Surface Modification and Characterization of Nano-Composite Polymers

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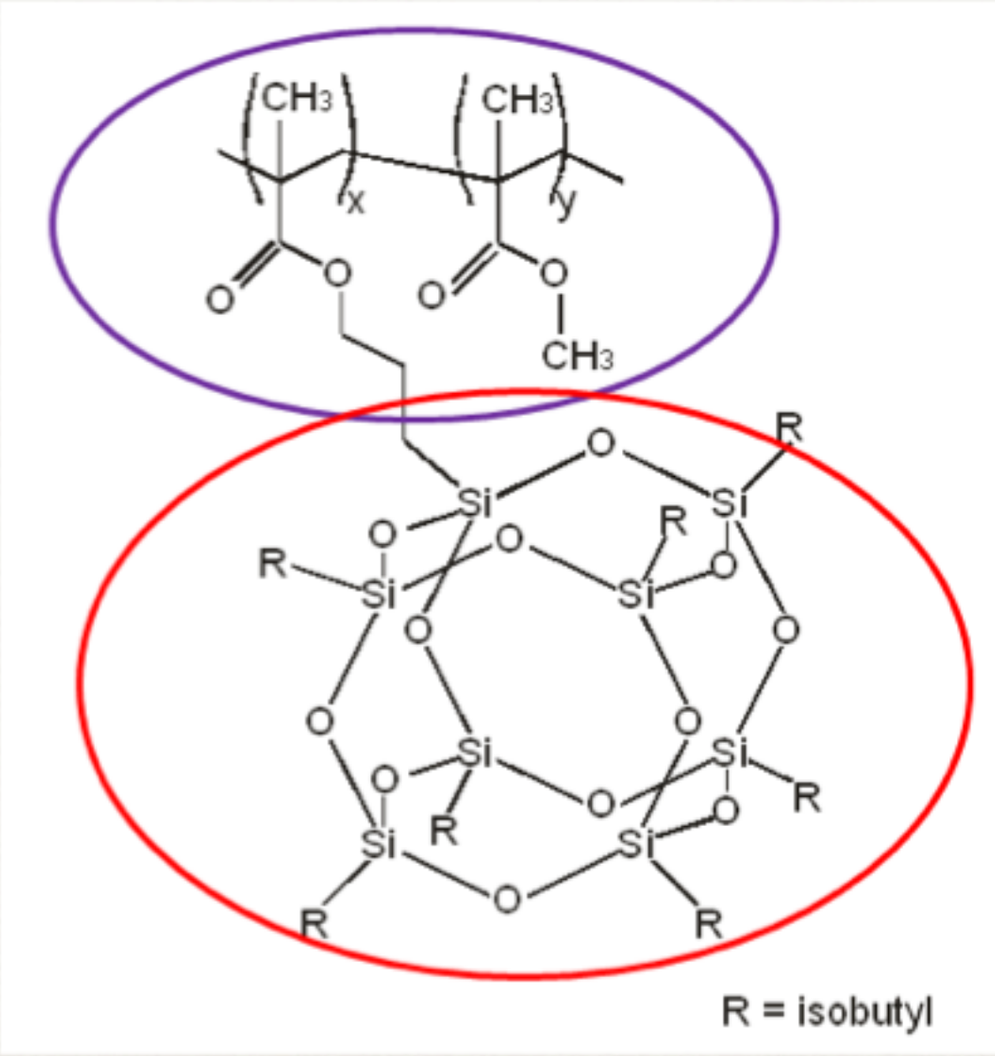
Outline

- Nano-Composite POSS-MA/PMMA
- Time Evolution of Surface Structures
- Adhesion Promotion of Metals on PMMA

POSS-MA/PMMA

PMMA Backbone



POSS Cage

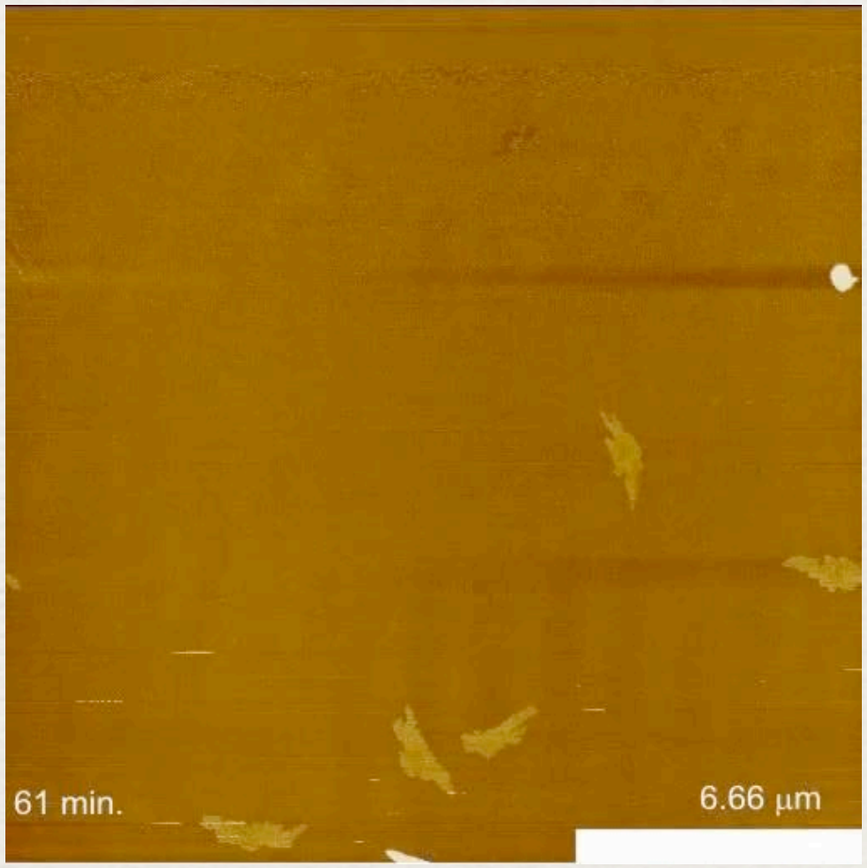
poly[(propylmethacryl-heptaisobutyl-polyhedral oligomeric silsequioxane)-co-(methylmethacrylate)]

Sample Prep

- Oxidized silicon wafers using a tube furnace at 1000°C for 4 hours.
- Cleaned 1 cm x 1 cm SiO_2 samples with acetone, isopropanol, and water using ultrasonic cleaner. Dried thoroughly with N_2.
- Spun-cast 0.2 - 0.3 mL POSS-MA dissolved in $CHCl_3$ using a 0.2 µm syringe filter onto clean substrates at 1000 rpm spin speed.

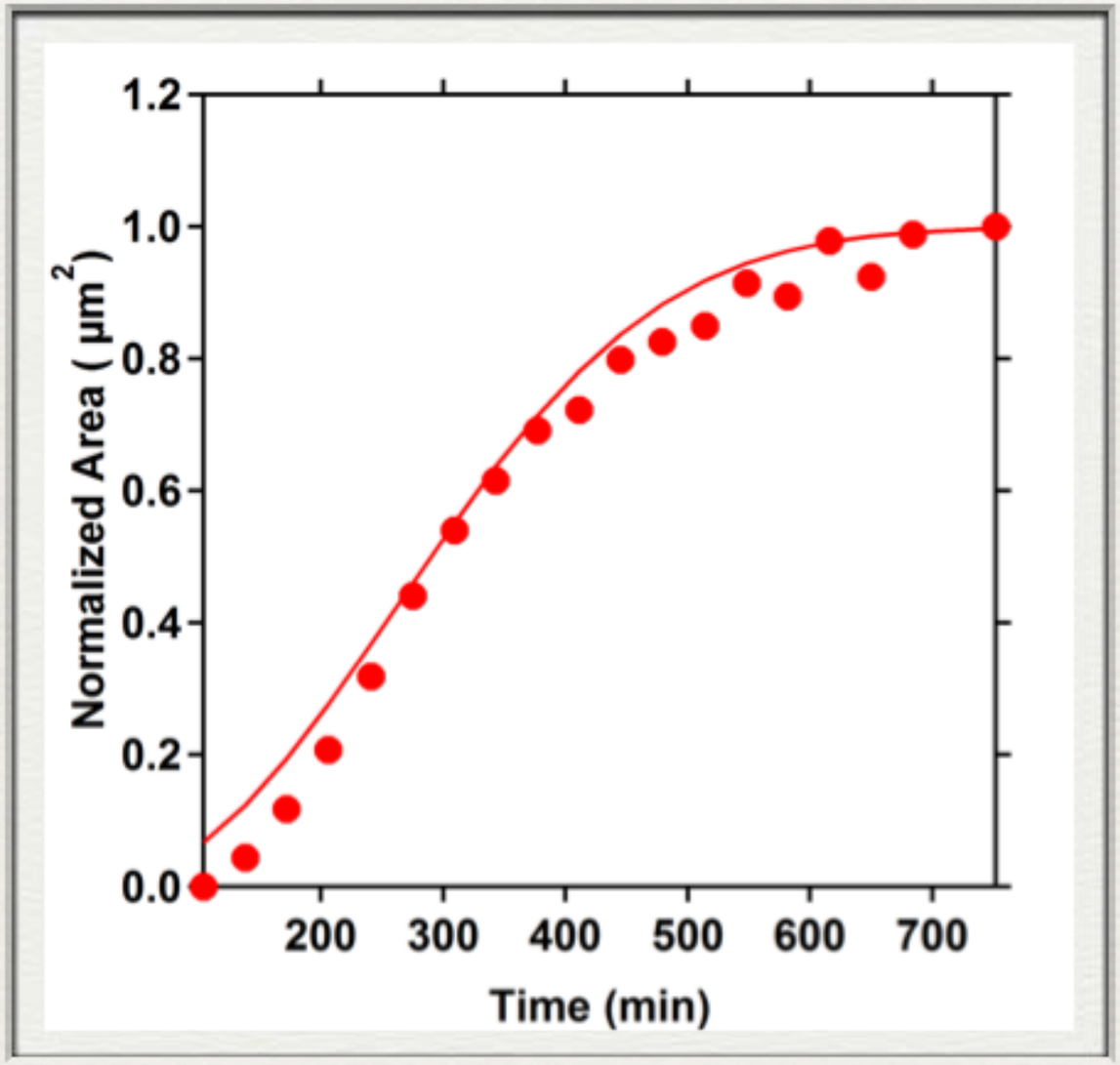
AFM Imaging

- Smooth surfaces were seen for low POSS wt% thin films.
- 45 wt% POSS films had micon-sized features on surface.
- 30 wt% POSS films showed an distinct evolution of structures over the space of hours.



Determining Kinetics

- Attempts have been made to determine the area of the growths as a function of time.
- Should fit to an Avrami relationship.
- Secondary growth was observed.



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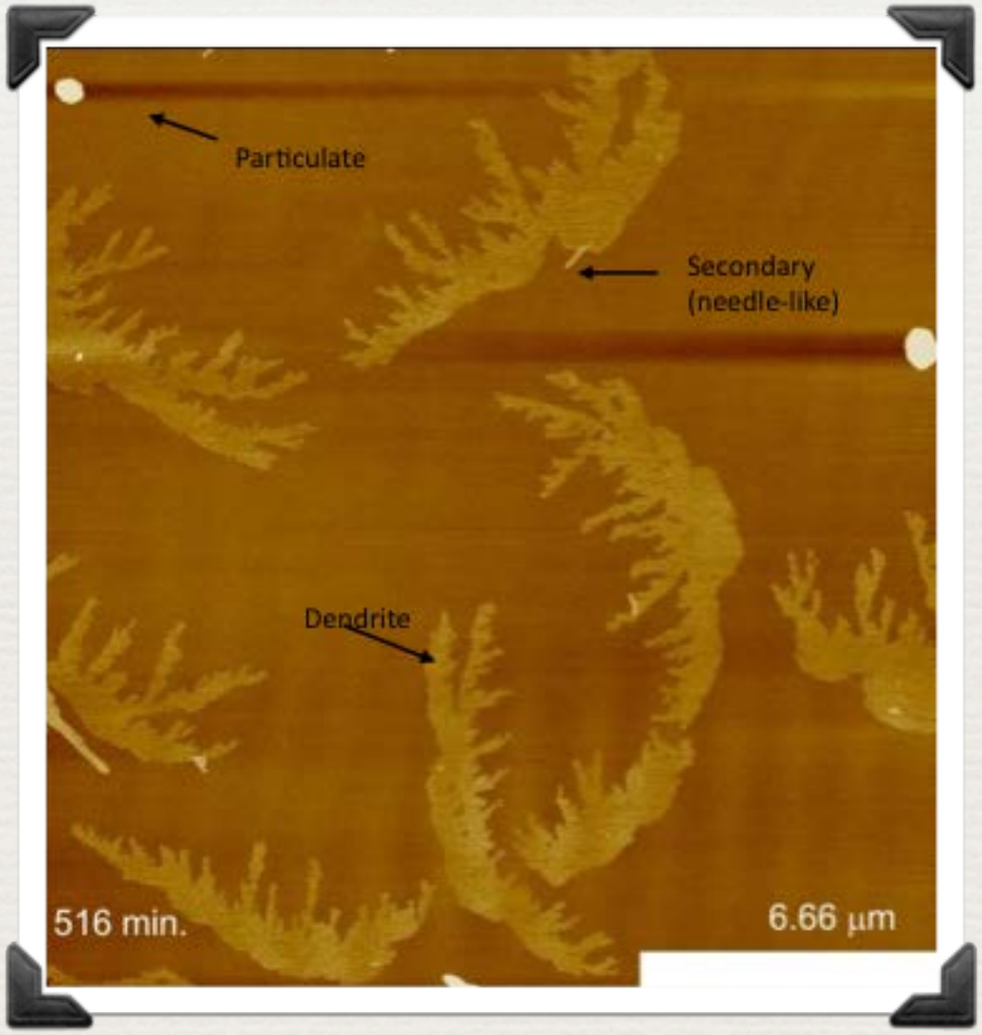
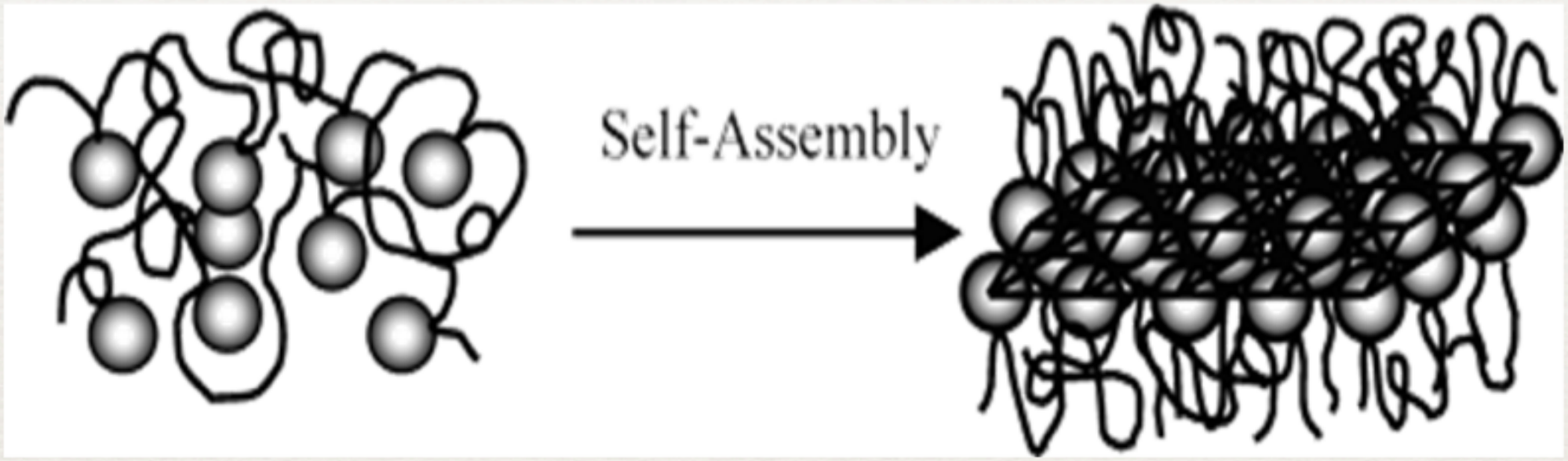


Possible Model

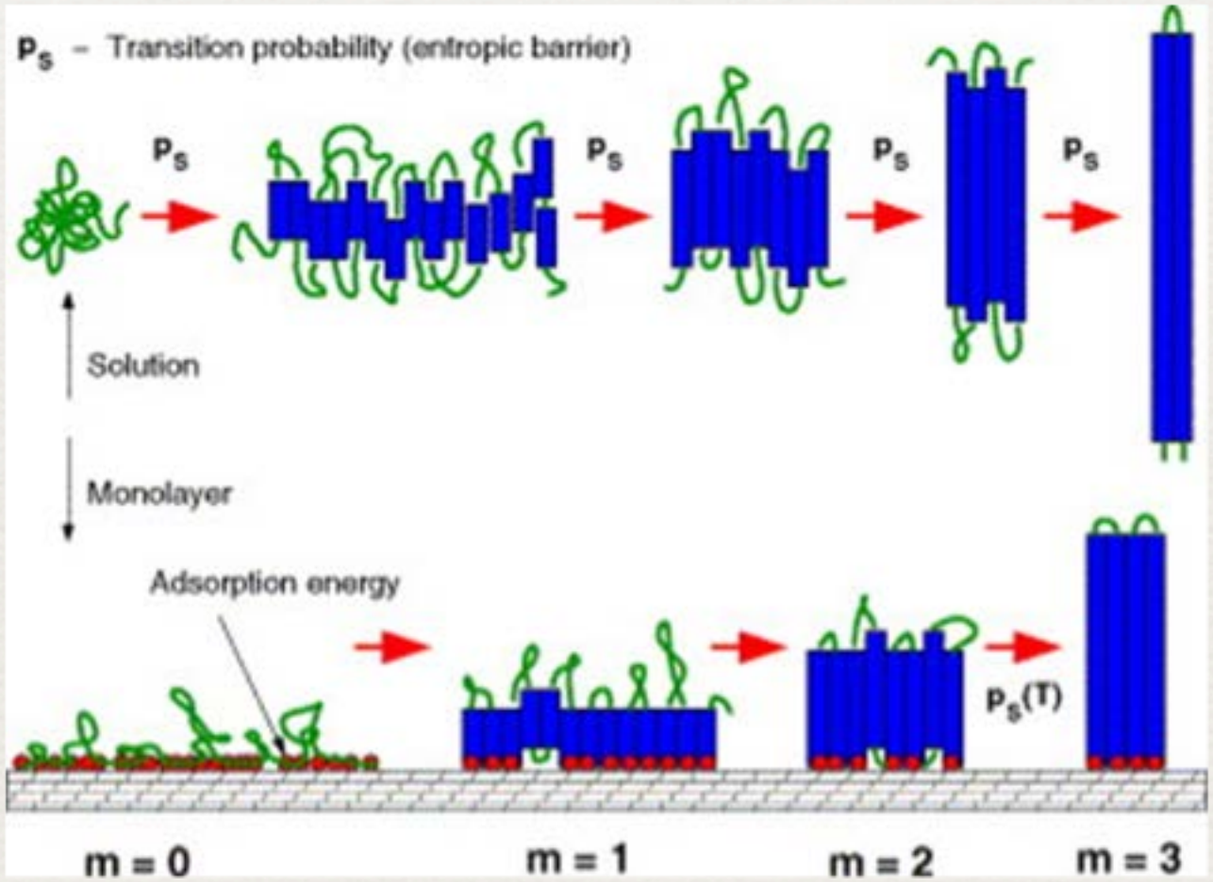
- At the moment, we aren’t sure what these structure are...
  - crystallization
  - phase separation
  - impurities

Possible Model



Zheng, et al., “Polymer Nanocomposites through Controlled Self-Assembly of Cubic Silsequioxane Scaffolds”, *Macromolecules*, **37**, (2004), 8606-8611

Possible Model



Sommer, J-U; Reiter, G.; “Crystallization in ultra-thin film polymer films: Morphogenesis and Thermodynamical Aspects”, *Thermochemica Acta*, **432**, (2005), 135-147

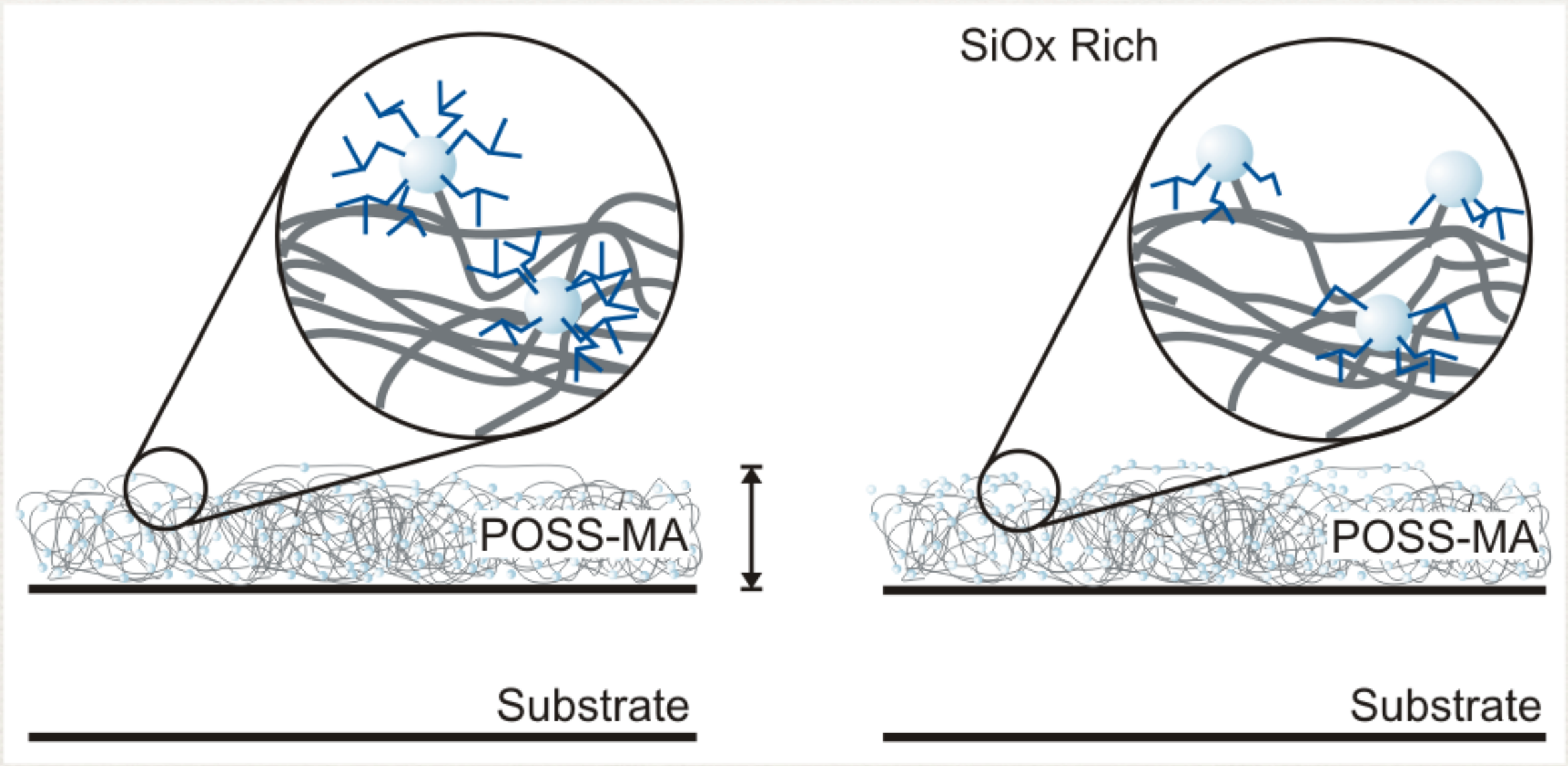
Standard Method for Au Adhesion on SiO_2

How to make this work on PMMA?

Our Model

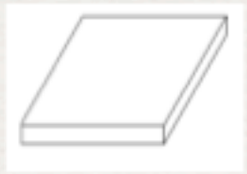
As-deposited

After Oxygen Plasma Exposure



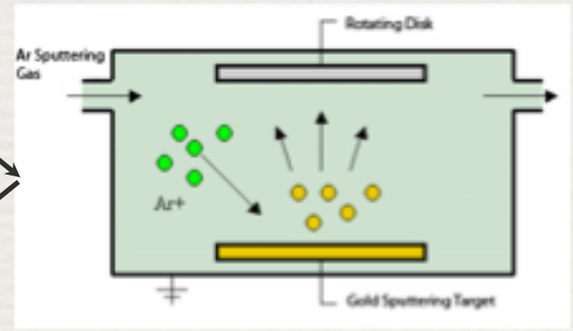
Tape Testing for Adhesion

PMMA Substrate (1 in x 1 in)



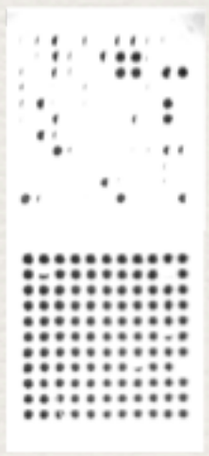
Spin cast solvent (1000 rpm, 1 min)

Sputter deposit metals (1 nm Cr; 54 nm Au)

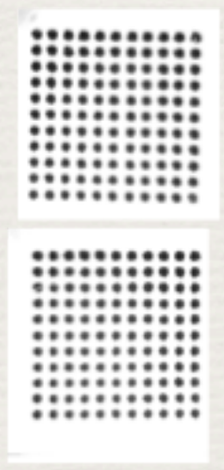


Control

$CHCl_3$



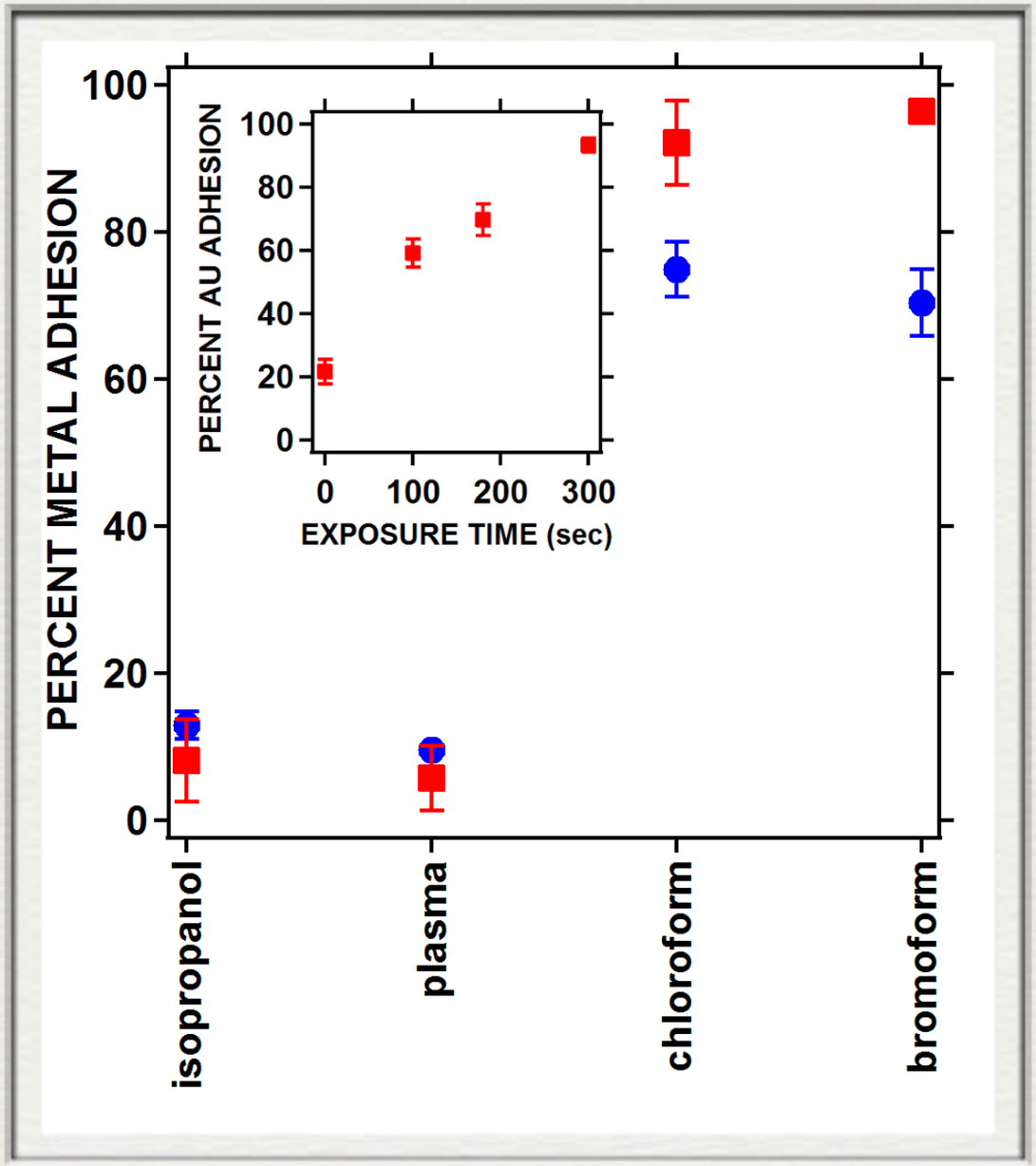
Tape Test



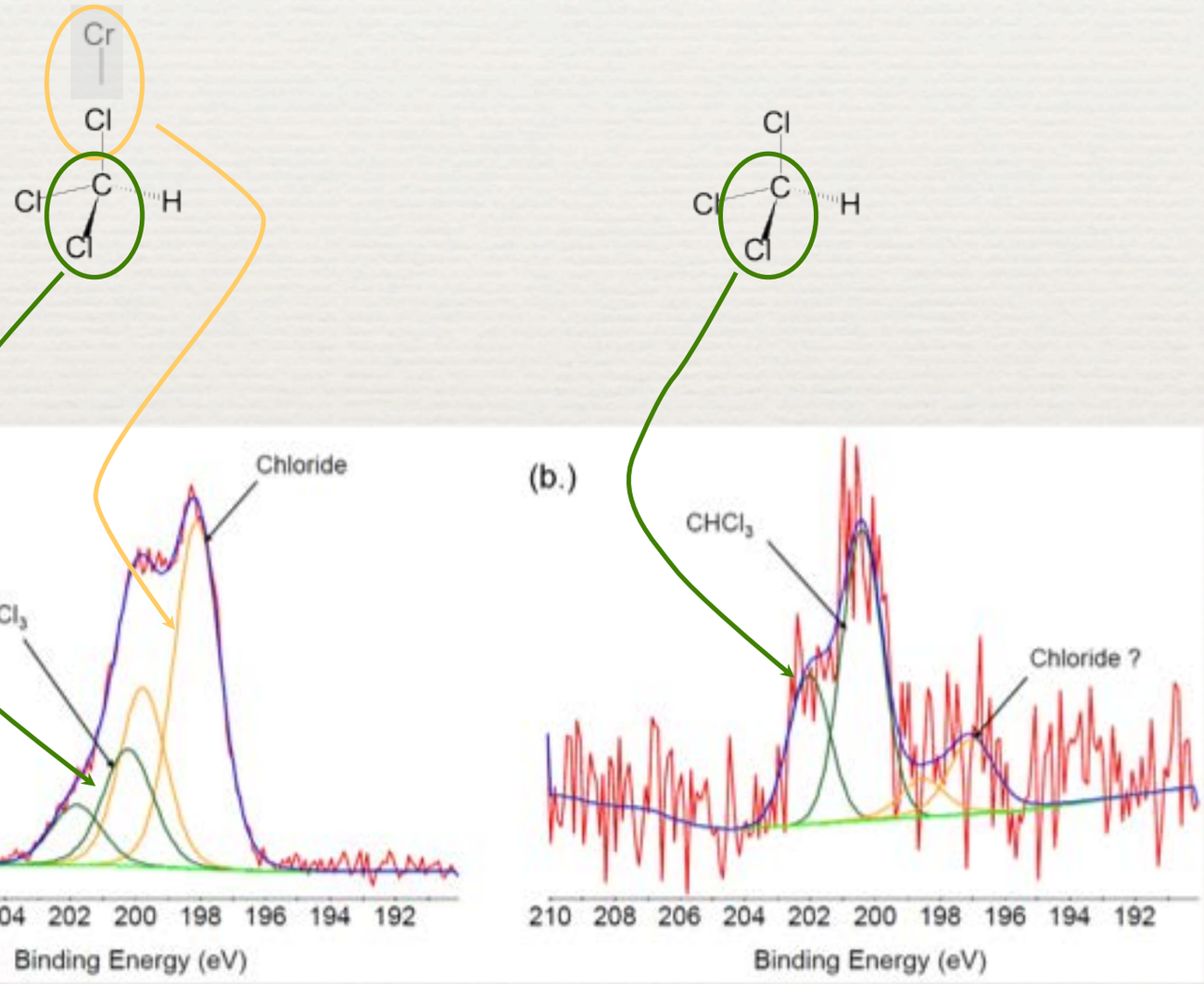
Optical Microscopy (calculate area)

Metal Adhesion Promotion

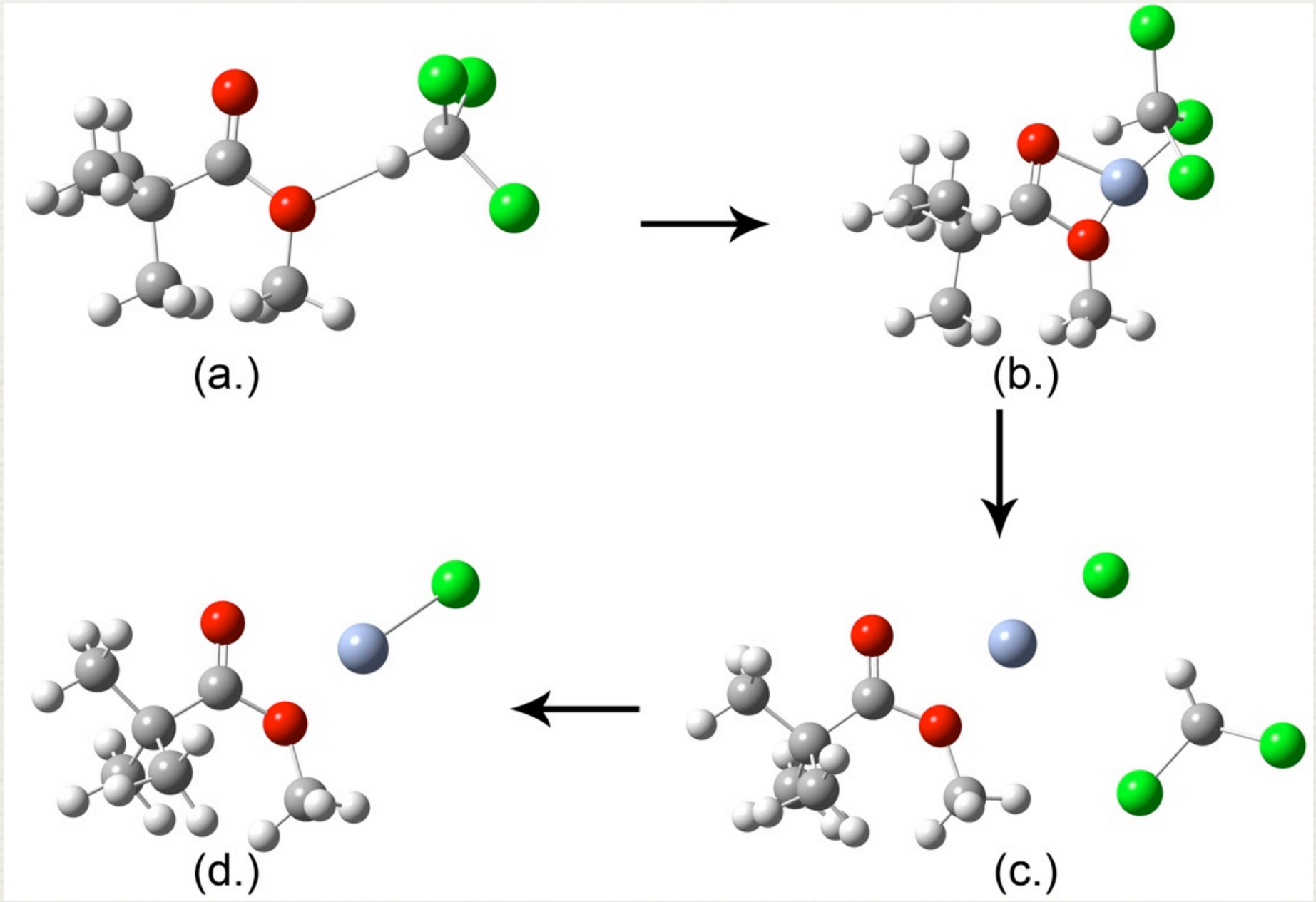
- Halogenated solvents are “complexing solvents” for PMMA.
- Form complexes with oxygens in PMMA backbone.
- Remain behind in polymer afterwards and can act as sites for metal adhesion.



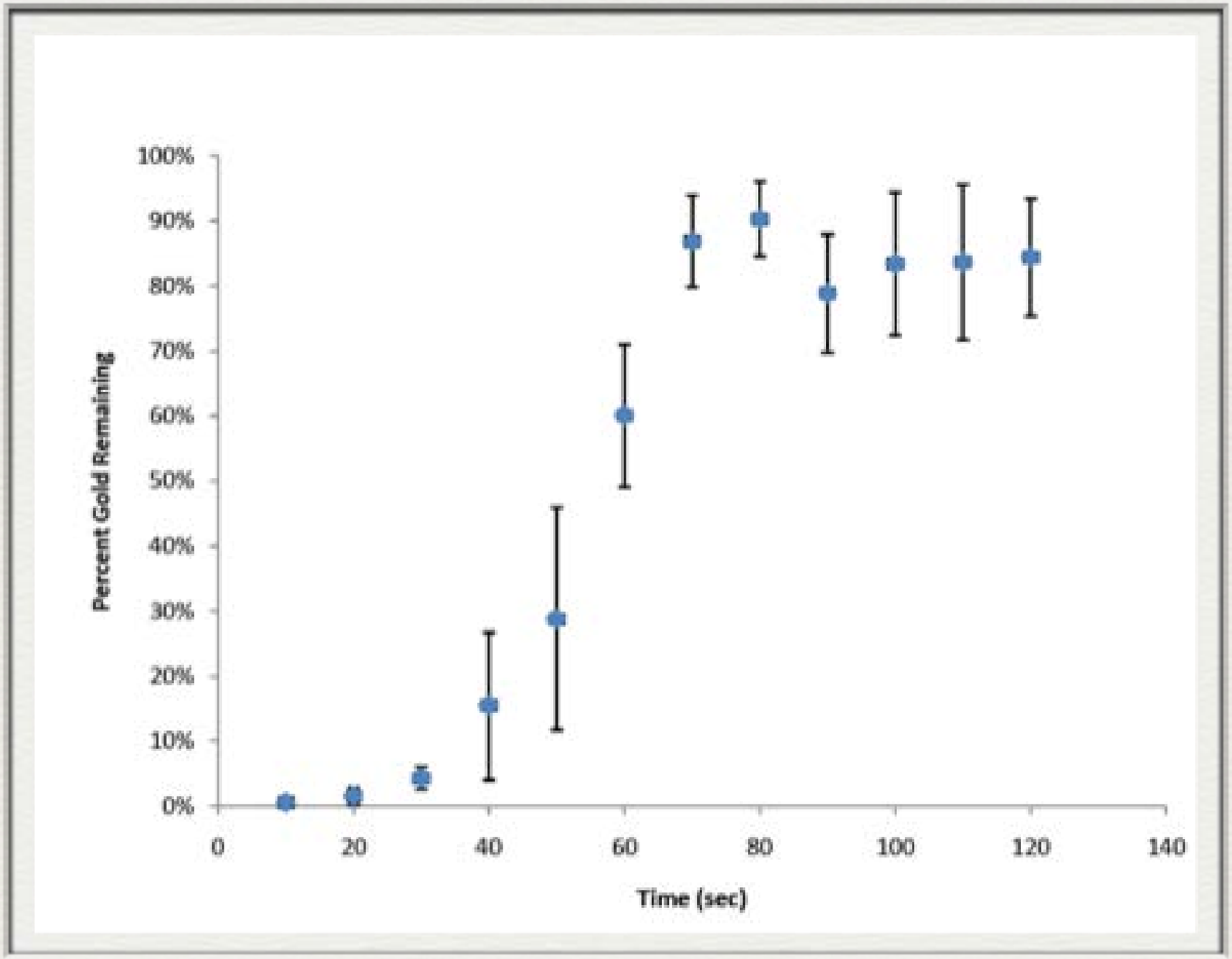
Chlorine XPS



DFT Modeling



UsingVapor Exposure to Introduce Chloroform



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