Measuring nanomaterial release during weathering of polymer nanocomposites & commercial products

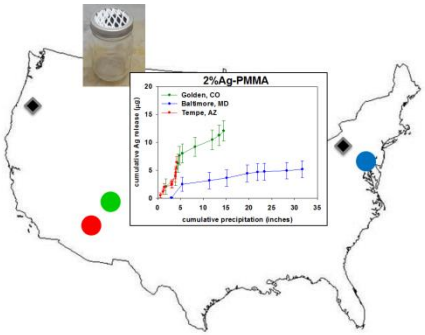
Howard Fairbrother
Department of Chemistry
Johns Hopkins University
Baltimore, MD, USA

LC nano

nano SAFE '16

Overview

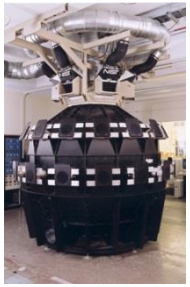
- **Part 1 - Release from polymer fragments**



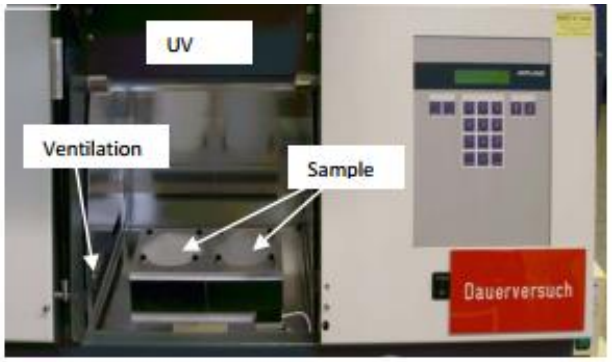
- **Part 2 - Release from commercial products**

- **How do CNTs impact polymer photodegradation and identifying CNT release form**

Accelerated, simulated, & outdoor weathering approaches



Simulated Photodegradation via High Energy Radiant Exposure (SPHERE)[1]



Suntest XLS+ (ISO 3892-2:2006)[2,3]

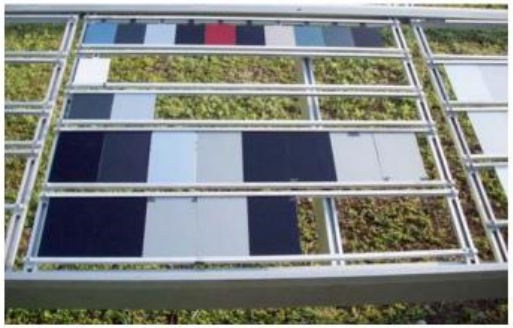
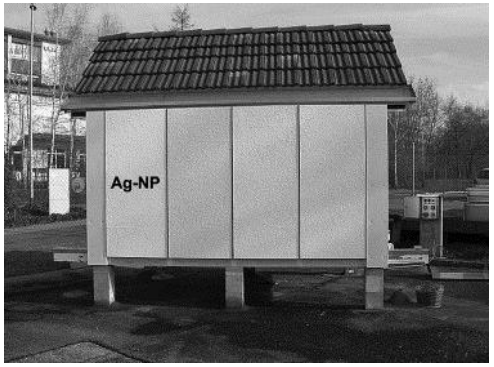


FIG. 1 Suitably Mounted Specimens in a Frame

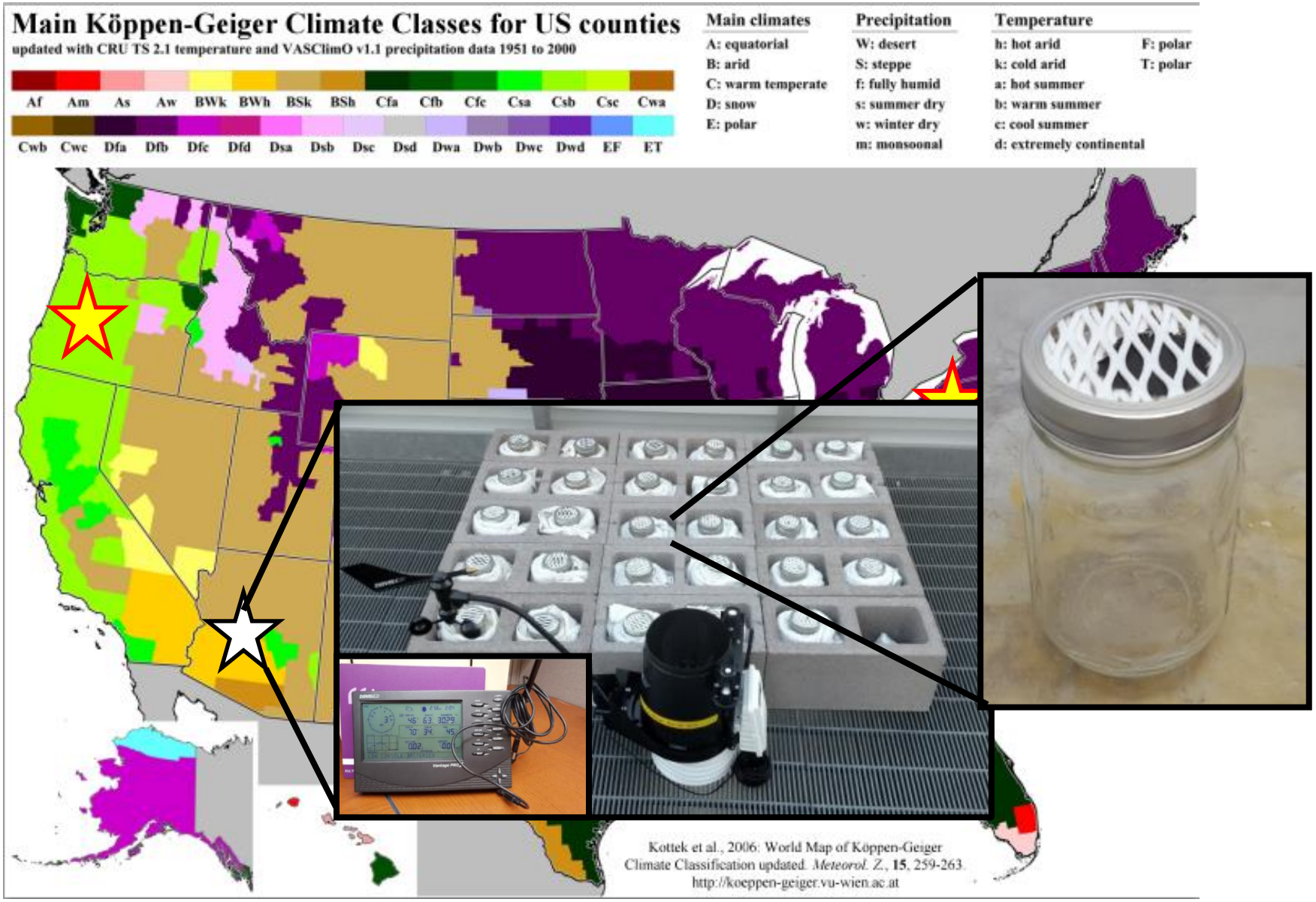
ASTM D1435 – Standard Practice for Outdoor Weathering of Plastics[4]



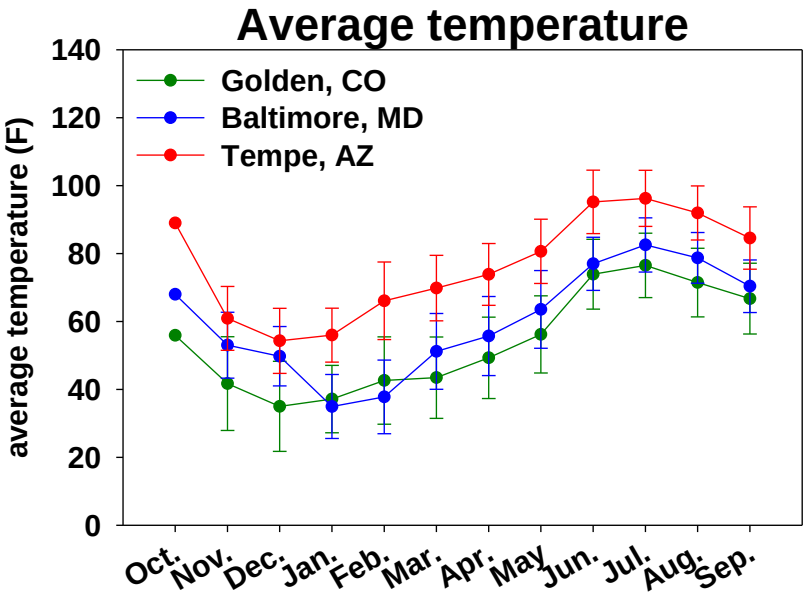
Model house for "façade run off"[5,6]

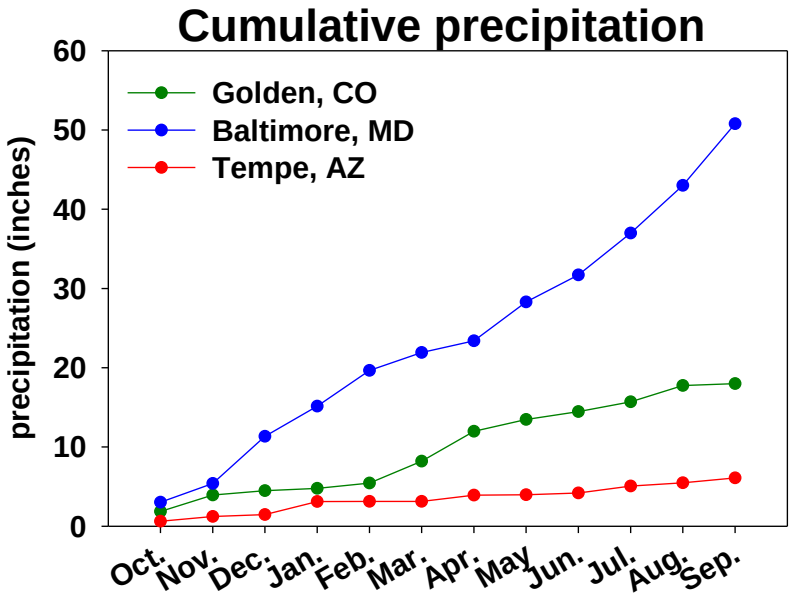
1) Chin, J.E., Ned, et al. Review of scientific instruments, 2004. 75(11): p. 8.
2) Petersen, E.J., et al. Carbon, 2014. **69**: p. 194-205.
3) Hirth, S., et al. J Nanopart Res, 2013. **15**.
4) Zaidi, L., et al. Polymer Degradation and Stability, 2010. **95**(9): p. 1751-1758.
5) Kaegi, R., et al. Environmental Pollution, 2010. **158**(9): p. 2900-2905.
6) Kaegi, R., et al., Environmental Pollution, 2008. **156**(2): p. 233-239.

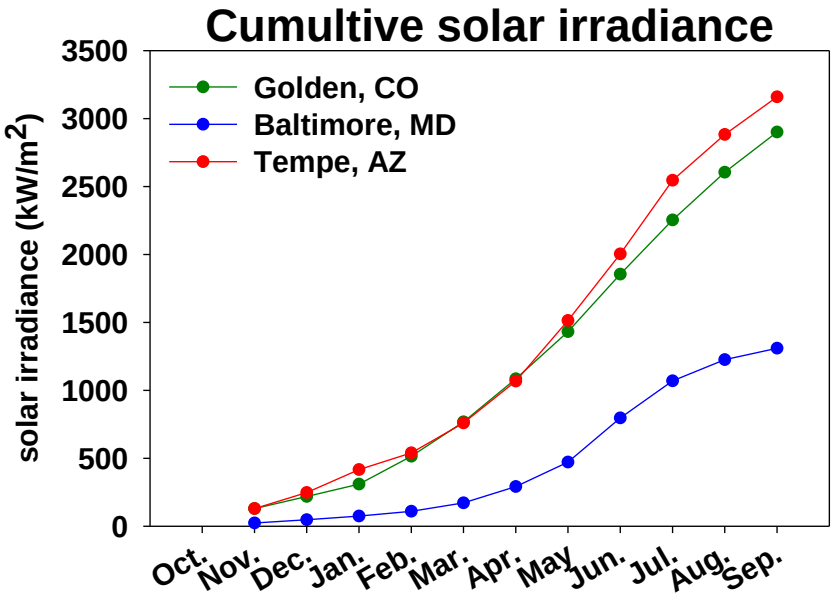
Outdoor Weathering Approach – completely natural



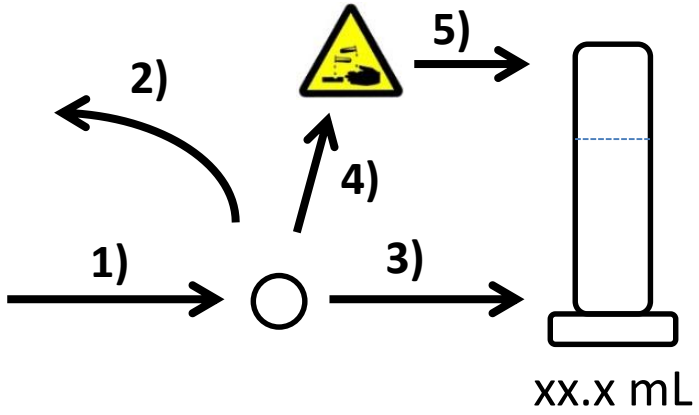
Results – Weather

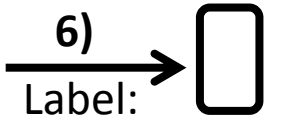






Sampling Procedure





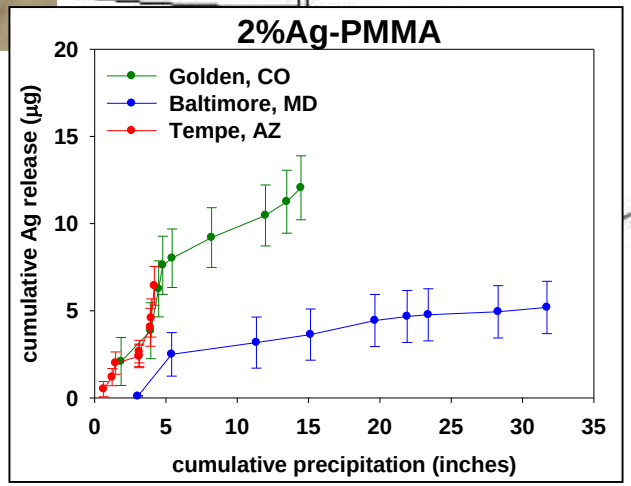
Sample retrieval and collection jar substitution

Rainwater collection and acid rinse

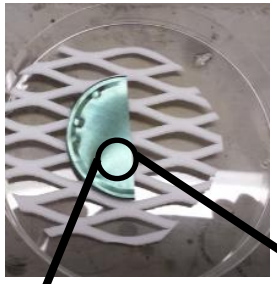
Seal for shipment

ICPMS used for detection due to specificity and sensitivity

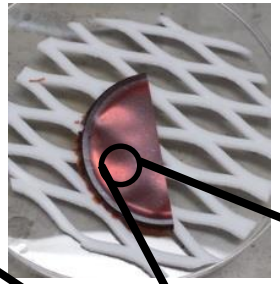
Part 1 – Polymer Fragments



Samples for weathering



2% Ag-PS

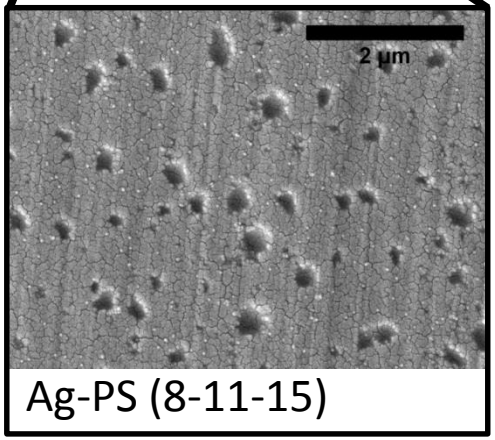


2% Ag-PMMA

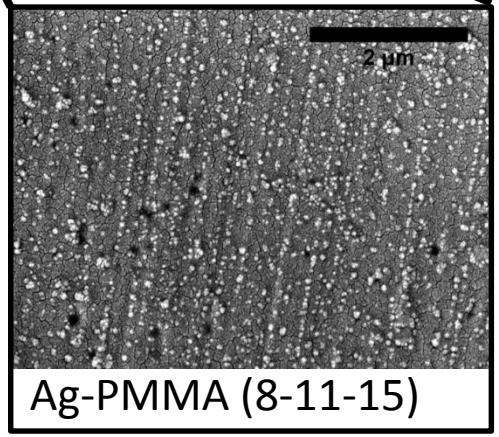
0.04% Ag-PS

1.5% SWCNT-PCL

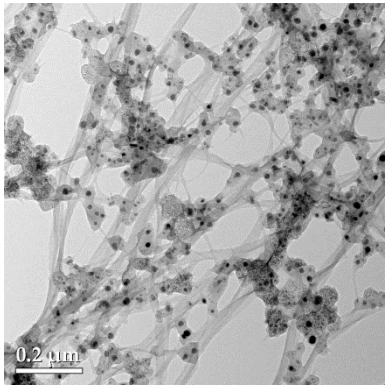
1.5% SWCNT-PS



Ag-PS (8-11-15)



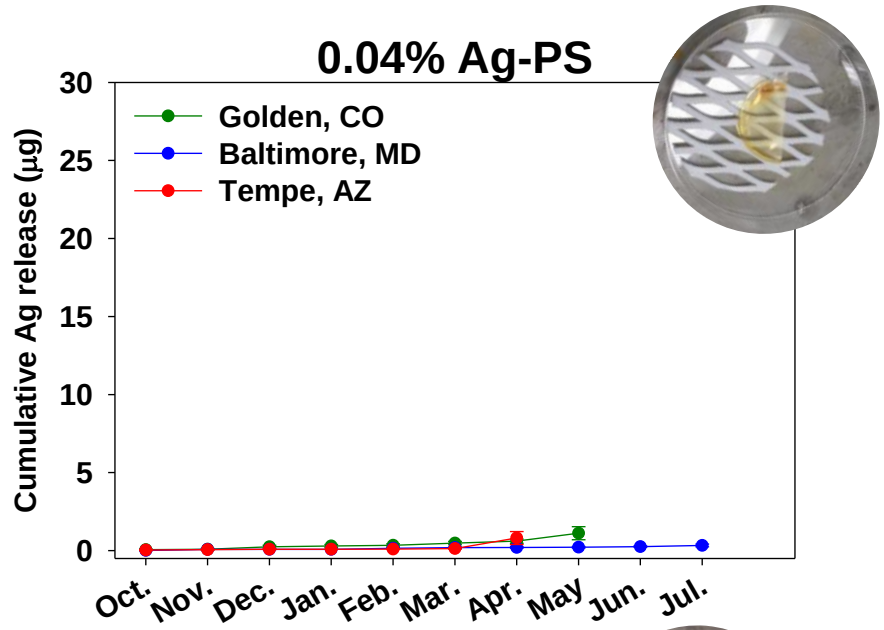
Ag-PMMA (8-11-15)

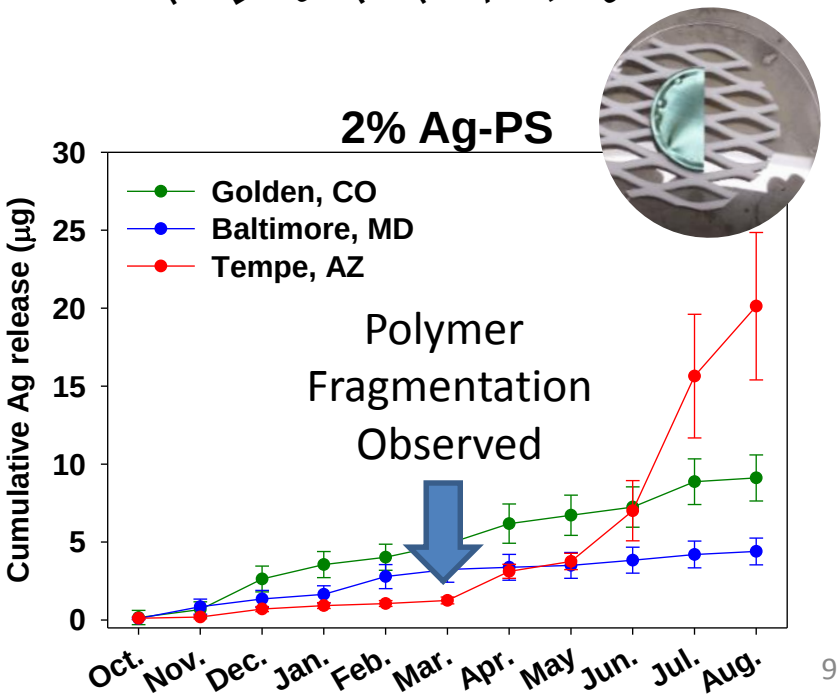


TEM of as received SWCNTs

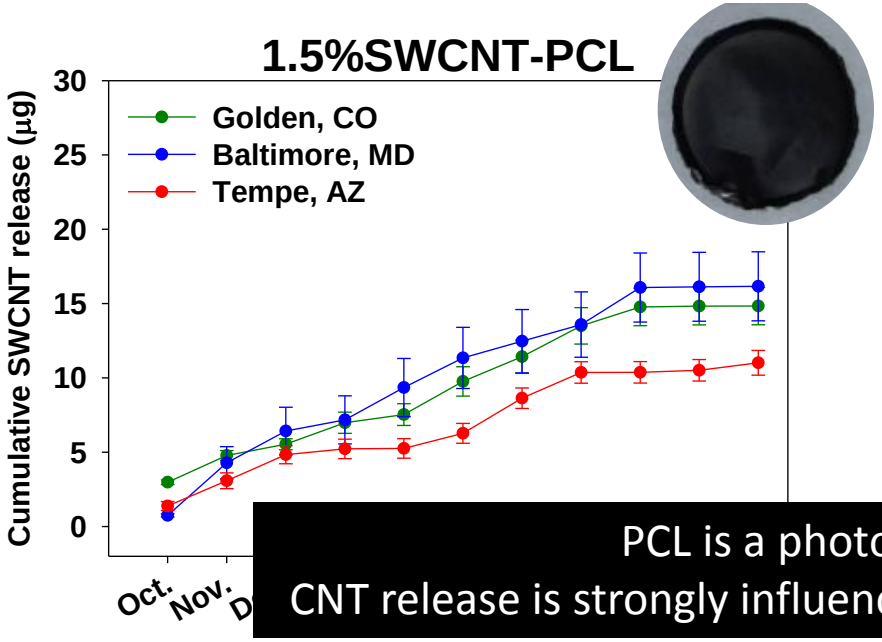
	mass (mg)	stdev	SA of PNC (cm^2)	stdev	[Ag] from XPS	[Ag%] from ICP-MS
2% Ag-PS	54.02	5.19	8.09	0.59	5.07% (+/- 0.61)	1.32 (+/- 0.12)%
400ppm Ag-PS	46.51	3.56	6.99	0.7	0.06% (+/- 0.01)	
2%Ag - PMMA	73.1	4.41	8.9	0.63	3.72% (+/- 3.89)	1.62 (+/- 0.19) %
1.5%SWCNT-PCL	41.23	1.15	11.1	0.37		
1.5%SWCNT-PS	69.3	2.71	10.11	0.39		

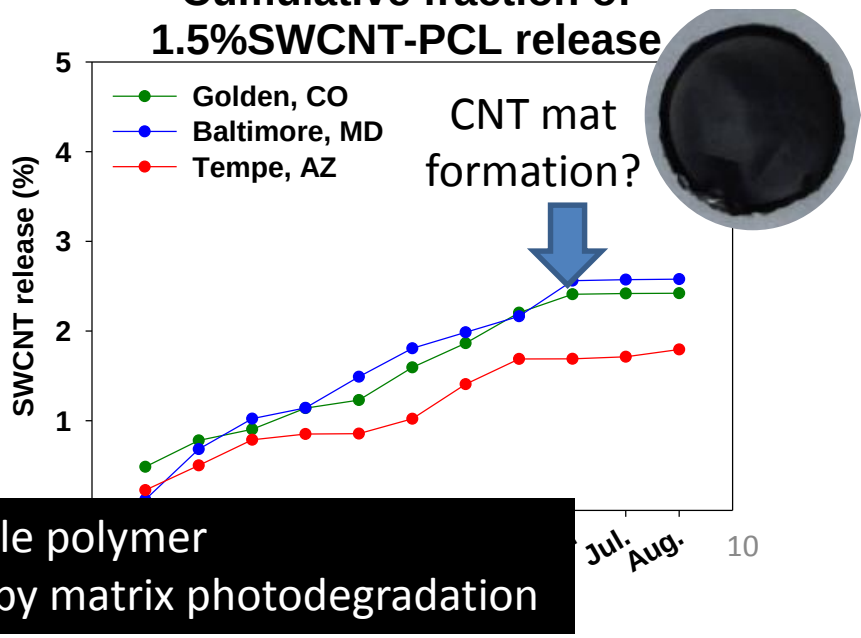
Results – Ag-PNCs Release



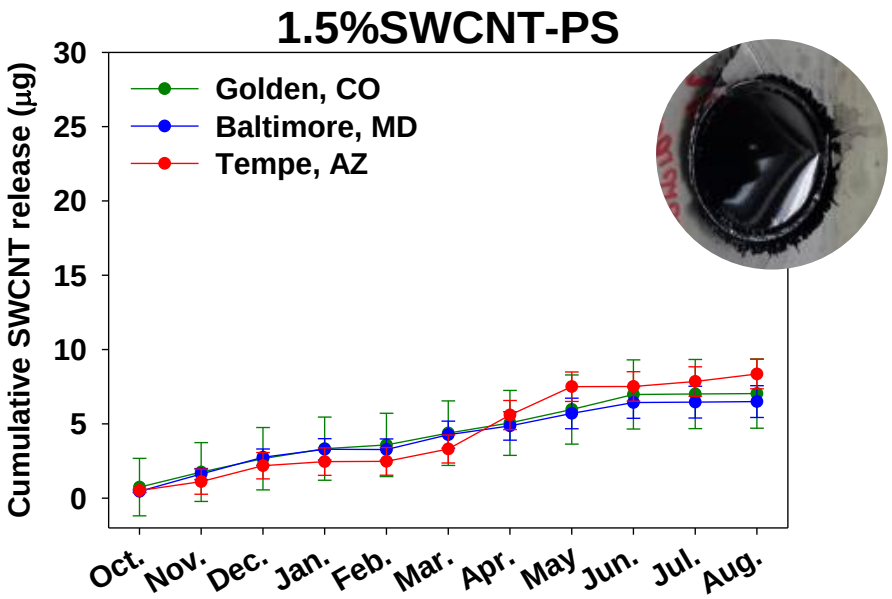


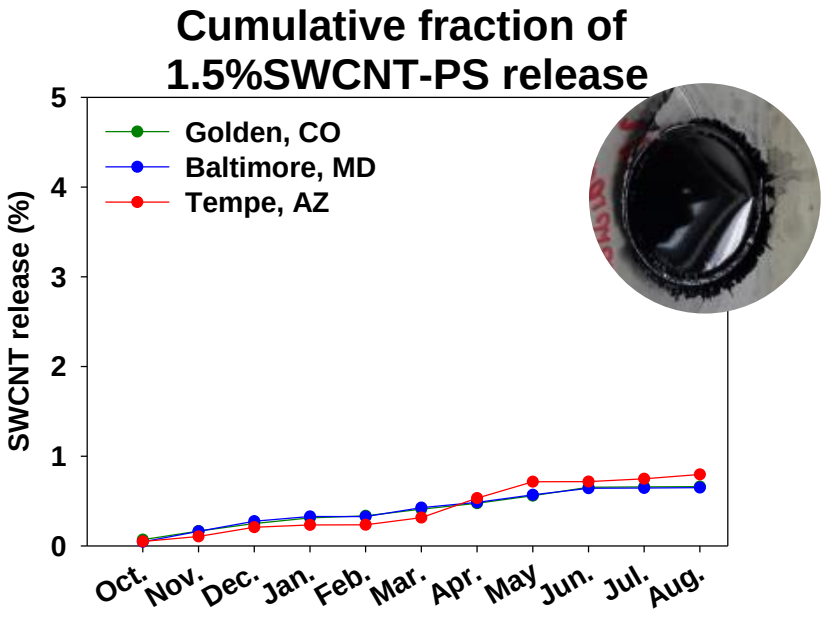
Results – SWCNT-PNCs Release



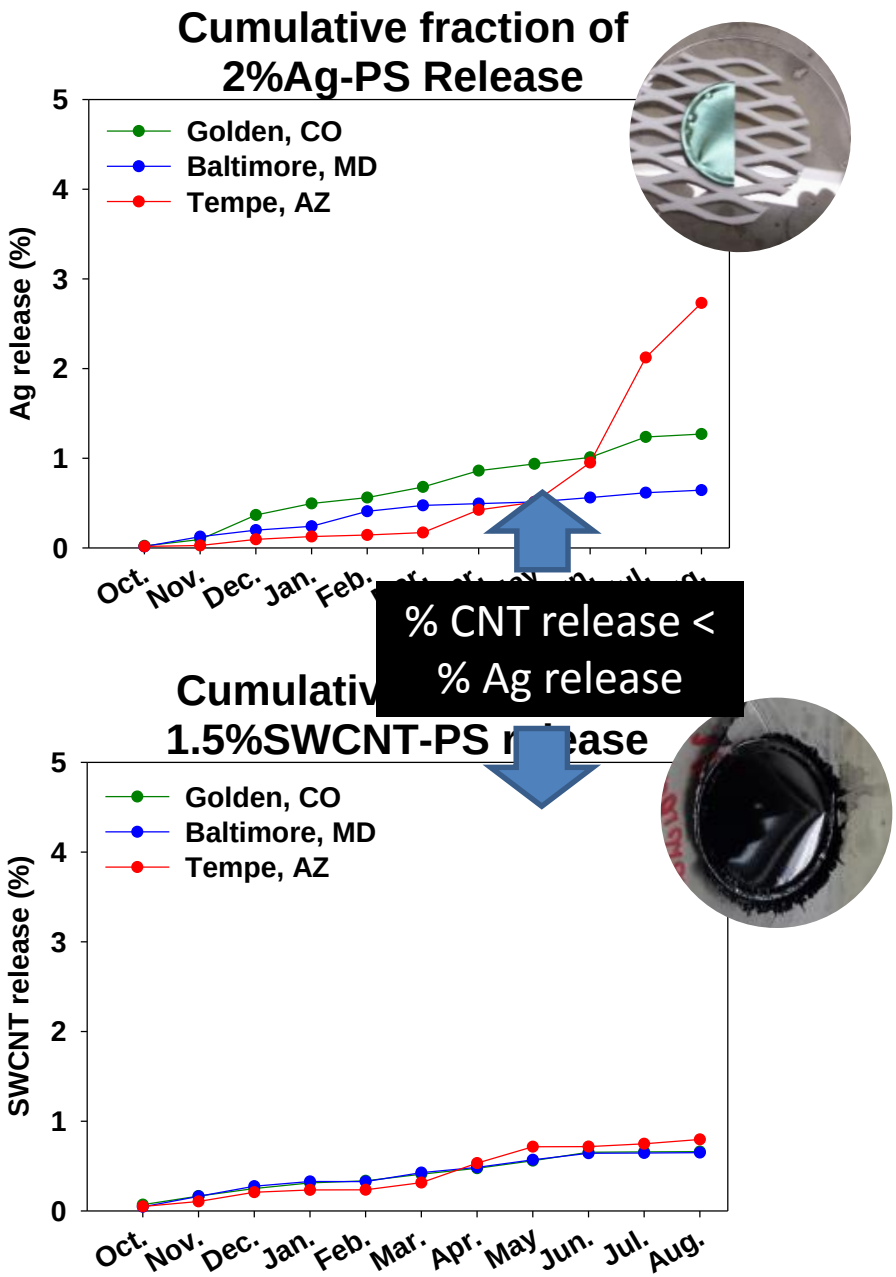


PCL is a photolabile polymer
CNT release is strongly influenced by matrix photodegradation

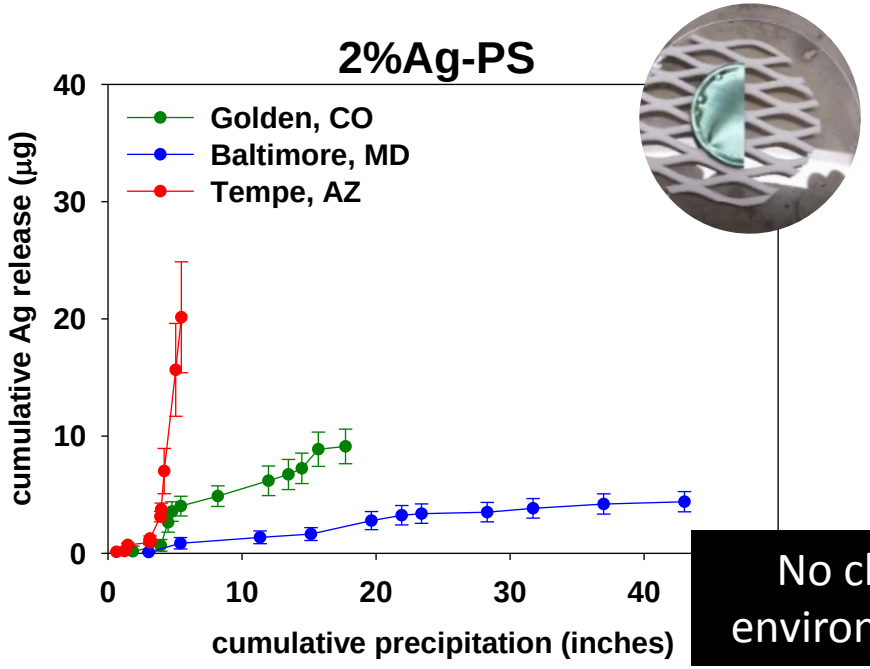


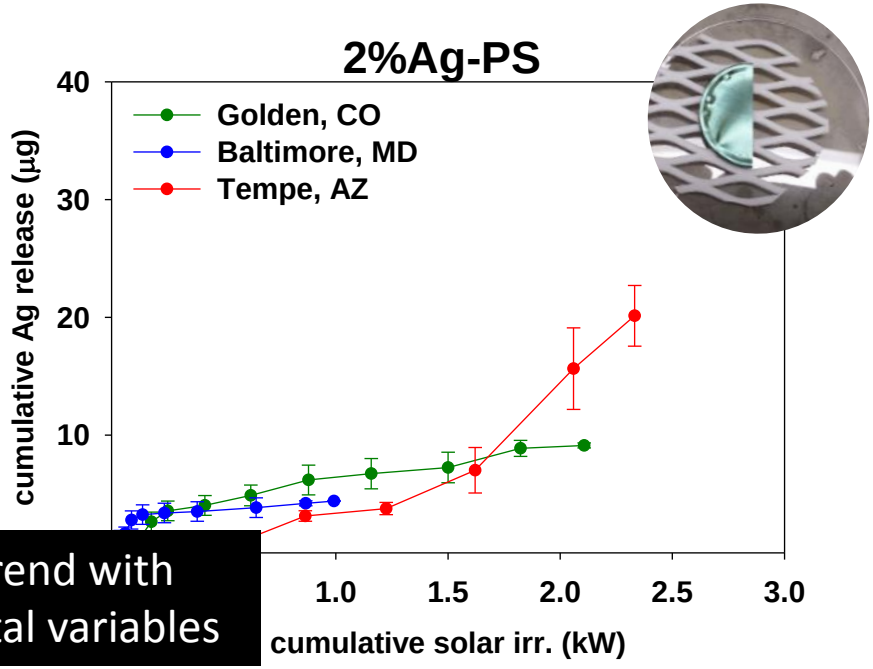


Results – Fractional Release from PNCs

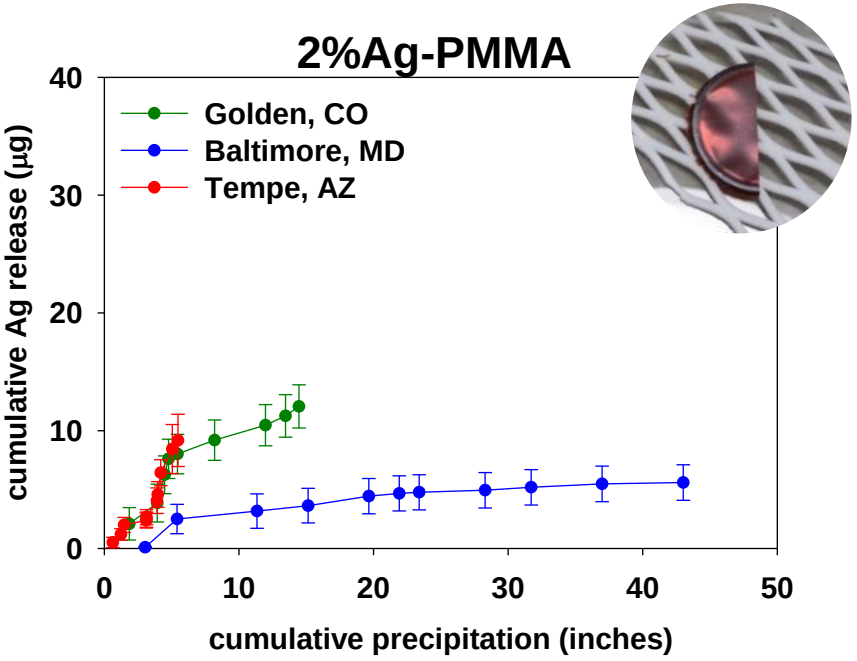


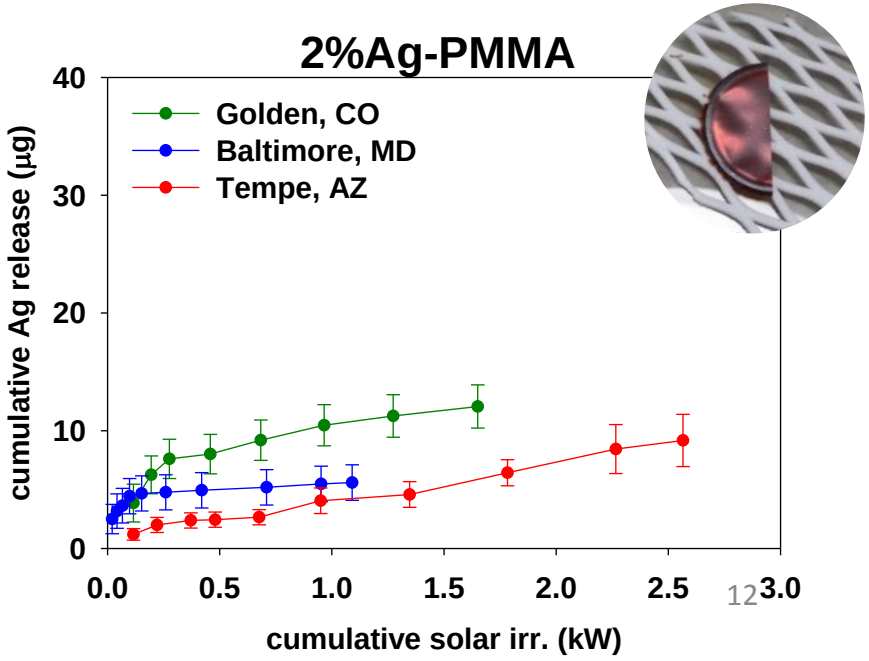
Results – Ag-PNC Release as a function of weather variables



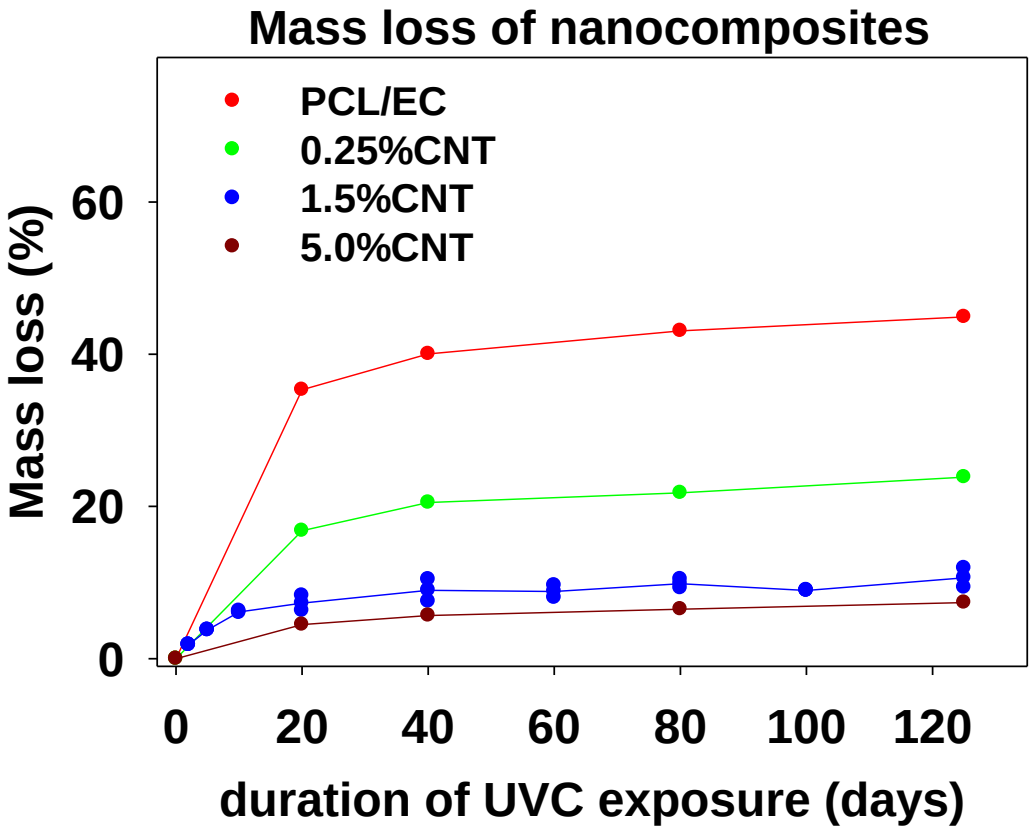


No clear trend with environmental variables

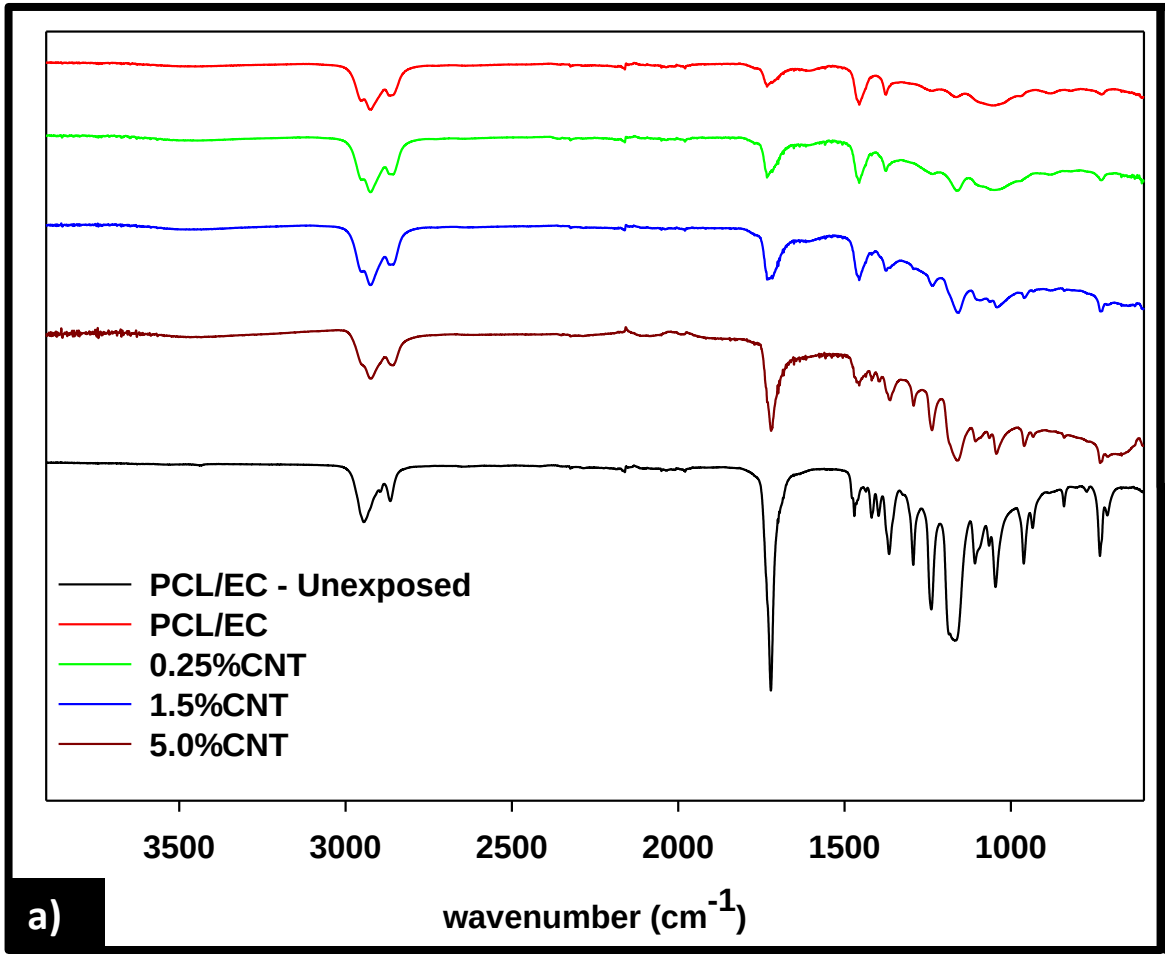


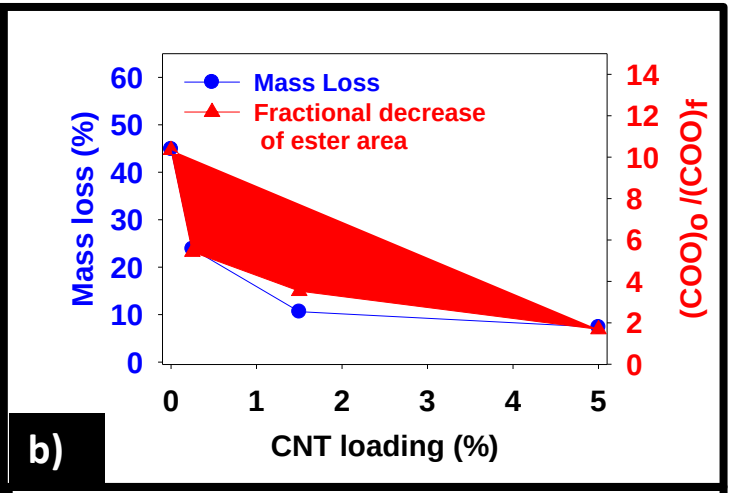


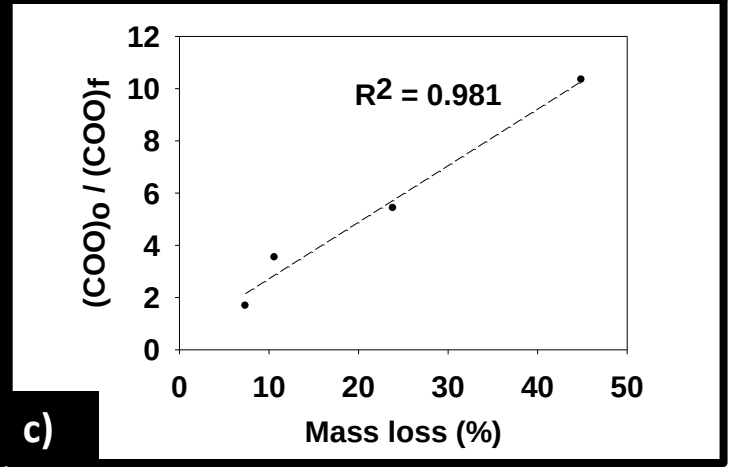
A slight sidebar:
Influence of CNT Loading



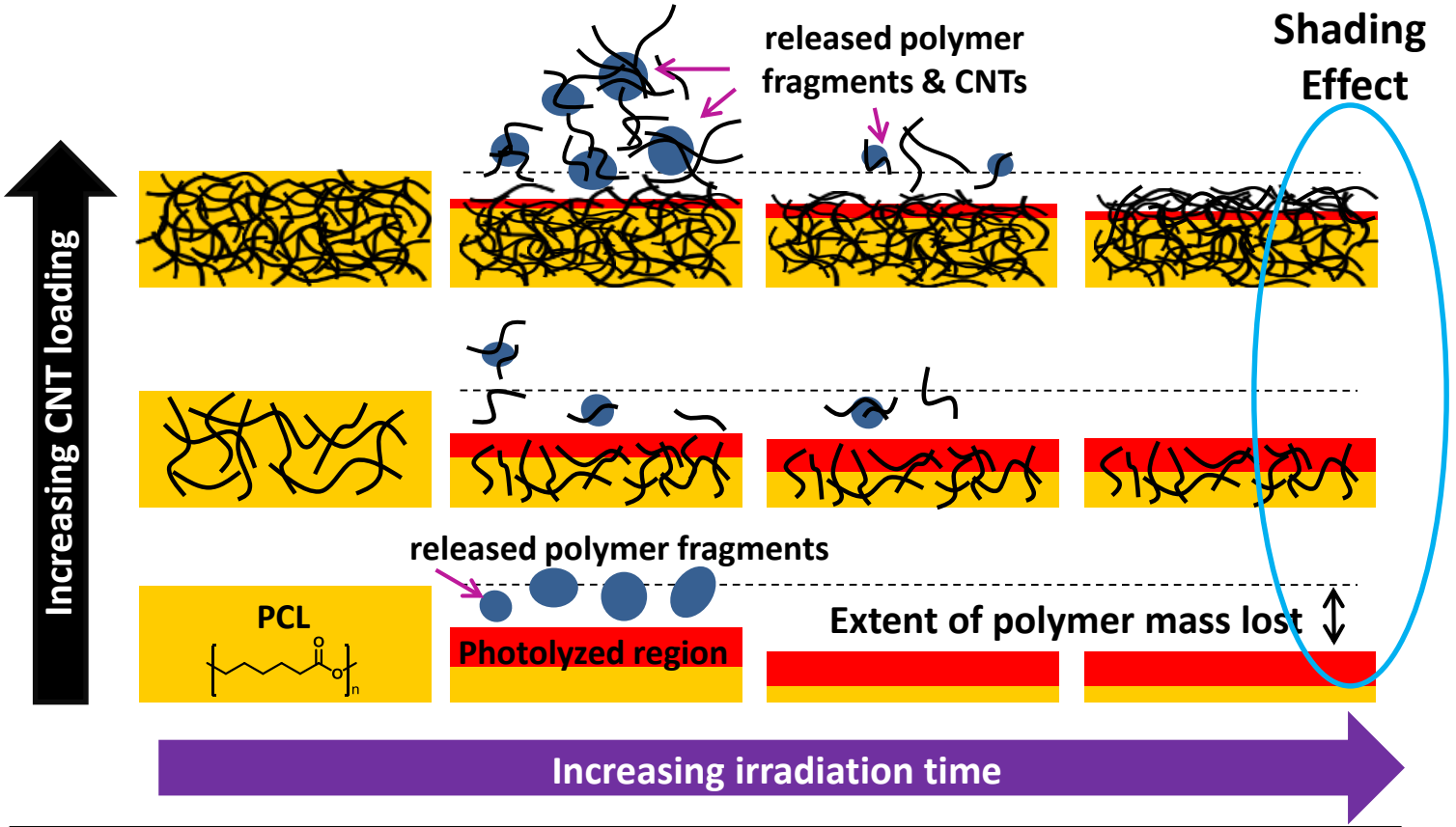
Mass loss of SWCNT-PCL nanocomposites with varying SWCNT concentration (%w/w) following incremental periods of irradiation with 254nm light.







(a) ATR-FTIR analysis of the nanocomposites shows a reduction in ester (1720cm^{-1}) intensity following 125 days irradiation. (b) Following 125 days of exposure, the final mass loss and fractional decrease of ester band area track similarly with increased CNT loading. (c) mass loss increases linearly with the fractional decrease in ester band area



Representation of how the interface of polymer-CNT nanocomposites evolve as photodegradation proceeds, as a function of CNT loading.

CNT release will NOT scale linearly with loading

Part 2 - Release from commercial products

Pressure treated lumber

Contains:
CuNPs & purchased from Home Depot

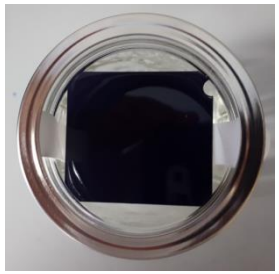
Blue pigment automotive paint

Contains:
CuNPs and provided by BASF

Wendel Wohlleben

CuNP – pigment

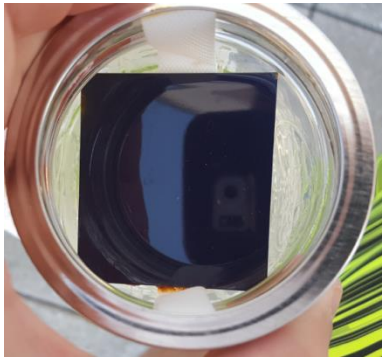
Initial Cu-pigment samples

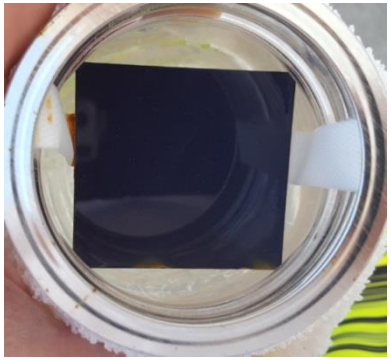


July	Blank	Cu-Sample	Reference
Golden, CO	0.8 +/- 0.5 ug	0.9 +/- 0.5 ug	0.7 +/- 0.2 ug
Baltimore, MD	1.7 +/- 0.3 ug	2.7 +/- 1.5 ug	1.5 +/- 0.2 ug

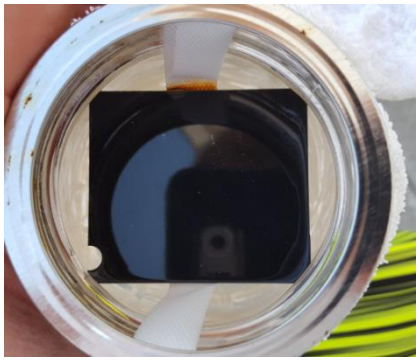
August	Blank	Cu-sample	reference
Golden, CO	0.3 +/- 0.1	0.4 +/- 0.1	0.4 +/- 0.1
Baltimore, MD	1.4 +/- 0.4 ug	2.7 +/- 1.8 ug	4.3 +/- 1.8 ug

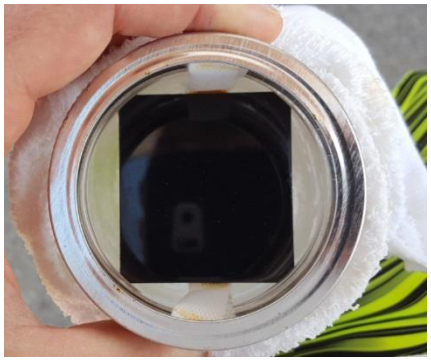
Cu-pigment samples following 2 months





Reference samples following 2 months

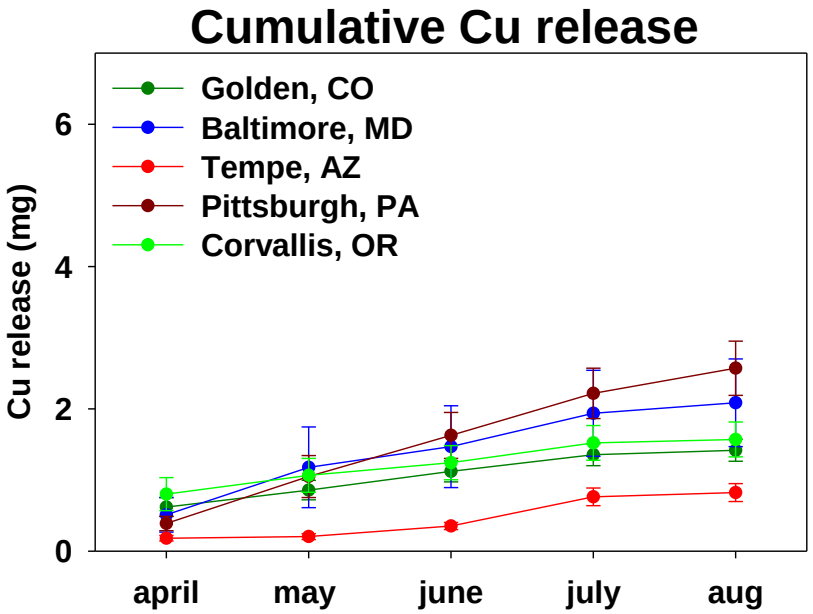


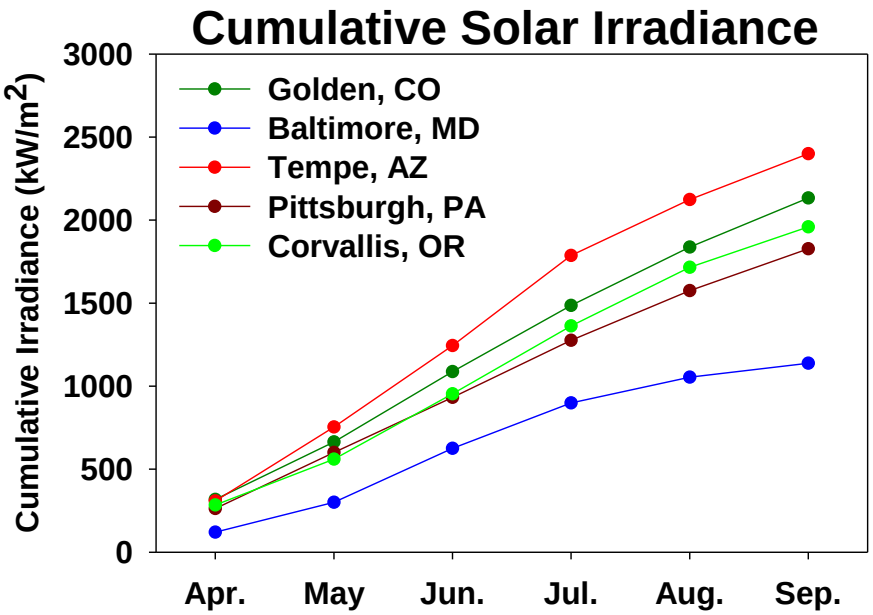


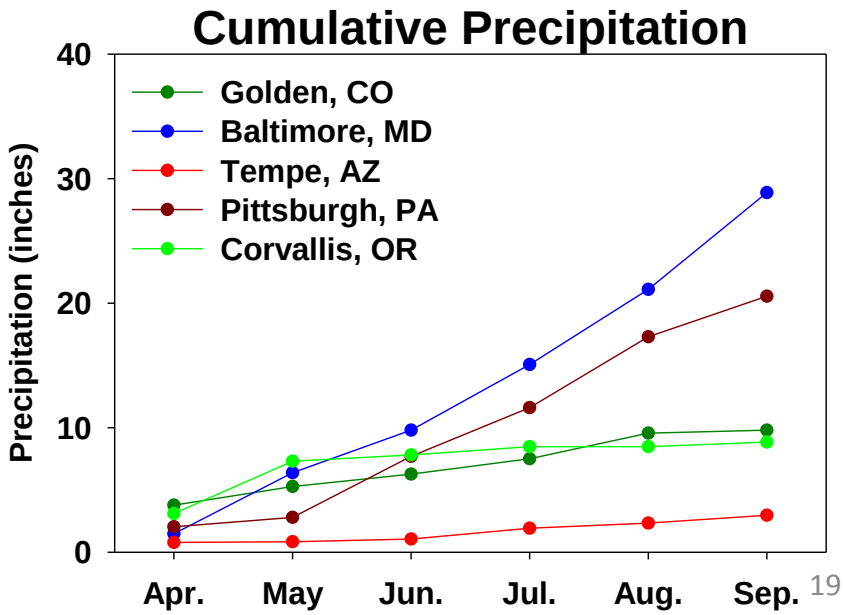
Background levels of Cu are much higher in Az

- Determining release of “naturally occurring NPs (e.g. Ti, Cu and Fe in some environments will be more challenging)

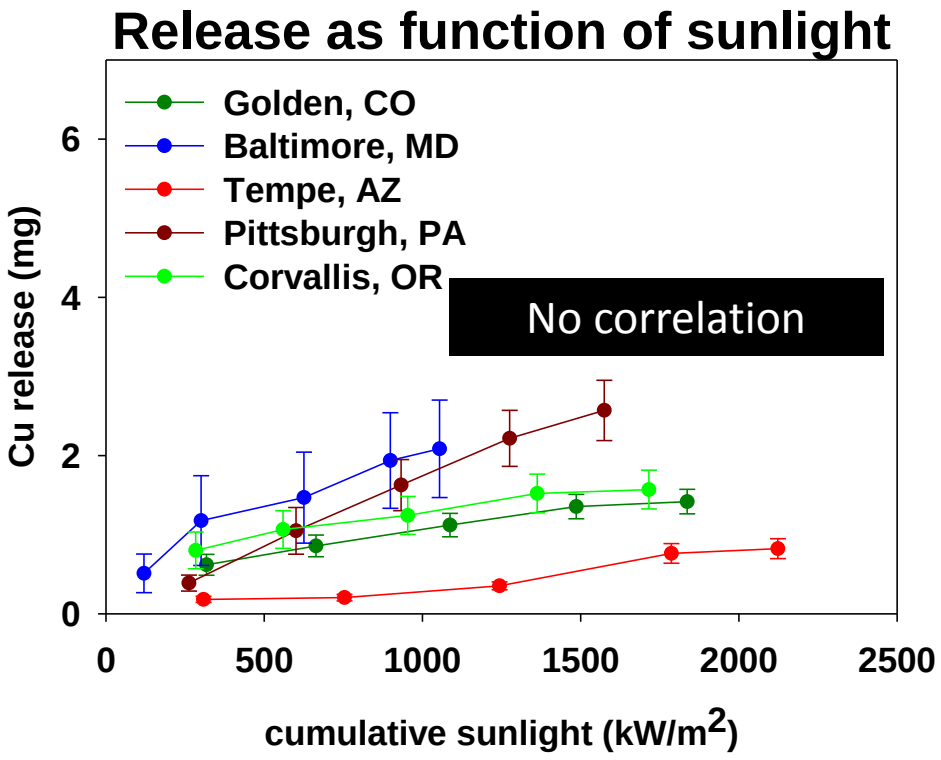
Release from Pressure treated lumber across the continental US

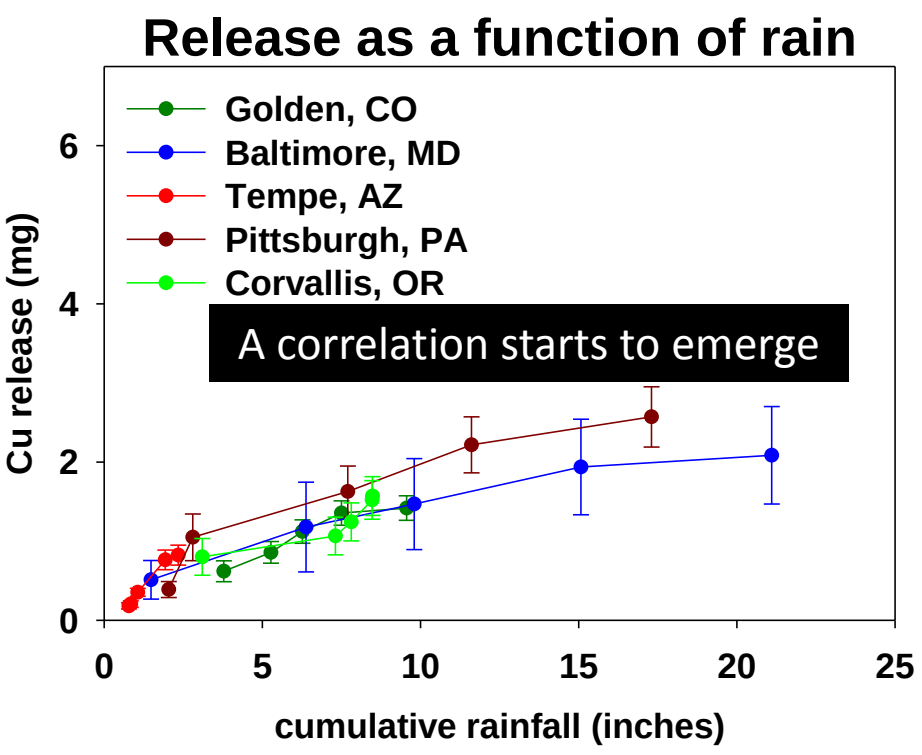






Release from Pressure treated lumber across the continental US – as a function of specific weather variables





Acknowledgements

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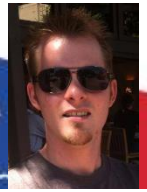

Mike Garland
OSU

Tatiana Zaikova
UO

Jingjing Wang
CSM

Leanne Gilberston
U Pitt

Greg Lowry
CMU

Paul Westerhoff
ASU

James Ranville
CSM

Yan Wang
U Pitt

Yuqiang Bi
ASU

Rob Reed
ASU & CSM

David Hannigan
ASU

Katie Challis
CSM

Ronald Lankone
JHU

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