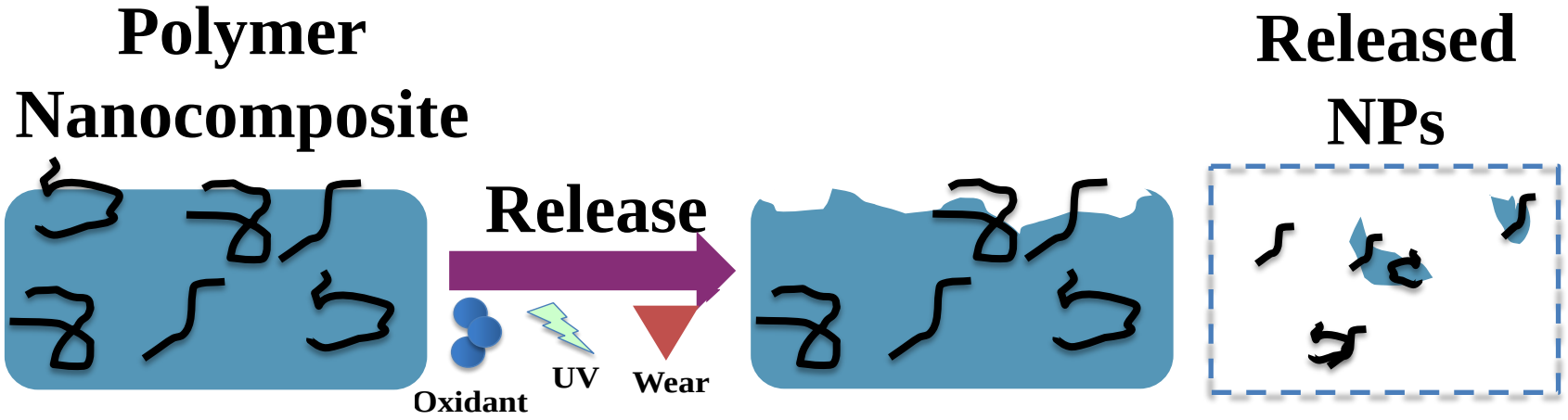
Nanoparticle release from polymer nanocomposites



Howard Fairbrother [1], James Ranville [2], David Goodwin [1], Ronald lankone [1], JJ Wang [2], Angie Barber[2]

1) The Johns Hopkins University
2) Colorado School of Mines

Overview

Introduction

Silver Release from Fabrics

Long-term Outdoor Weathering Studies

Accelerated Photolysis of SWCNT-Polymer Nanocomposites

- SWCNT Release and Detection

The Need for Model Systems

Why Study NP Release?

RISK = TOXICITY x EXPOSURE

NP toxicity is being studied by many...

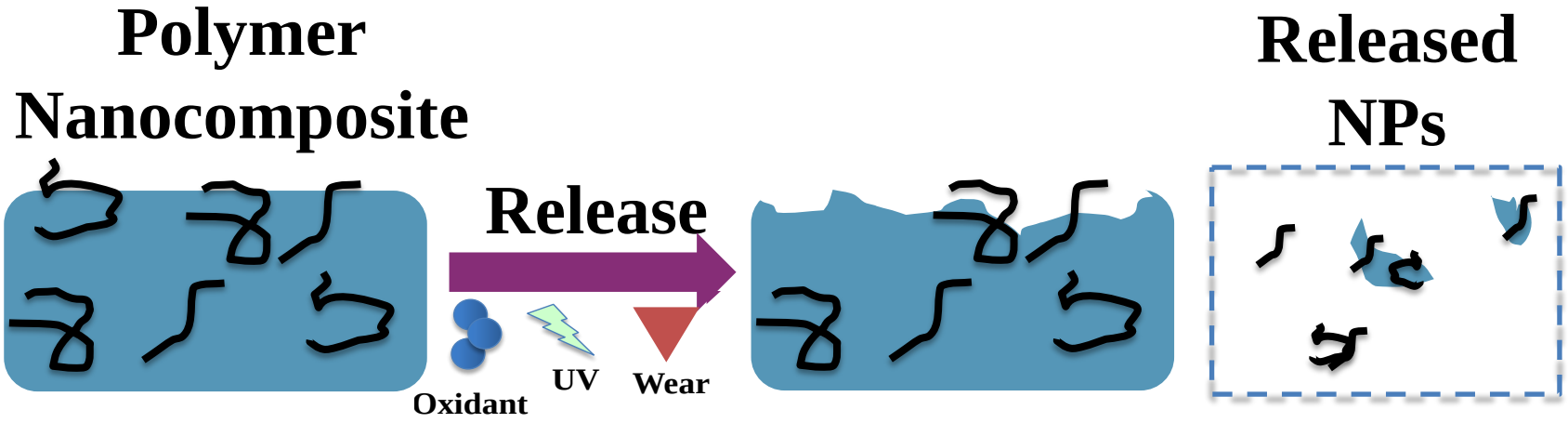
NP Exposure is not

Three Important Release Characteristics

Release Kinetics (time dependence)

Released Quantity

Released Form



~~Introduction~~

Silver Release

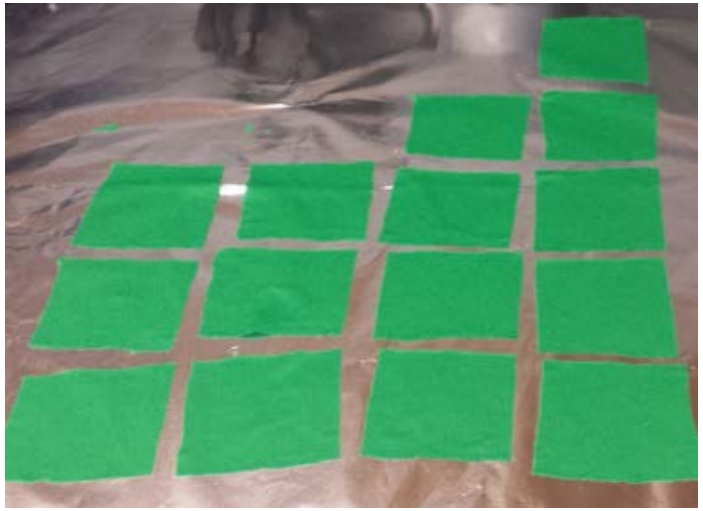
Out Door Weathering

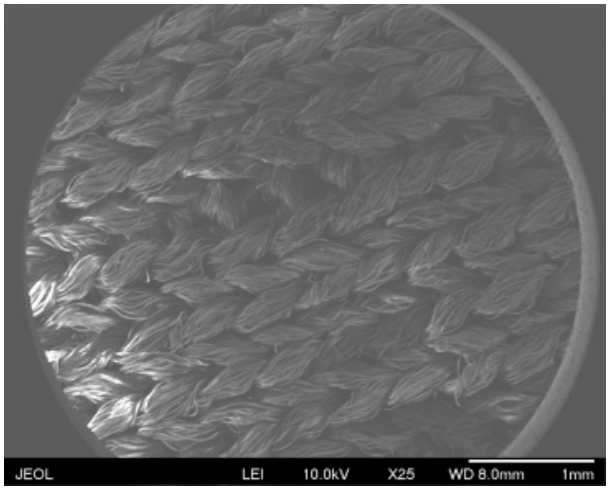
Accelerated Photolysis of SWCNT-Polymer Nanocomposites

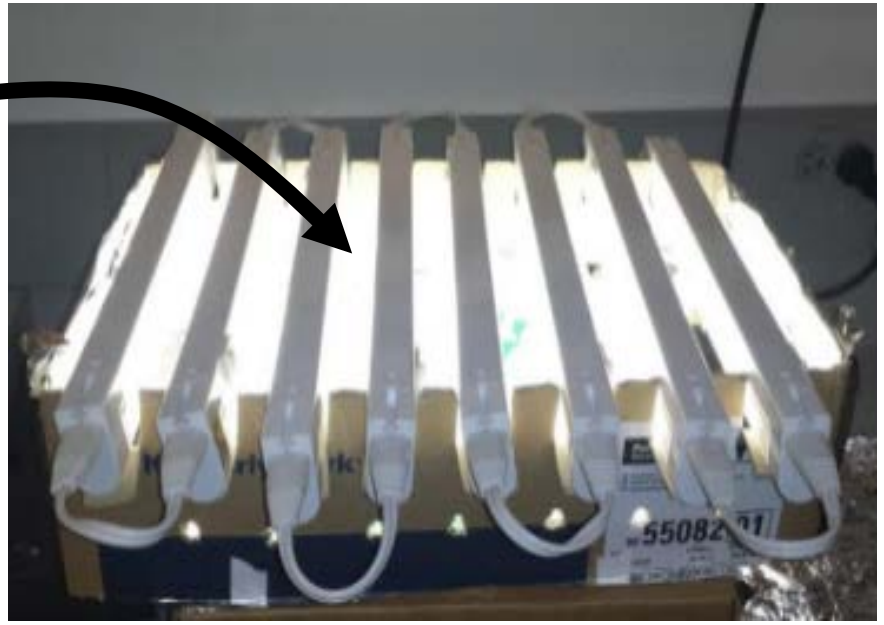
SWCNT Release

Silver Release

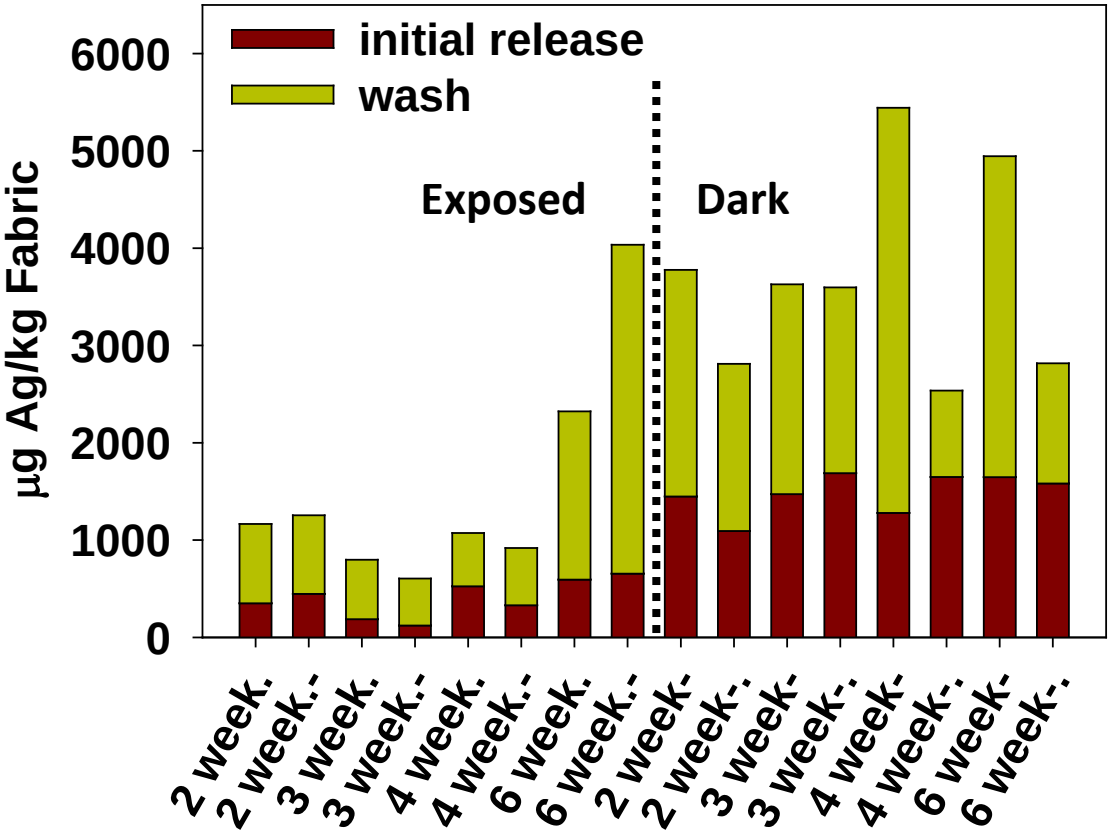
Effect of Photolysis on Silver Release from Fabrics







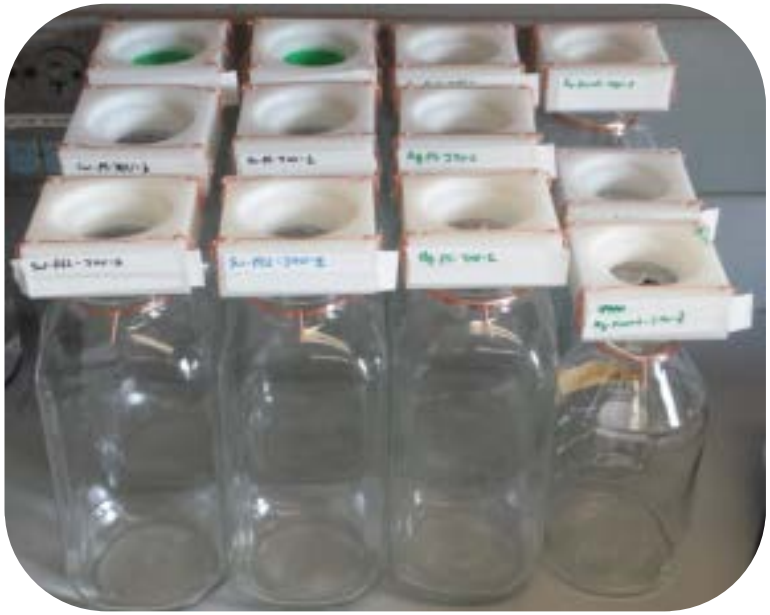
ICP-MS analysis shows that photolysis of nanotextile inhibits the initial relase of silver

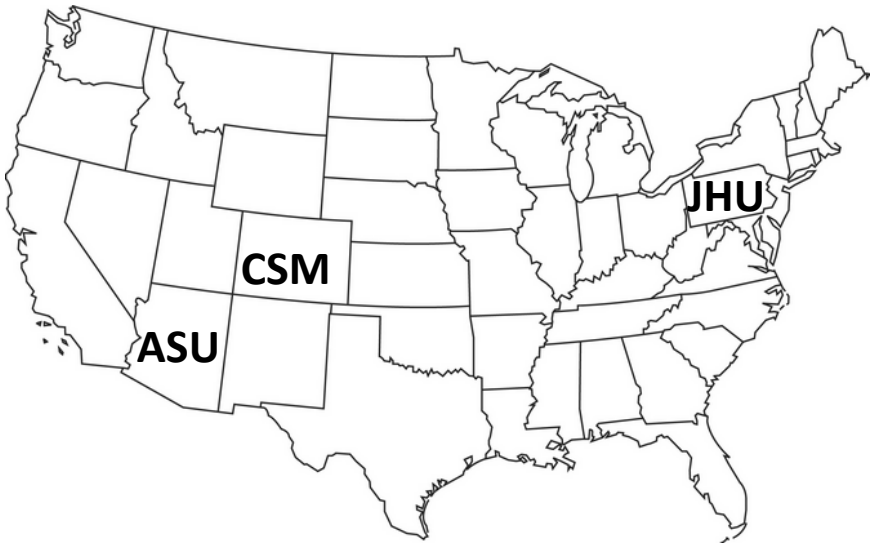


Out Door Weathering

Long Term Weathering Studies of Nanocomposites

Nanocomposite

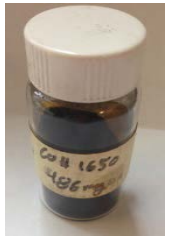




Accelerated Photolysis of SWNT Polymer Nanocomposites
- SWNT Release Characteristics and Detection

A Model System

Construction of Model CNT-Polymer Nanocomposites



CNT loading

Organic solvent

Polymer

Sonicate

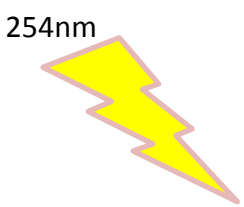
Pour

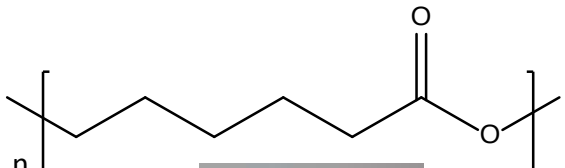
Dry

Construction of Model CNT-Polymer Nanocomposites

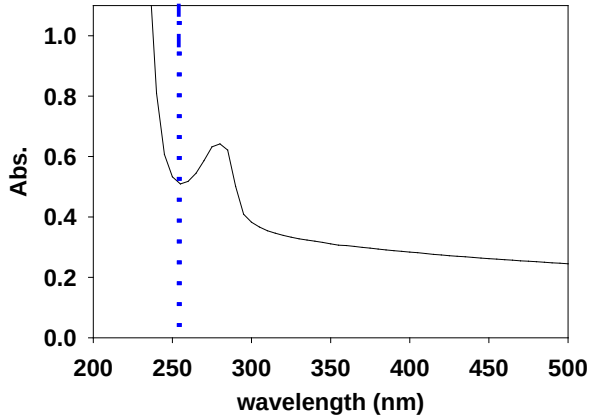
Accelerated Photodegradation Study:

pristine Single Wall Carbon Nanotube – polycaprolactone (pSWCNT-PCL) composites

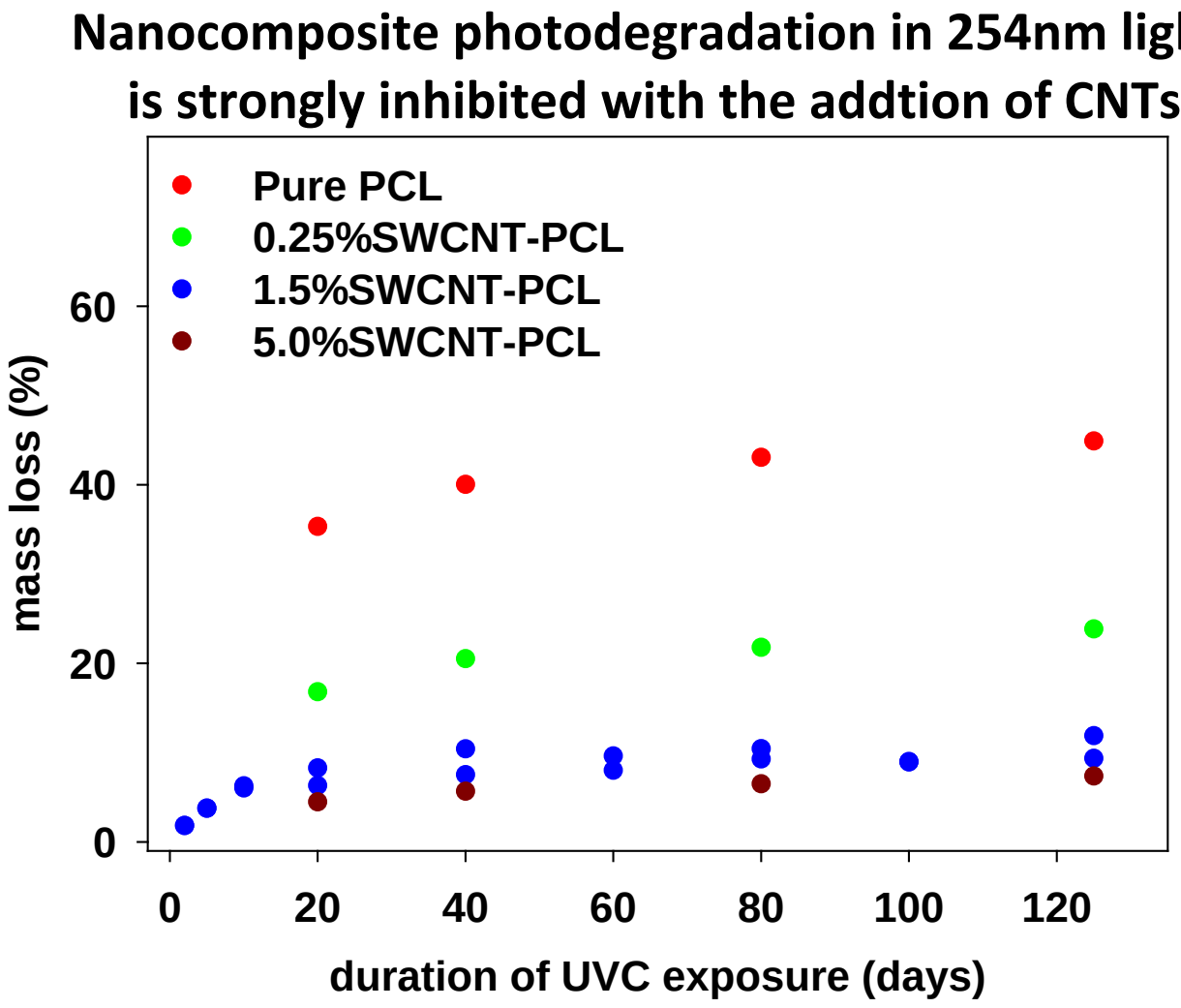




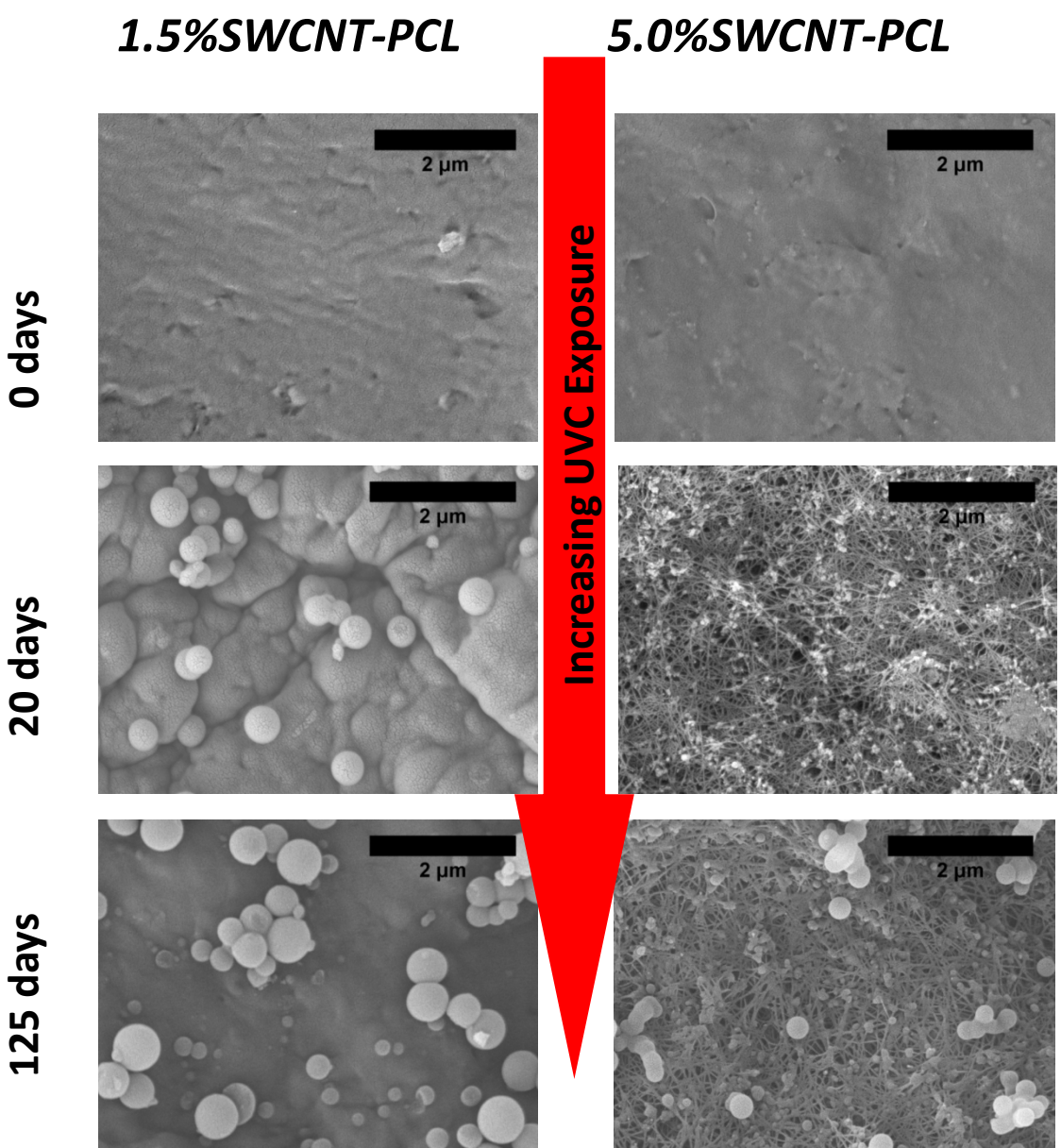
254nm light used in this study is absorbed strongly by poly-e-caprolactone



Photolysis of SWCNT-polycaprolactone nanocomposites



SEM imaging shows high concentration (5% w/w) of CNTs are required to for accumulation at the surface to occur

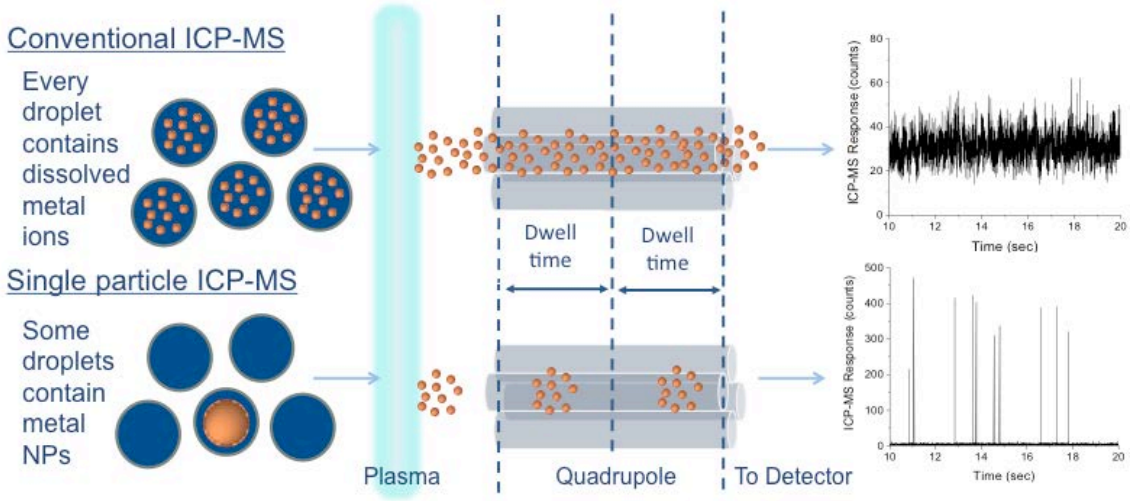


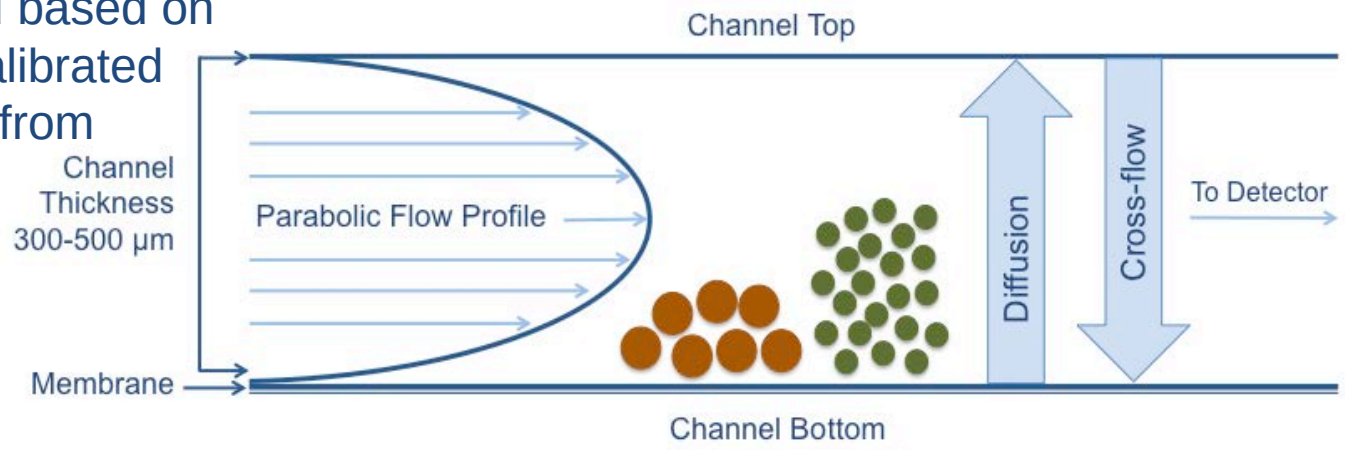
Detection of CNTs

Single particle ICP-MS (spICP-MS) detects NPs particle-by-particle The number of pulses is related to the particle **number concentration.**

Intensity of the pulse is related to the **particle mass** (and size with assumed shape and density).

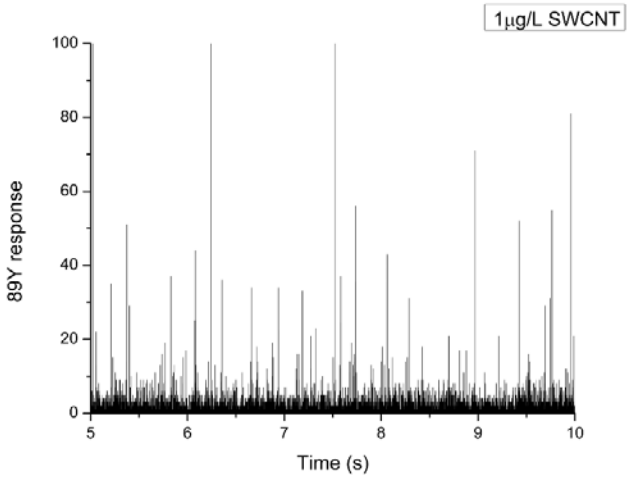
AF4 separates NPs based on their **hydrodynamic diameter** Size can be determined based on retention times when calibrated (can also be computed from theory)



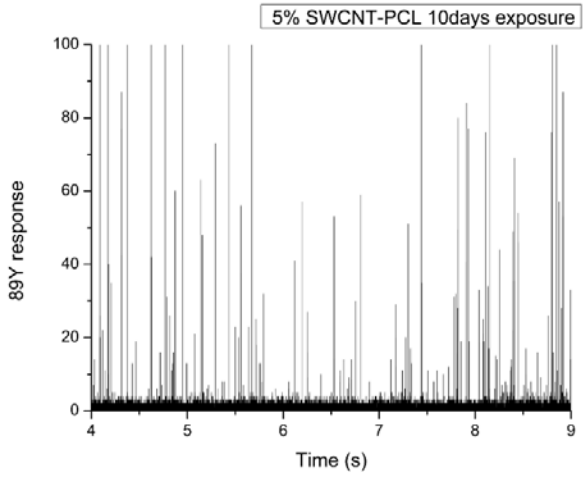


sp-ICP-MS Analysis of SWNCTs

Analysis of SWCNT suspension

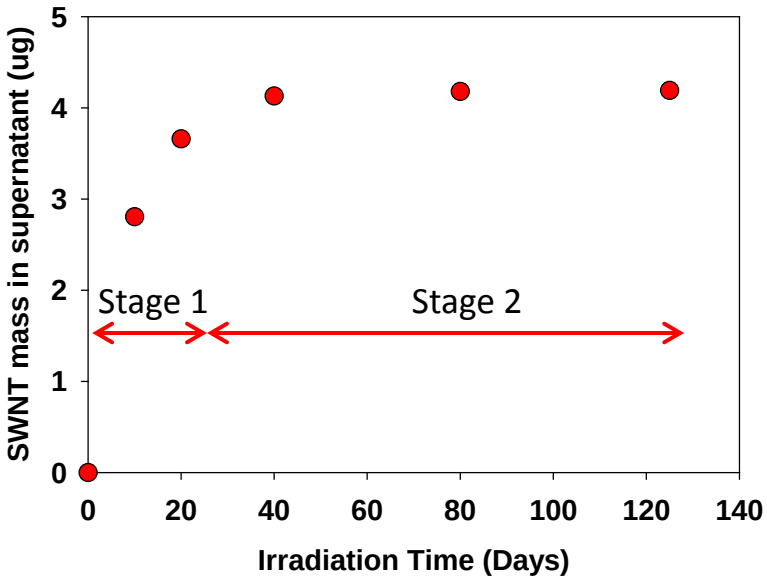


Analysis of SWCNT-PCL release supernatant

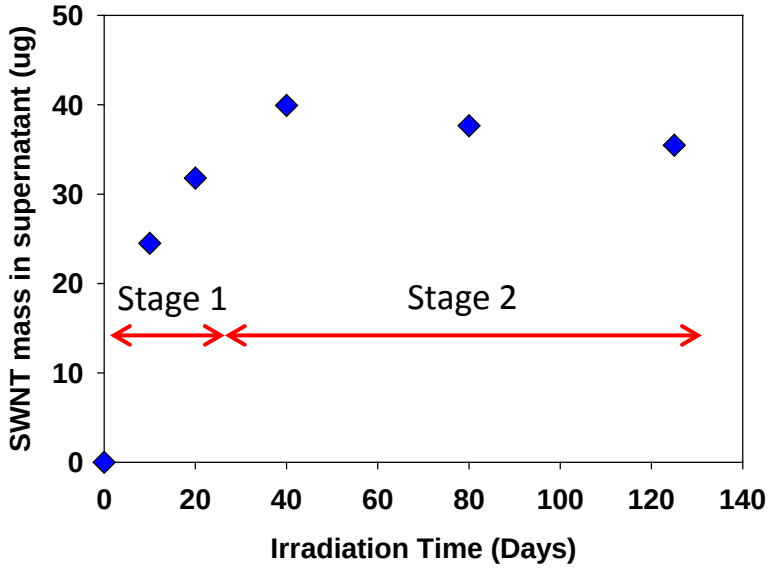


Release Kinetics of CNTs from Polymer Nanocomposites

0.25 % CNT /PCL



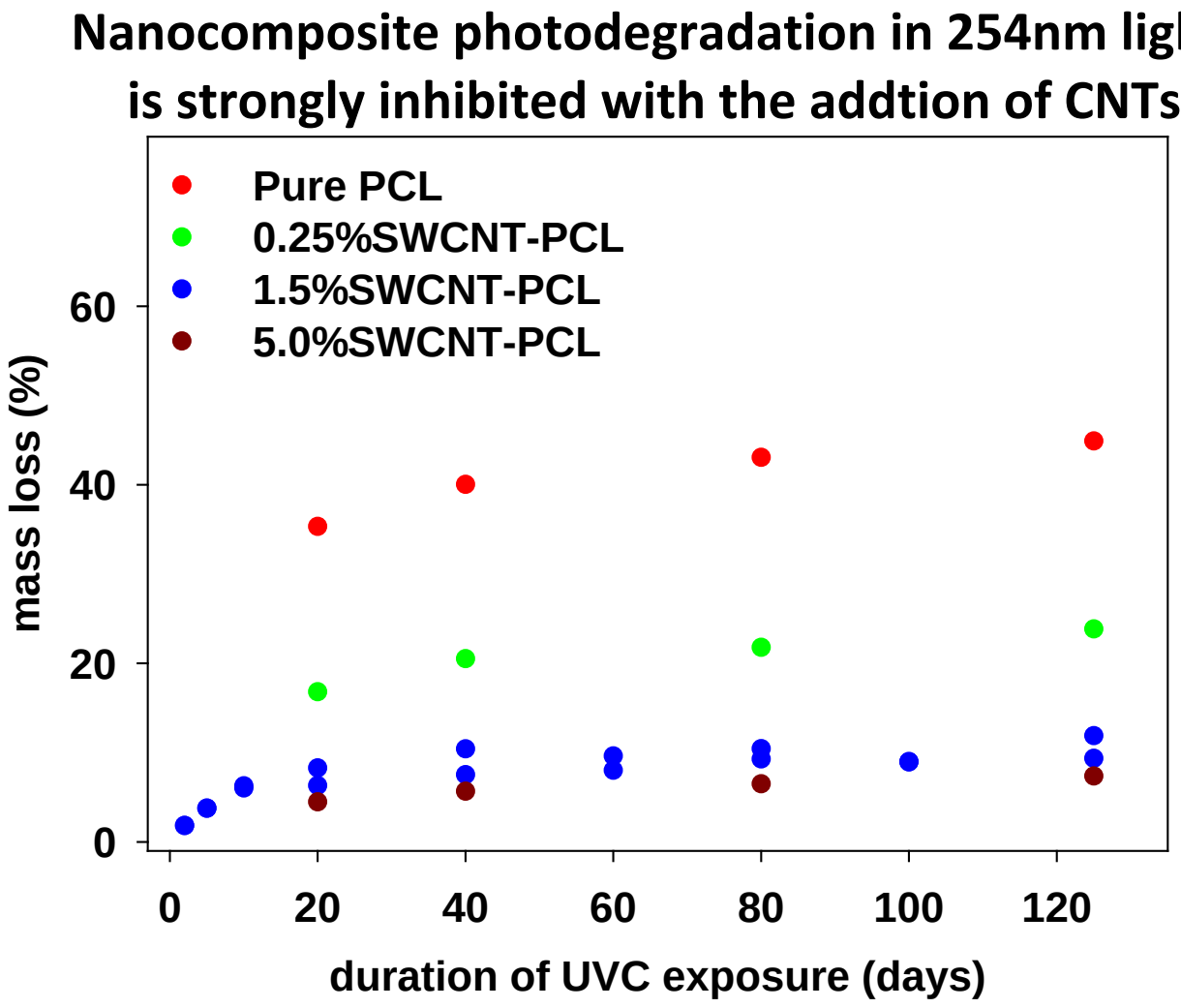
5% CNT/PCL



Stage 1: Initial CNT Release

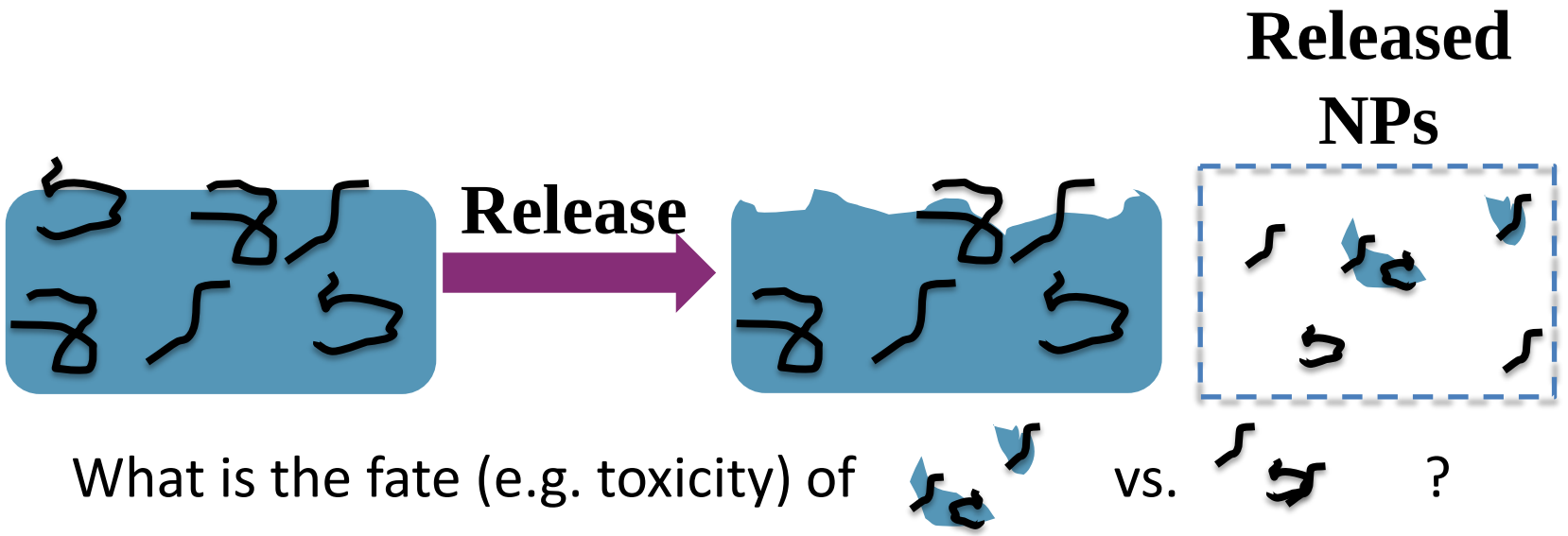
Stage 2: No further CNT Release

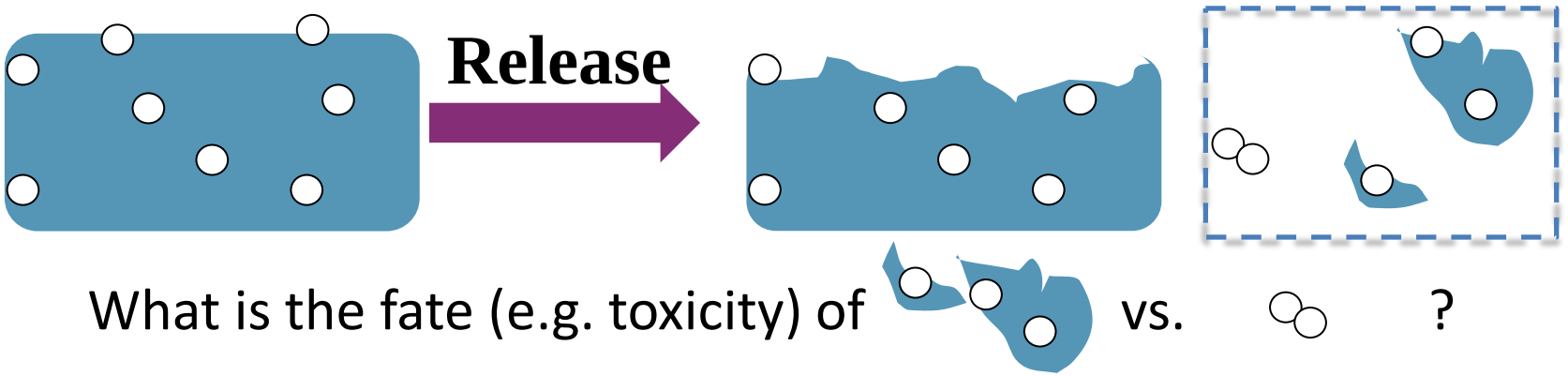
Photolysis of SWCNT-polycaprolactone nanocomposites



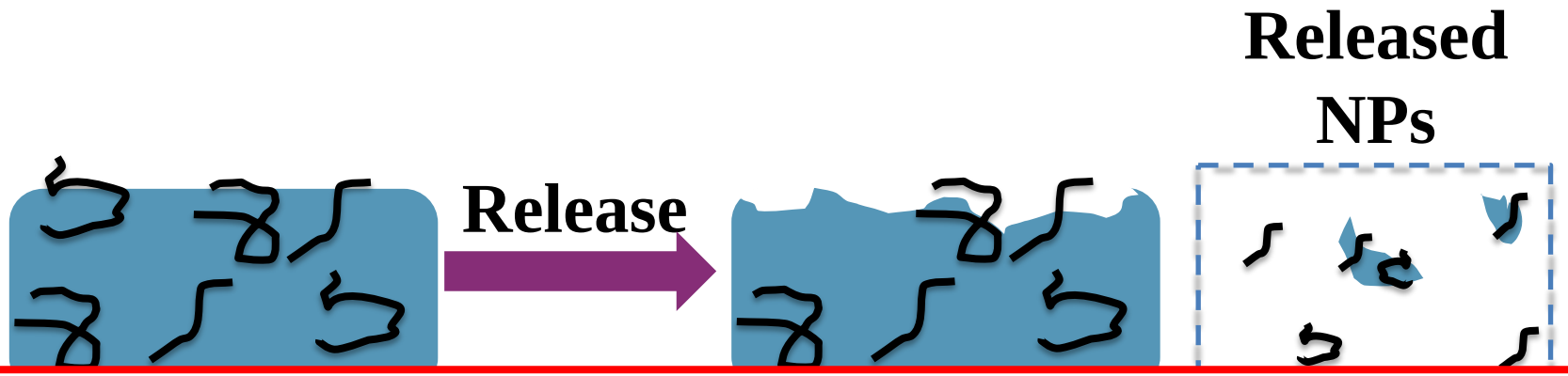
The Need for Model Systems

NP Release from Polymer Nanocomposites: Unresolved Questions

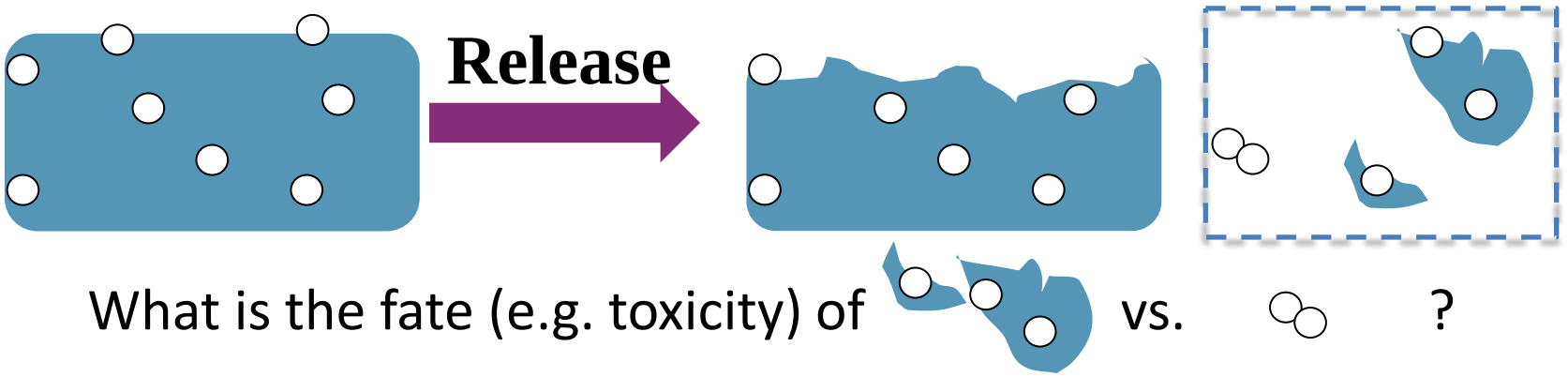




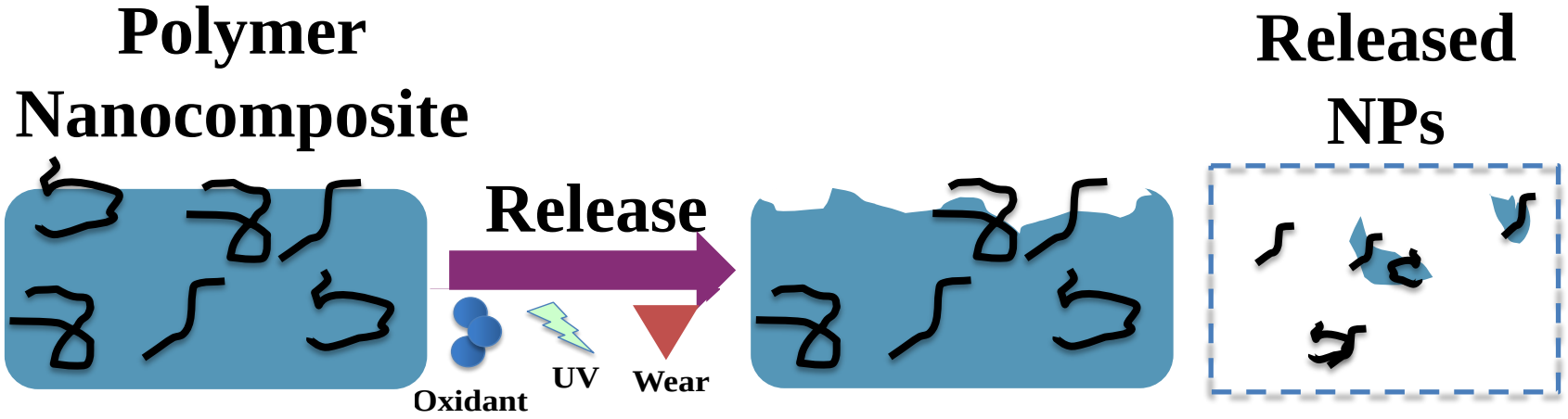
NP Release from Polymer Nanocomposites: Unresolved Questions



The Biggest Issue is Characterization of Released Materials and the Difficulties in Generating Enough (Release Quantities are Small)



NP Release from Polymer Nanocomposites: Unresolved Questions



What is the yield of  vs.  and how will it depend on (i) polymer characteristics and (ii) potential release scenario?

To develop a fundamental understanding we need model composites and well-defined potential release scenarios. To date almost all studies have been performed on commercial products.

Why Do We Need Model Systems?

- The number of potential polymer nancomposites and release scenarios are almost limitless. In a model approach:

- Polymer nanocomposites can be prepared with well-defined and systematically varied characteristics (e.g. NP loading and type)

- Consequently studies on model systems have the potential to allow us to develop ***predictive capabilities***

Why Do We Need Predictive Capabilities?

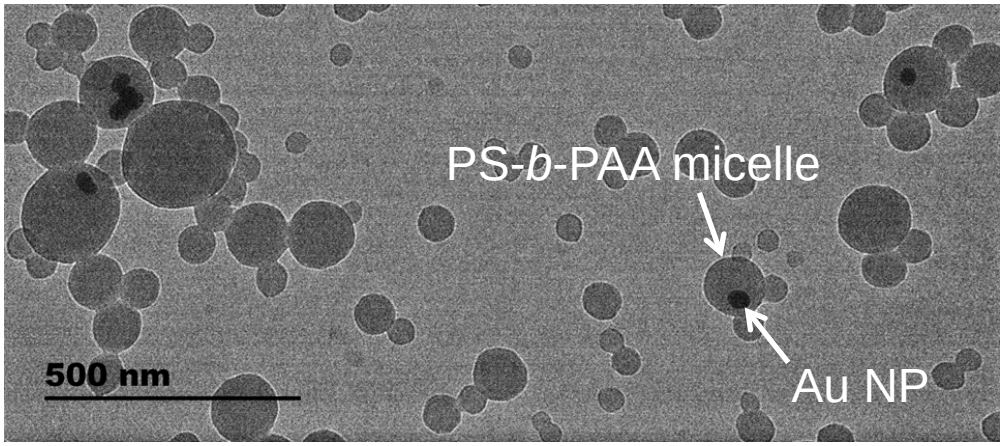
- Predictive Capabilities could allow us to:
  - Estimate release characteristics (released quantity, rate, and type) based on knowledge of the polymer and the NP under a given release scenario.
  - Or in other words… if we know the behavior of the polymer in a given release scenario and we know the details of the NP and nancomposite, such as NP loading, can we predict release characteristics?
  - Predict release properties for nanocomposites *a priori*

Acknowledgements:

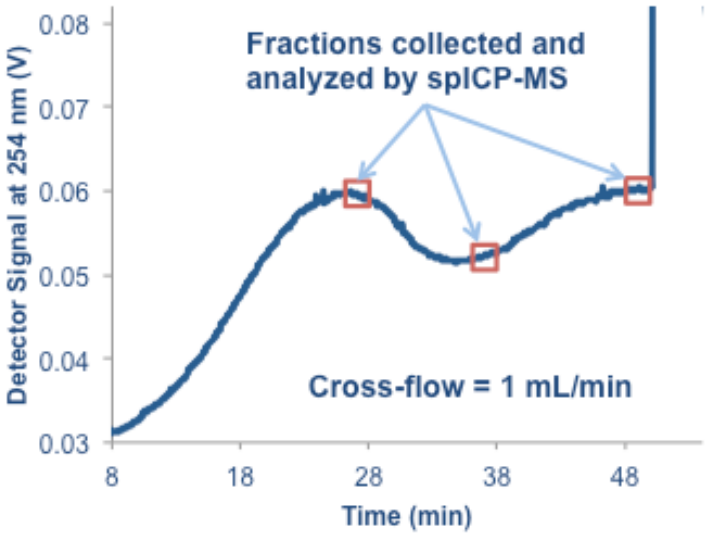
This research is funded by
U.S. EPA - Science To Achieve Results (STAR) Program
Grant #

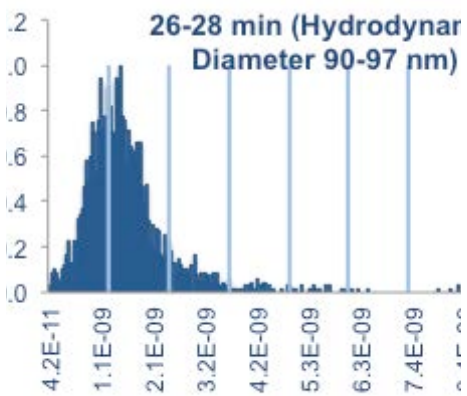
Model Systems: Polymer –Au composites as model particles for released polymer fragment/ENP

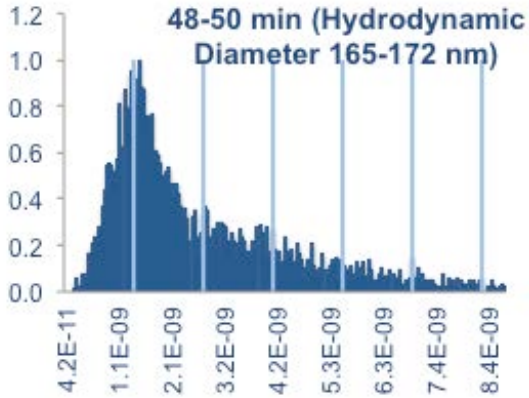
Synthesis: 50 nm Au NPs were incorporated into amphiphilic block copolymer PS-*b*-PAA micelles by self assembly in a microfluidic reactor.



The Au-PS-*b*-PAA NP was analyzed by spICP-MS and AF4-UV-vis. Fractions collected during AF4 analysis were analyzed by spICP-MS.







Larger polymer particles contain more Au NPs