degradation and Stability, Nylon 6.6 accelerated aging studies: thermal-oxidative degradation and its interaction with hydrolysis 2005, 88, 480-488.
(2) Bernstein, R.; Derzon, D. K.; Gillen, K. T. Polymer Preprints (American Chemical Society, Division of Polymer Chemistry), Nylon degradation studies: Humidity and aging 2002, 43, 1349.
(3) Bernstein, R.; Derzon, D. K.; Gillen, K. T. Polymer Preprints (American Chemical Society, Division of Polymer Chemistry), Kevlar degradation studies 2003, 44, 952.
(4) Bernstein, R.; Derzon, D. K.; Gillen, K. T. Polymer Preprints (American Chemical Society, Division of Polymer Chemistry), UV-VIS studies of nylon degradation 2003, 44, 1237-1238.
(5) Alam, T. M.; Winters, S. T.; Bernstein, R.; Derzon, D. K. Polymer Preprints (American Chemical Society, Division of Polymer Chemistry), Solution 17O NMR Investigations of Hydrolysis and Oxidation in Nylon 2003, 44, 247-248.

Nylon Tensile Strength Loss



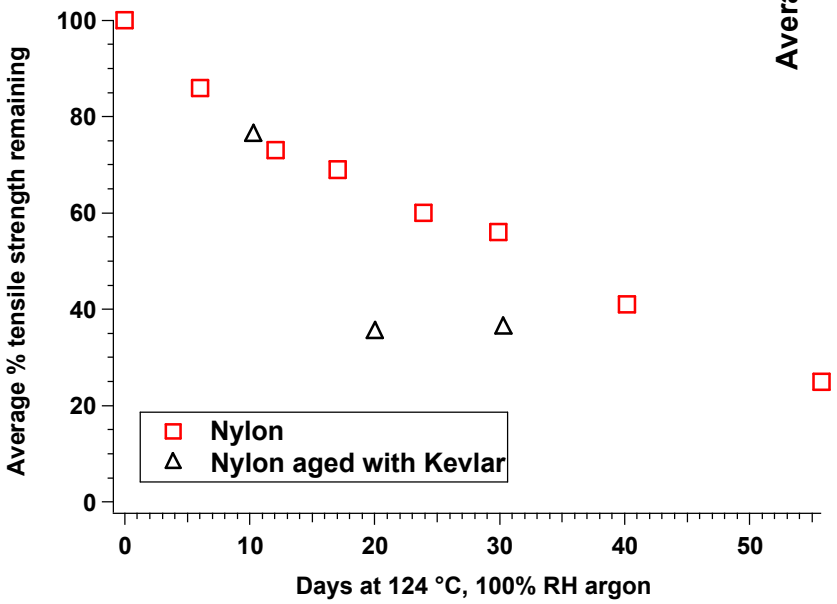
Nylon Tensile Strength Loss Comparison

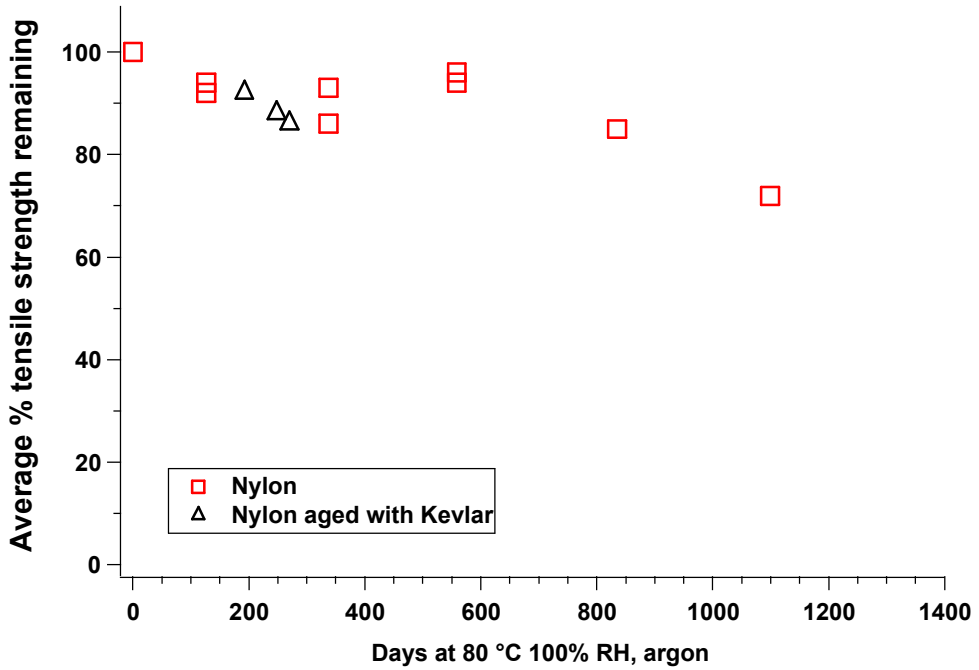
Nylon degradation slope comparison for sample exposed to 80 °C under different conditions.

Condition	Normalized slope
70% RH Oxygen	0.3
100% RH Oxygen	1
100% RH Oxygen with Kevlar	1.7

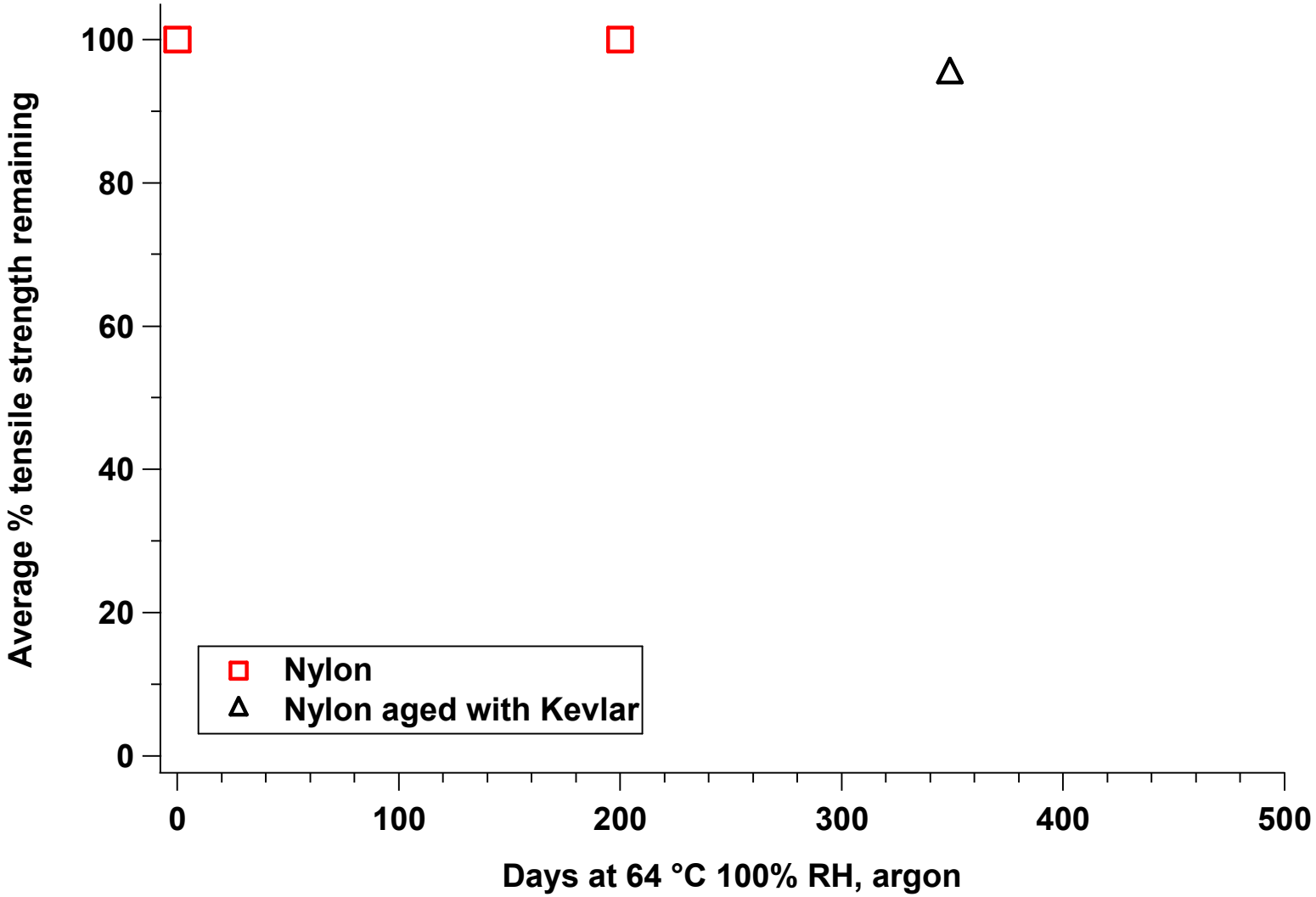
Nylon Aged in Argon Atmosphere

No real difference?
or
Not enough data?

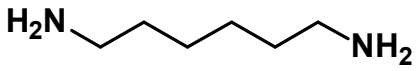




Nylon Aged in Argon Atmosphere 64 °C

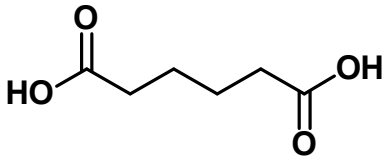


Nylon vs. Kevlar:
Aliphatic vs. Aromatic

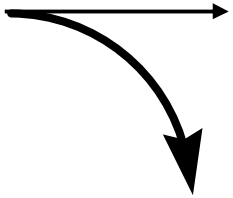


1,6 -Hexanediamine

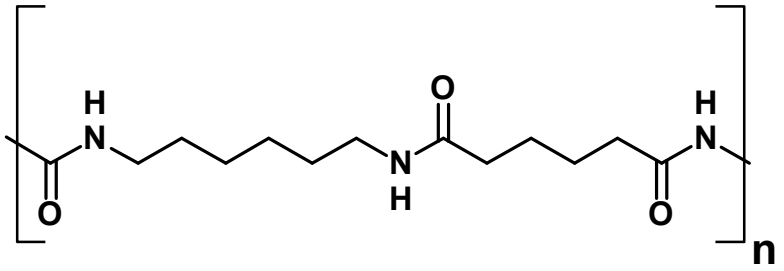
+



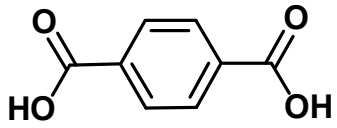
Adipic Acid



H_2O



Nylon 6.6



Terephthalic Acid

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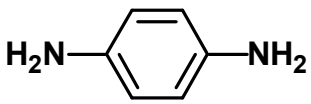
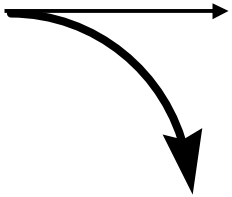
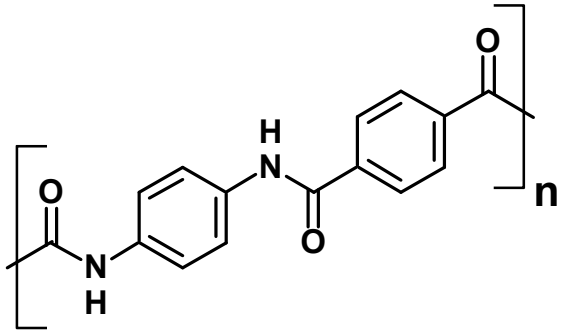


1,4 Phenylenediamine

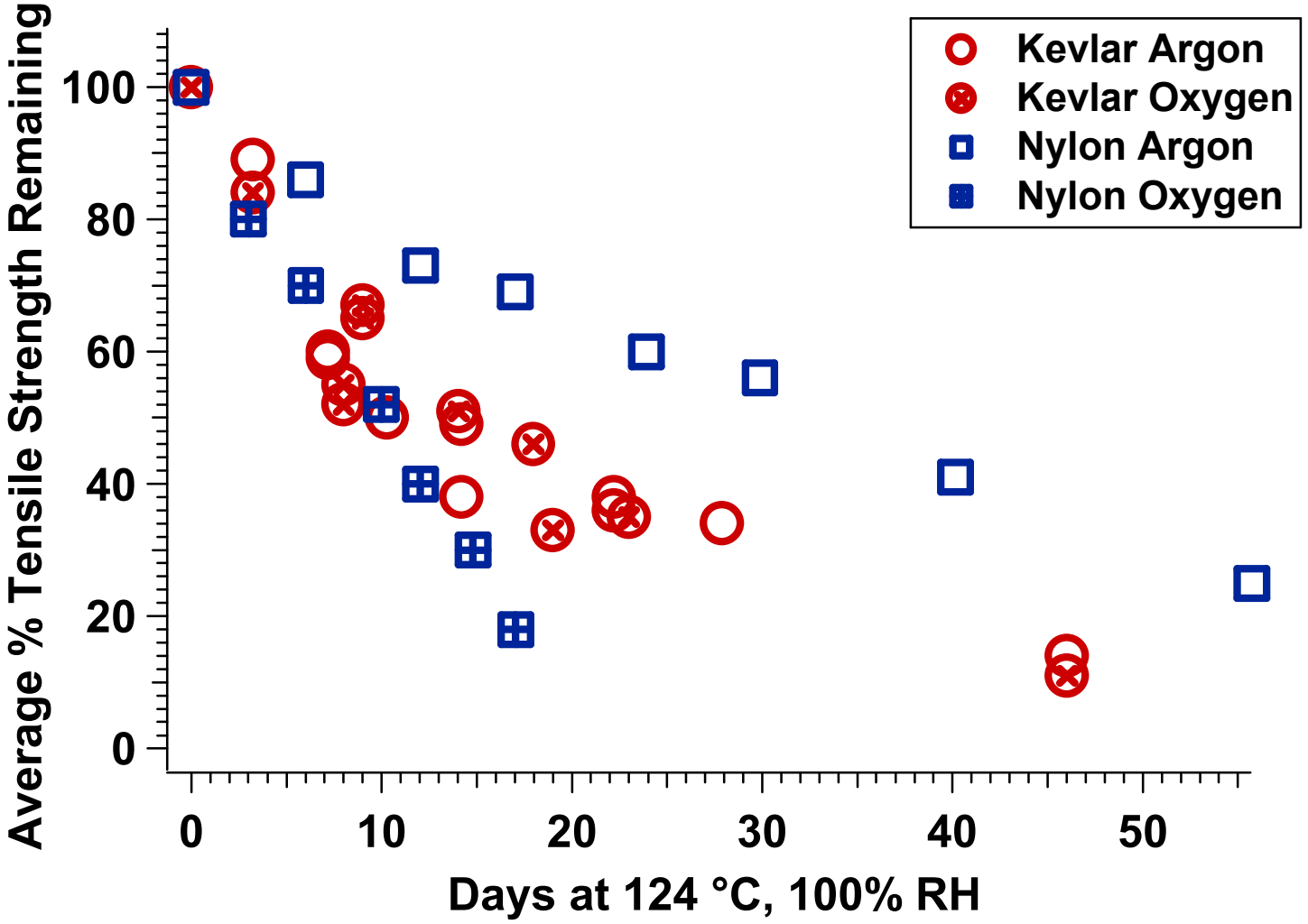


H_2O



Kevlar

Nylon vs. Kevlar 100% RH



Conclusions

Nylon degradation (tensile strength loss) in oxygen under a humidity environment is influenced by the presence of Kevlar

Kevlar degradation (tensile strength loss) under a humidity environment is not influenced by the presence of oxygen

Nylon degradation (tensile strength loss) under argon may not be influenced by Kevlar, however difficult to prove

Acknowledgements

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-DOE $$$$$

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