PREM
PARTNERSHIPS FOR RESEARCH AND EDUCATION IN MATERIALS

Globular Proteins Assemble in Bulk Solution and at the Air/Water Interface: Effect of Silicone Oil

Thomas Murray (Fayetteville State University)

Guangcui Yuan (NCNR)

FAYETTEVILLE STATE BRONCOS

NIST CENTER FOR NEUTRON RESEARCH

NSF CHRNS CENTER FOR HIGH RESOLUTION NEUTRON SCATTERING NIST

CONTENTS

INTRODUCTION

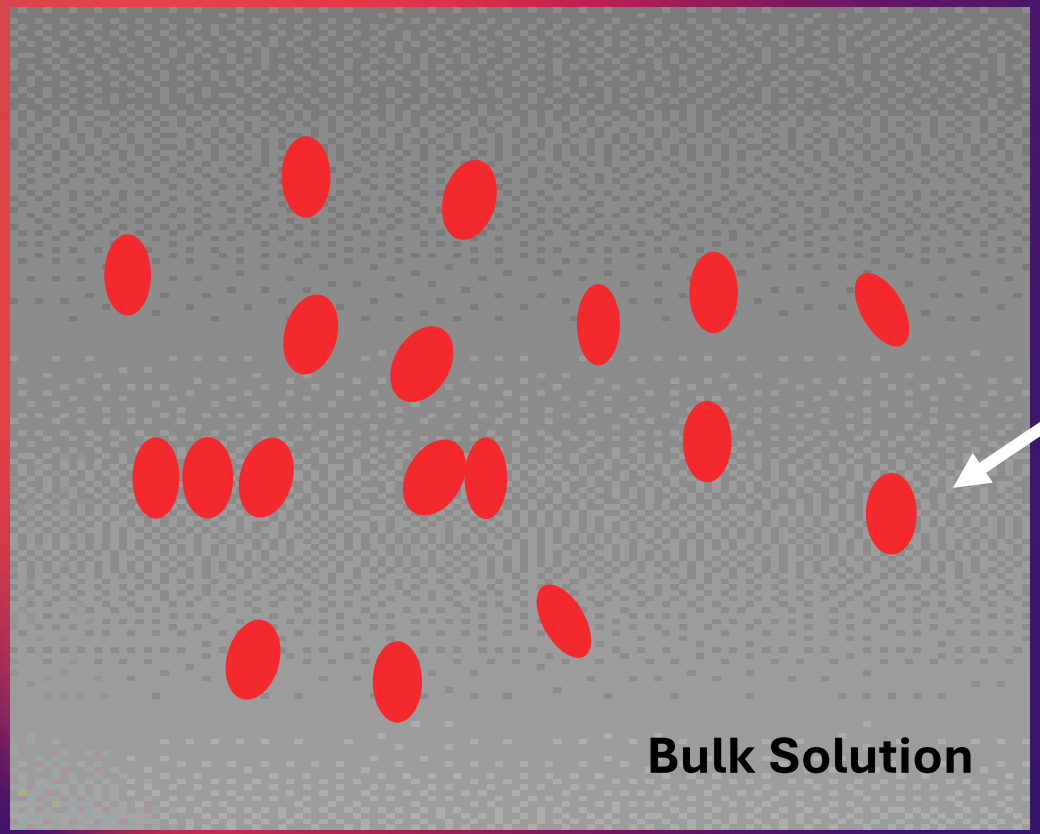
- **Importance of the study:**
- **Syringes, containers and vial adapters are commonly lubricated with silicone oil, ensuring smooth plunger depression.**
- **There's a general concern that the silicone oil may leach into the drug product, potentially affecting protein aggregation, purity and stability.**
- **The aim is to understand how silicone oil influences protein assembly in bulk and at interface.**

https://www.homequestionsanswered.com/what-is-silicone-oil.html

APPROACH

Dynamic Light Scattering (DLS)

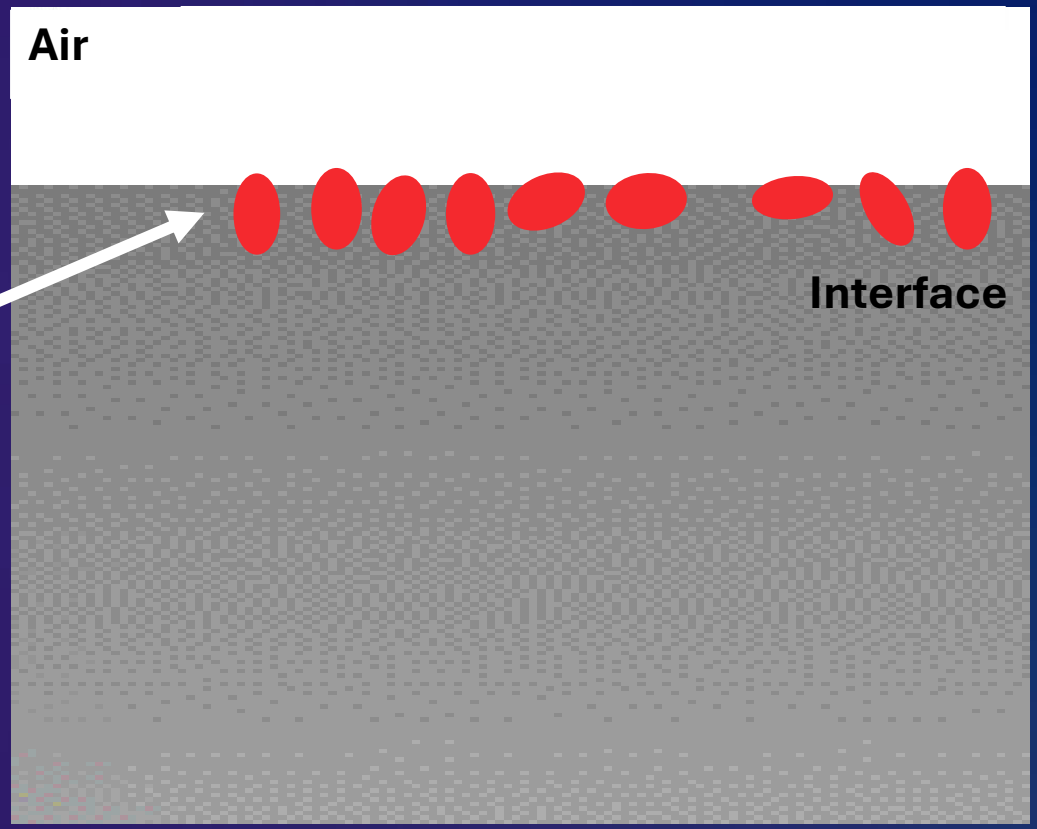
Bulk solution characterization



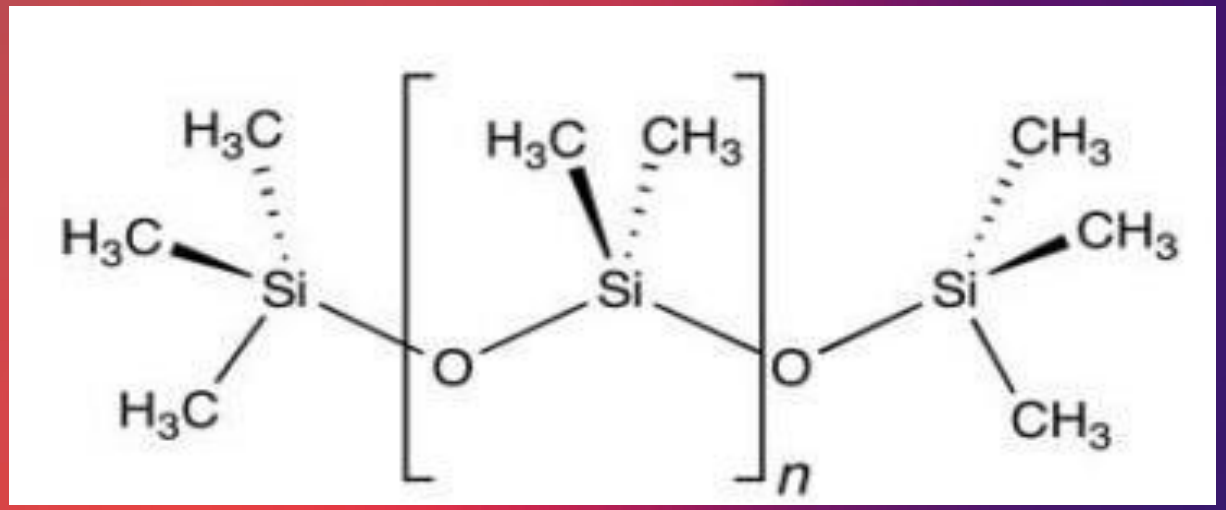
Proteins

X-ray Reflection (XRR)

Surface characterization



MATERIALS

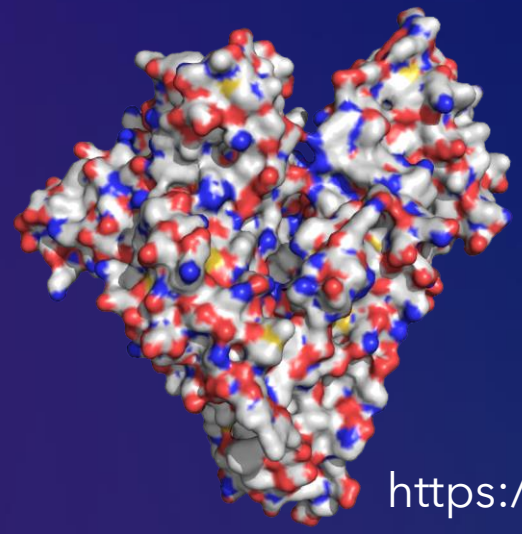


- **Polydimethylsiloxane (PDMS)** – a silicone polymer with a wide range of applications

Siloxane Backbone: Silicone oil has a flexible backbone consisting of alternating silicon and oxygen atoms.

Methyl Side Groups: This structure imparts hydrophobicity to PDMS, making it resistant to wetting by water and other polar solvents.

Si-O-Si Linkages: Additionally, the silicon-oxygen (Si-O) bonds in the backbone provide PDMS with exceptional thermal stability and chemical inertness.



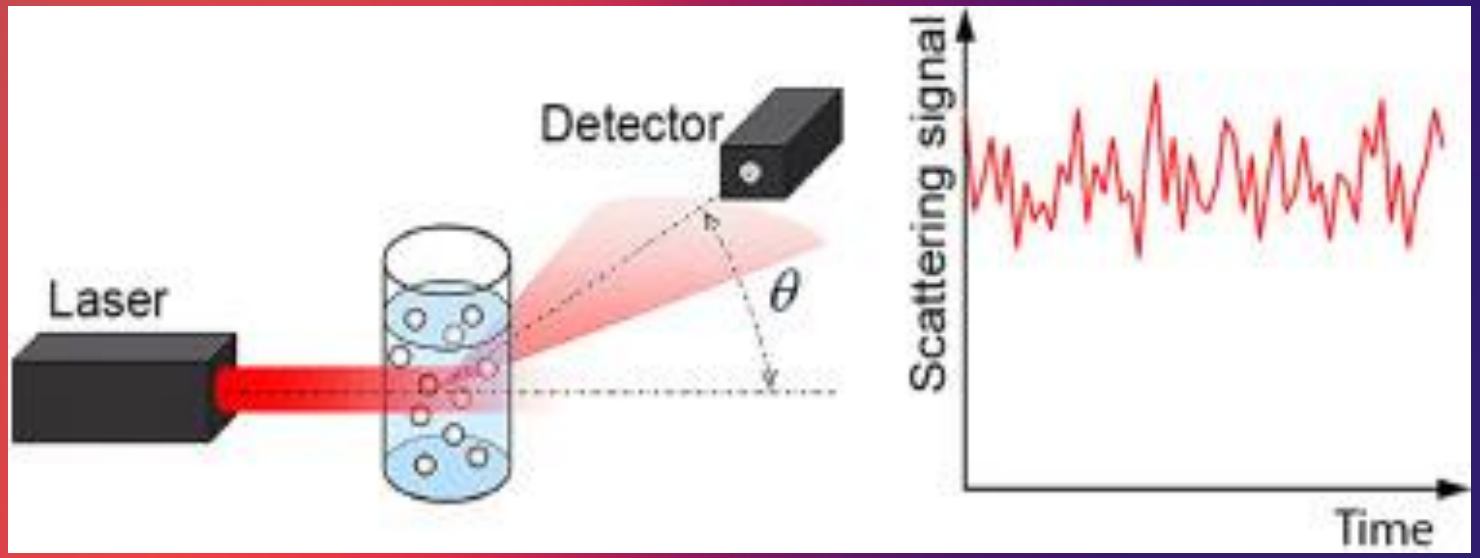
https://snl.no/albumin

Bovine Serum Albumin (BSA)

- **A serum albumin protein derived from cows. It is often used as a protein concentration standard in lab experiments.**
- **Molecular weight: 66.5 kDa**
- **Isoelectric point: 4.7**

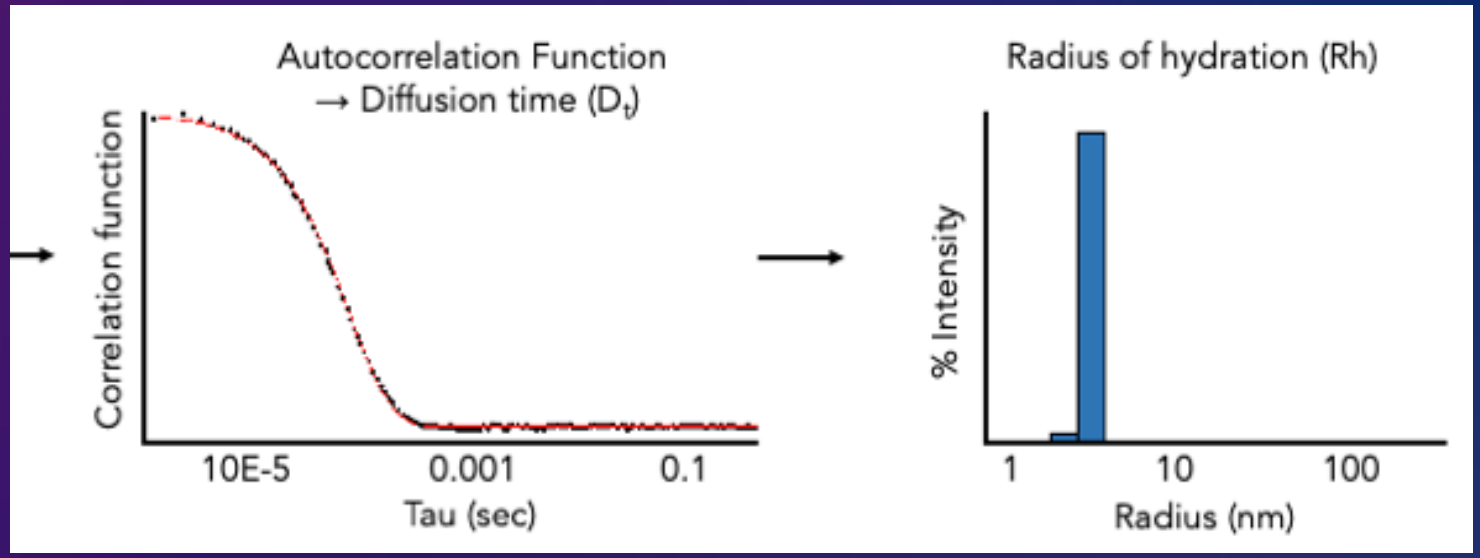
DLS METHOD

DLS principle



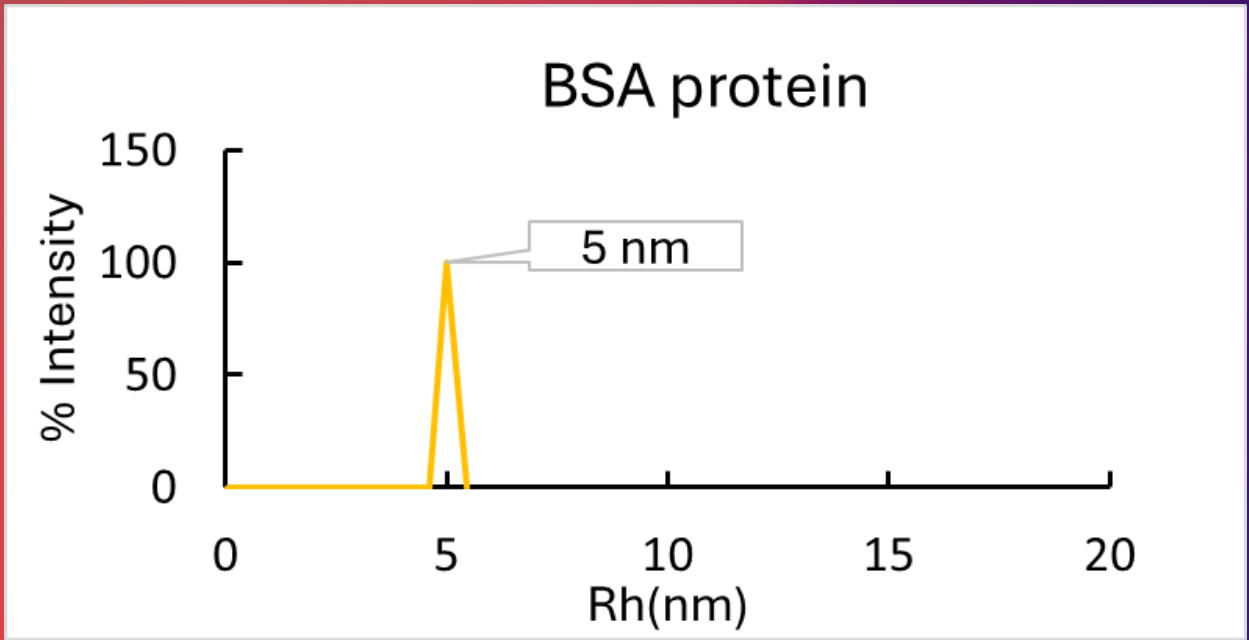
Typical DLS Data

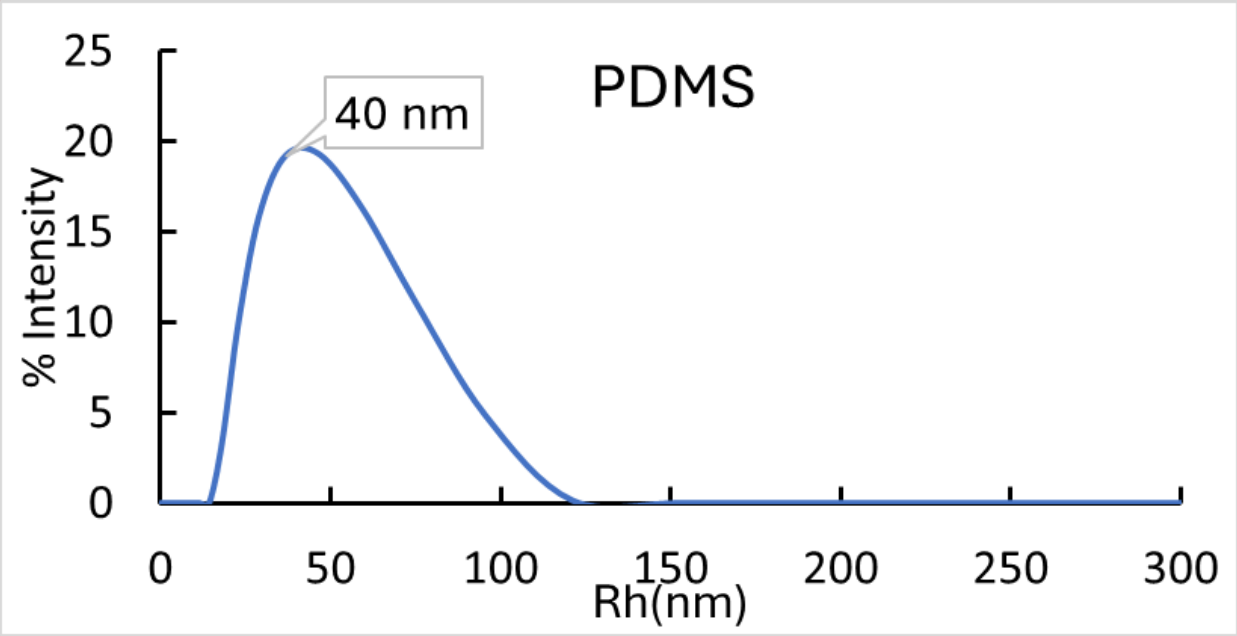
DLS is used to determine the size distribution profile of small particles in suspension.

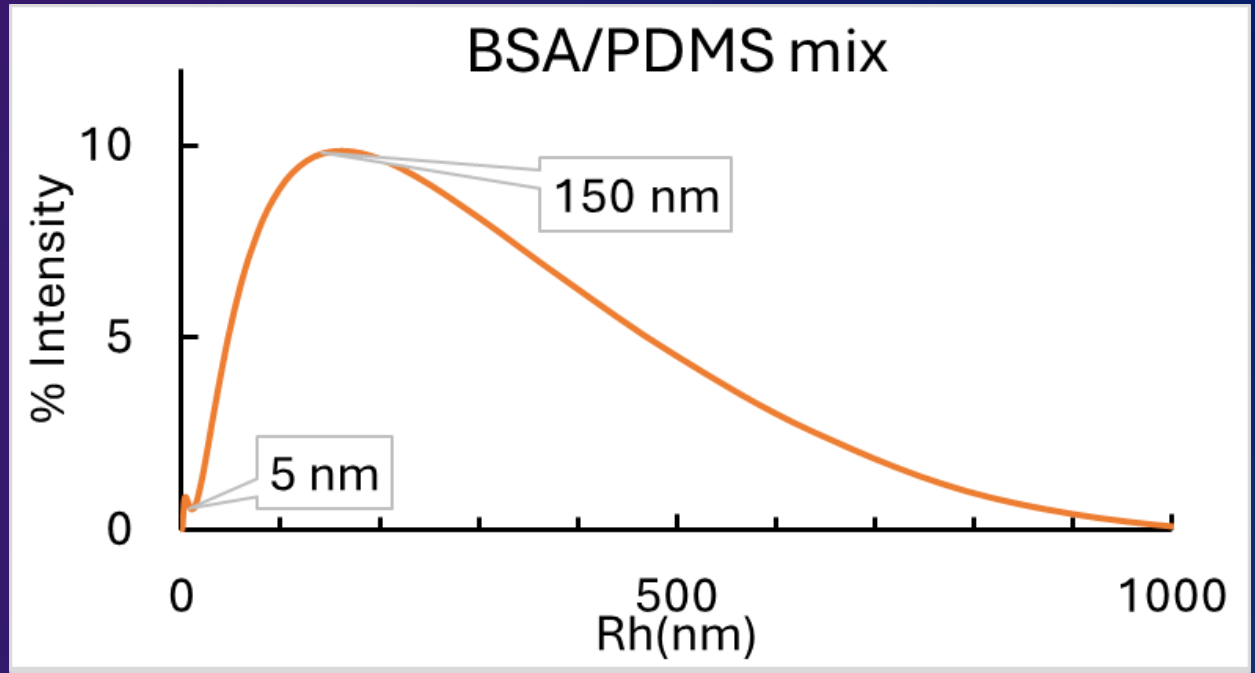


https://www.sciencedirect.com/science/article/pii/B9780128141823000109

DLS RESULTS





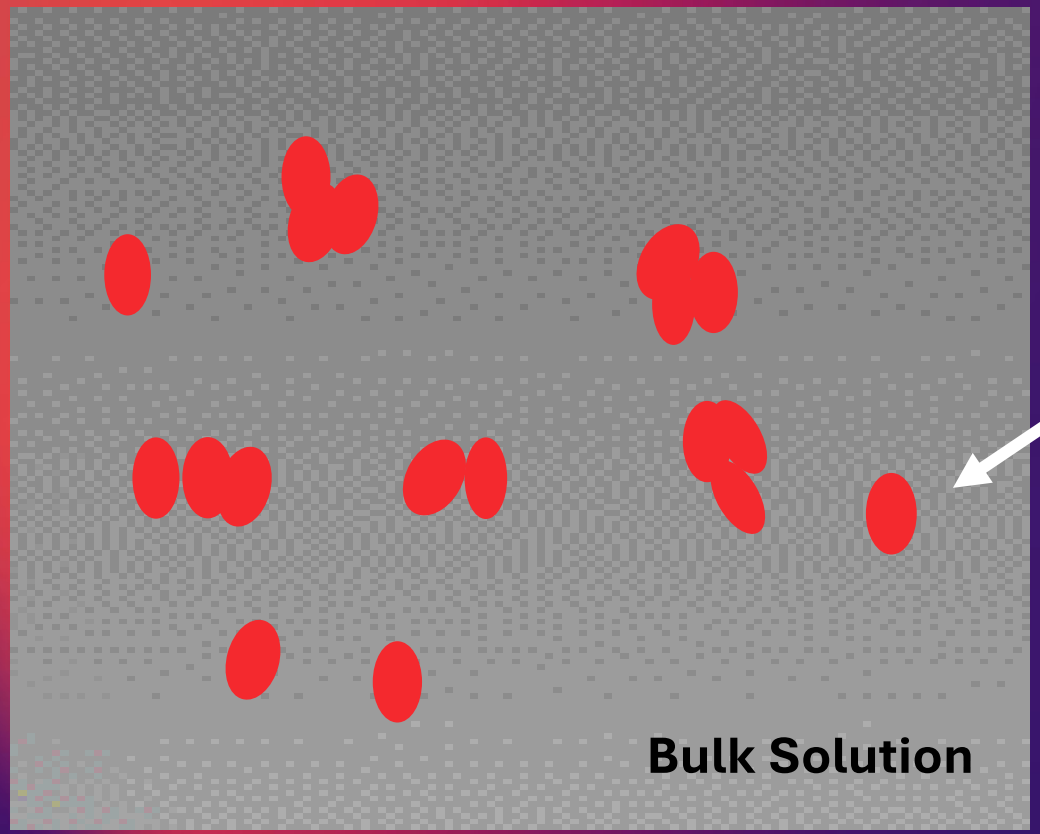


The particle size distribution profile of the BSA/PDMS mixture reveals the impact of silicone oil on BSA protein, resulting in **aggregation**.

APPROACH

Dynamic Light Scattering (DLS)

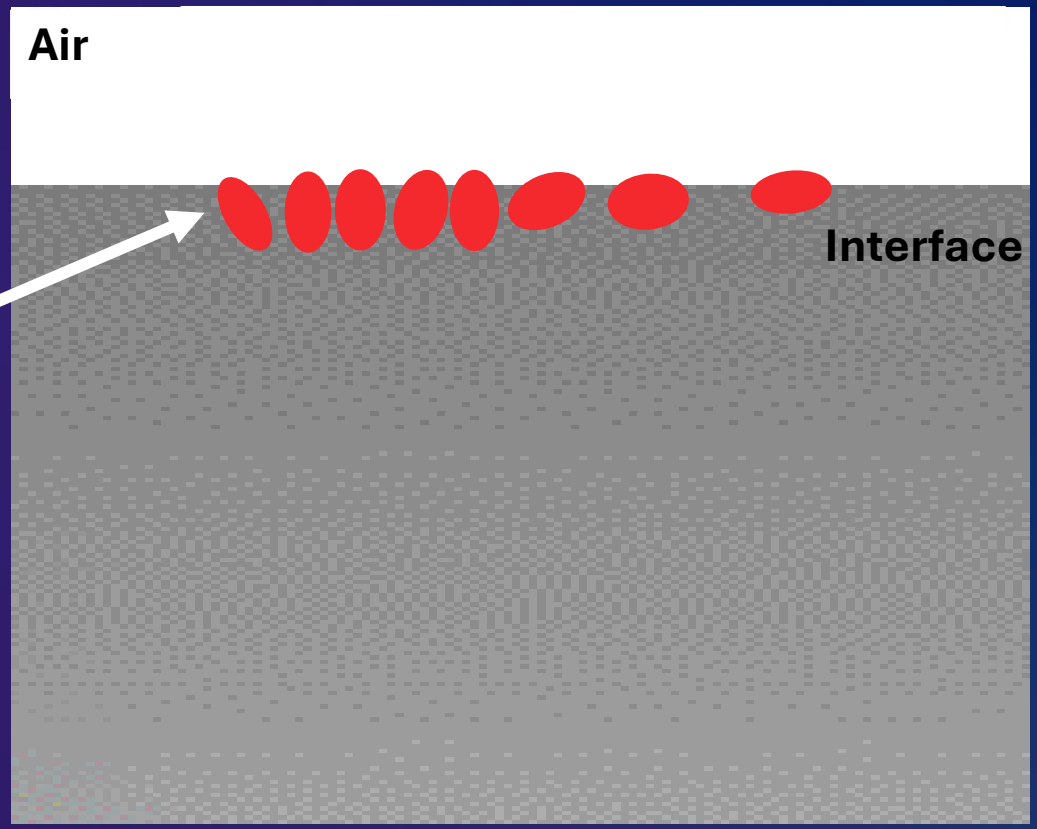
Bulk solution characterization



Proteins

X-ray Reflection (XRR)

Surface characterization



PROTEIN ADSORPTION

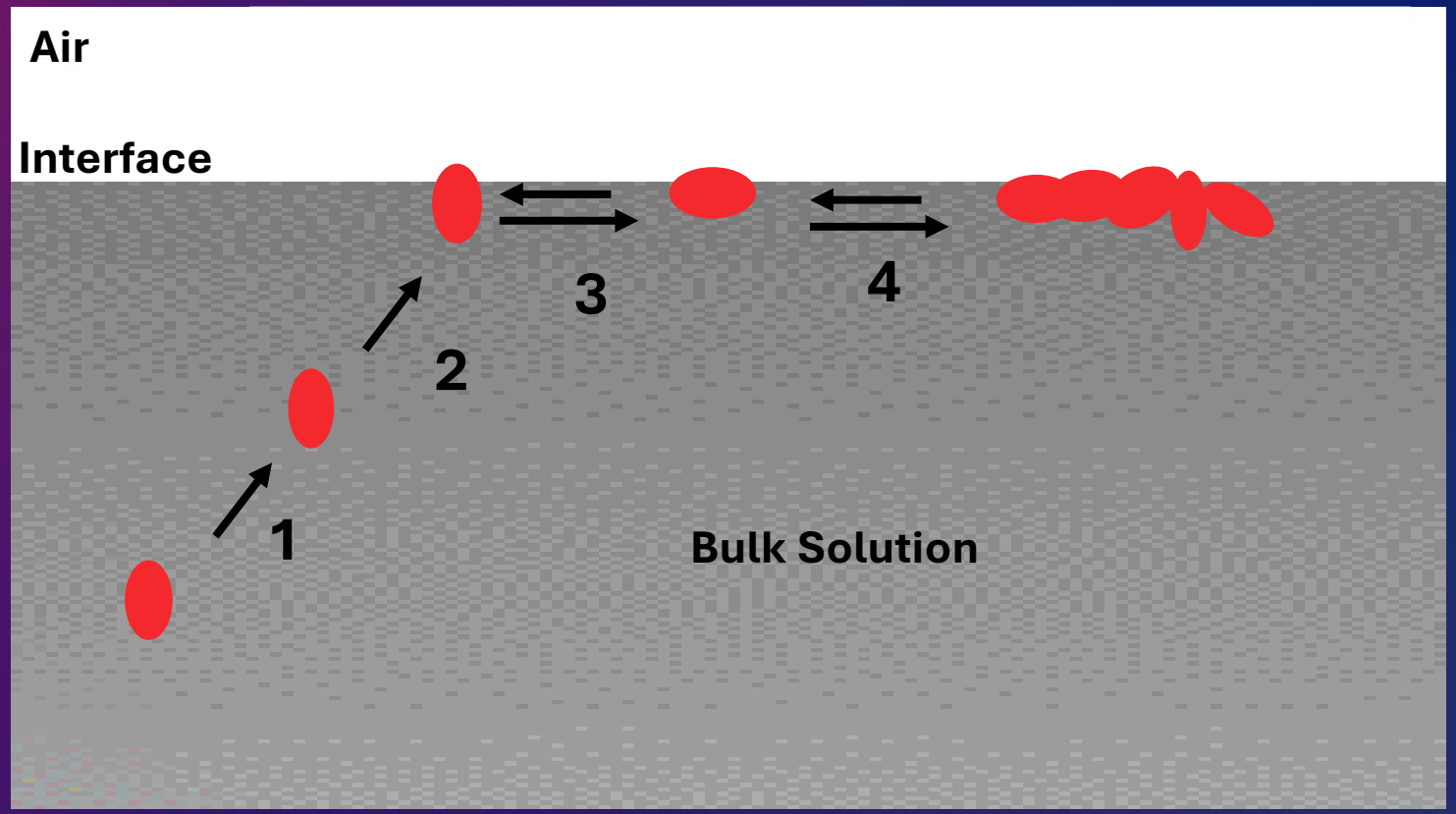
1) Diffusion

2) Adsorption

3) Unfolding

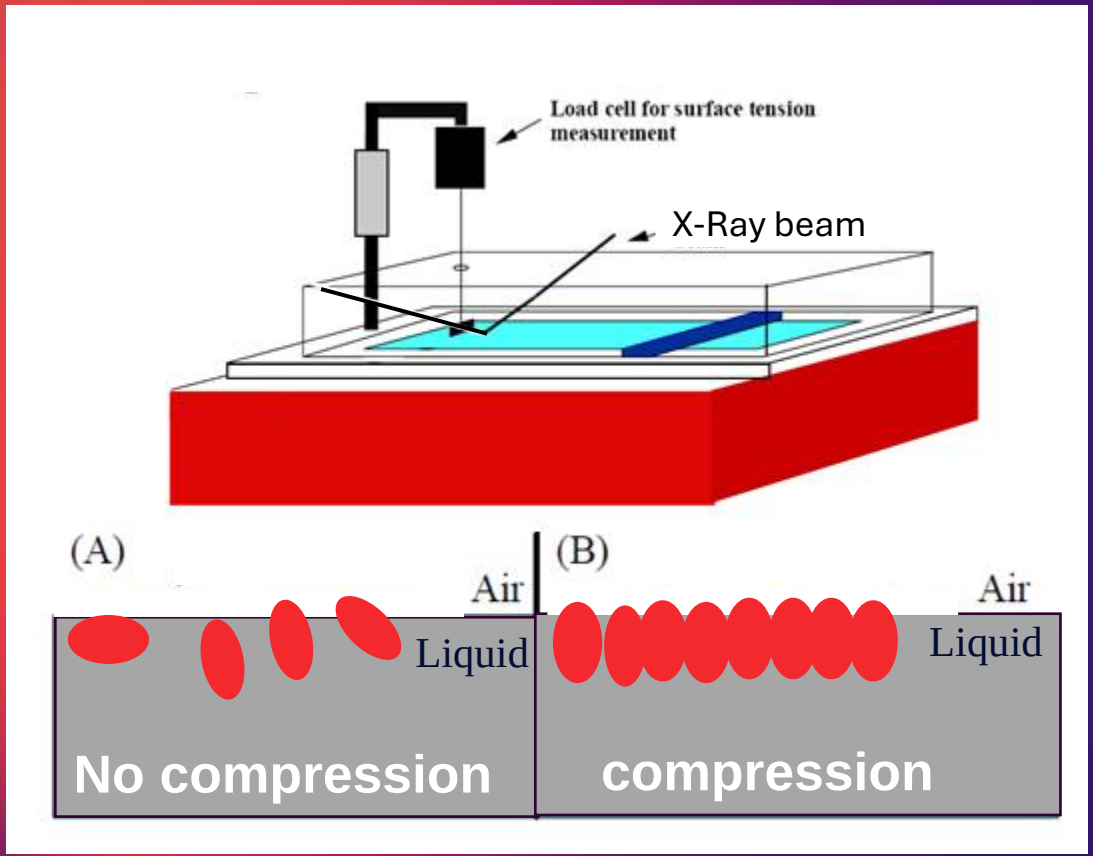
4) Saturation

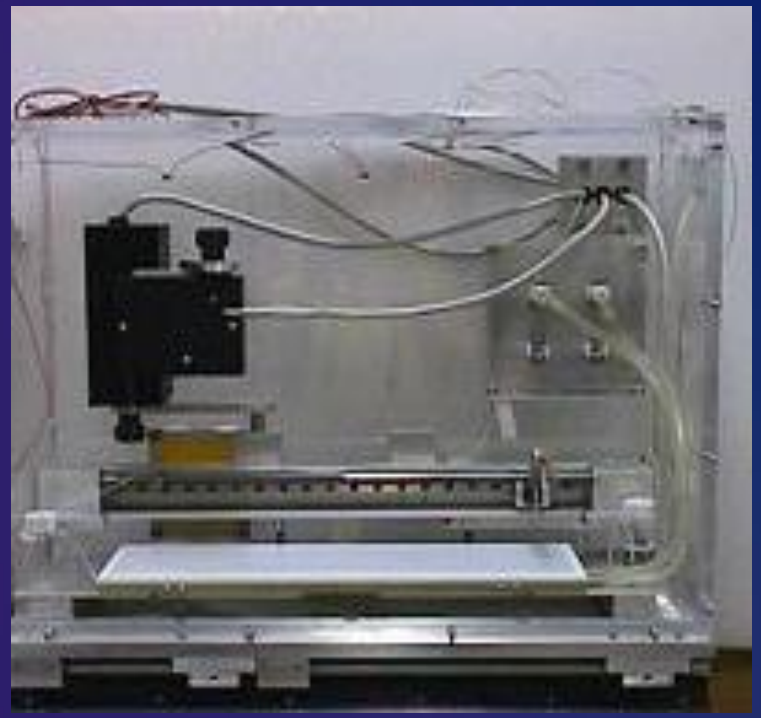
Illustration of protein surface assembly



LANGMUIR TROUGH

Langmuir Trough principle





KSV Langmuir-Blodgett Minitrough, NCNR

XRR METHOD

XRR principle

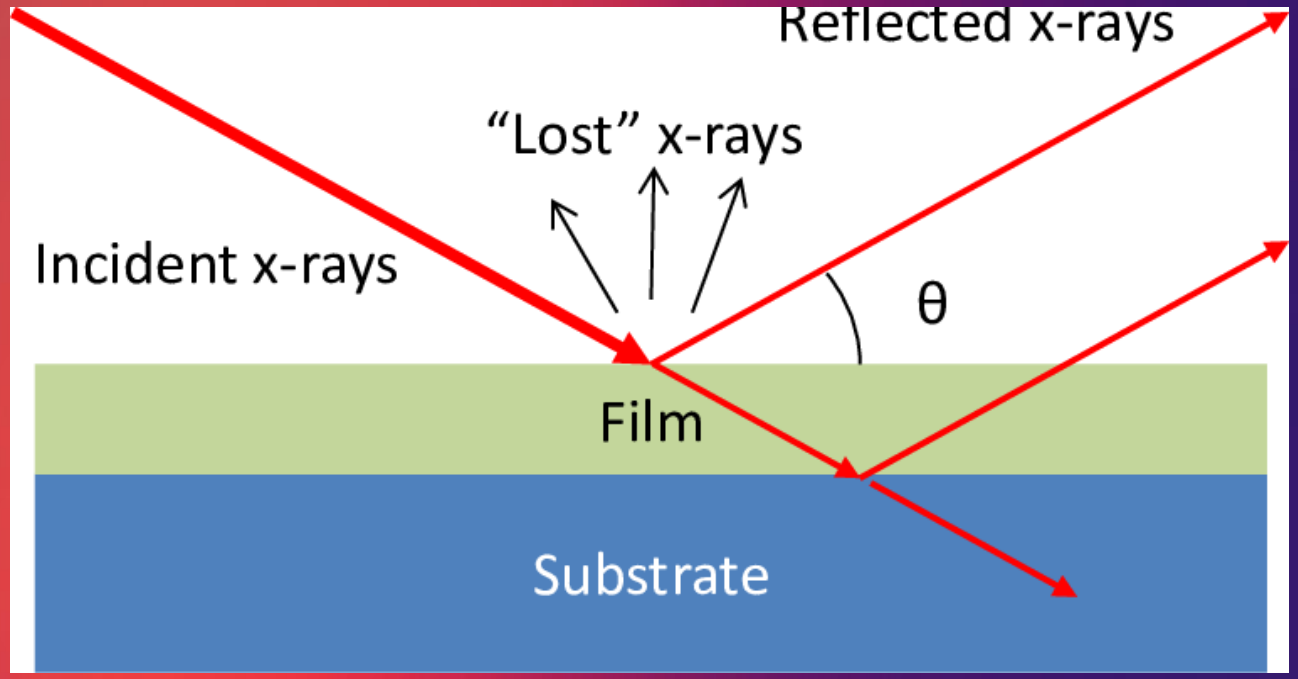
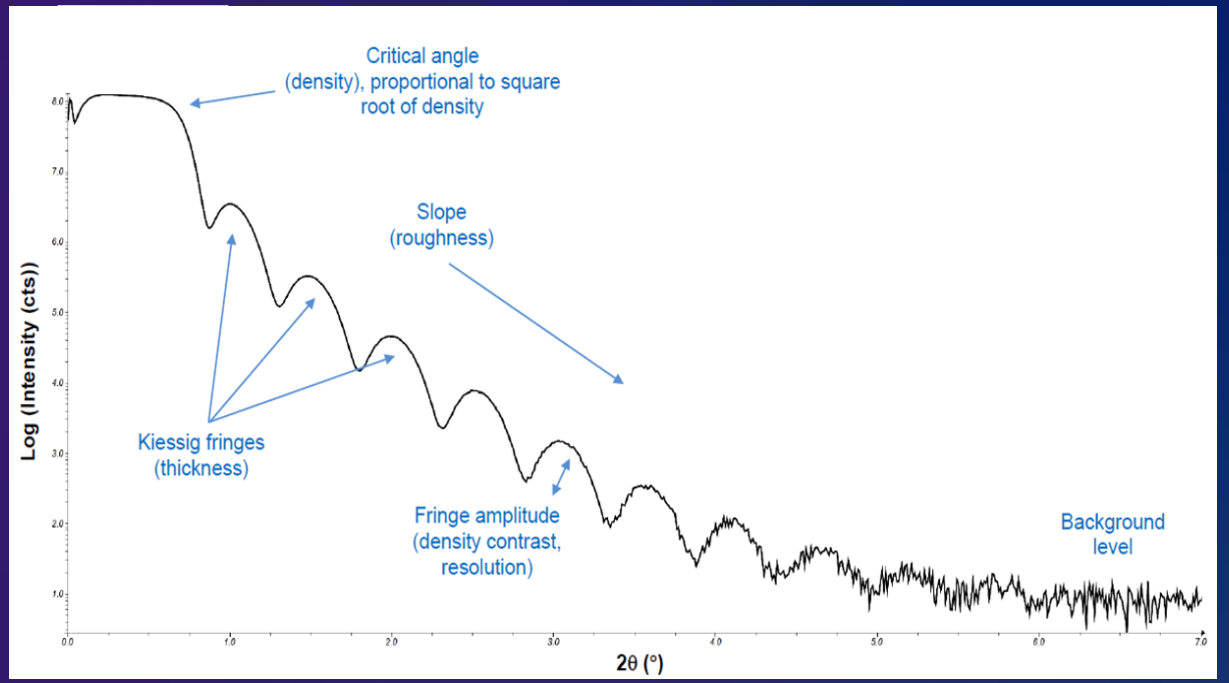


Diagram illustrating the process of x-ray reflectivity measurement. Incoming x-rays bounce off the film surface and the film-substrate interface. Some x-rays are absorbed through specular reflection or diffuse scattering, while others penetrate the substrate.

Typical XRR Data

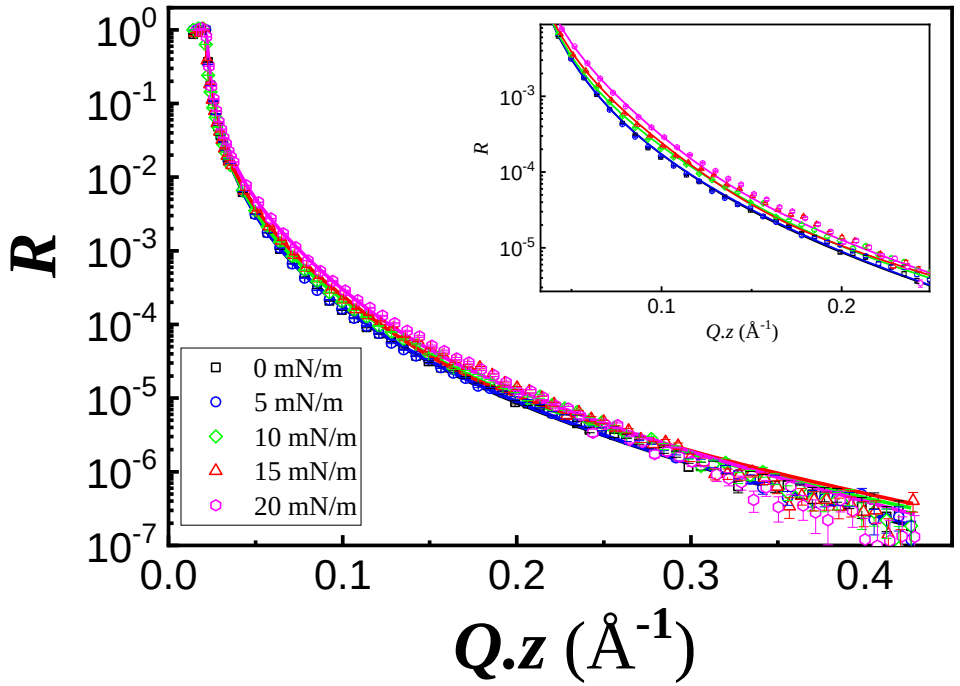


XRR provides information of **composition, thickness and roughness** of membrane materials.

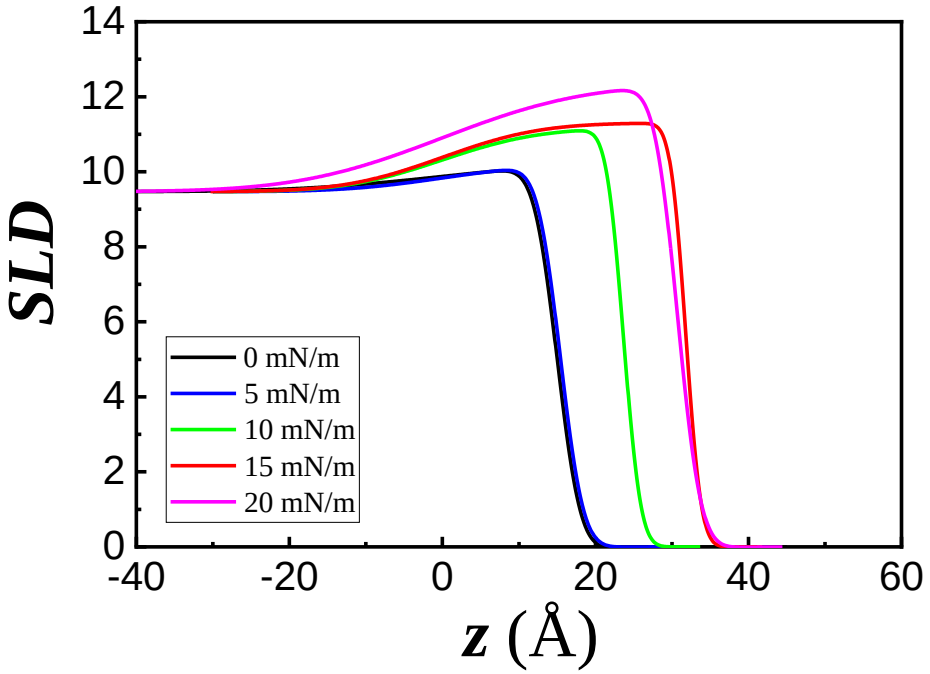
XRR RESULTS

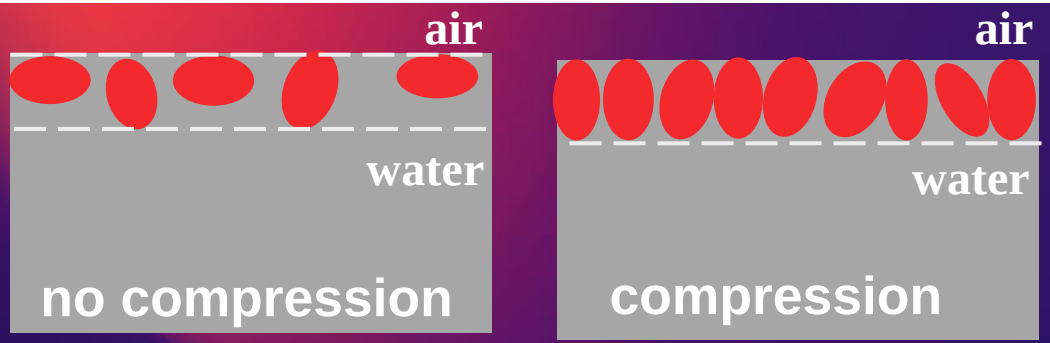
BSA solution

Reflectivity Profile



SLD Profile



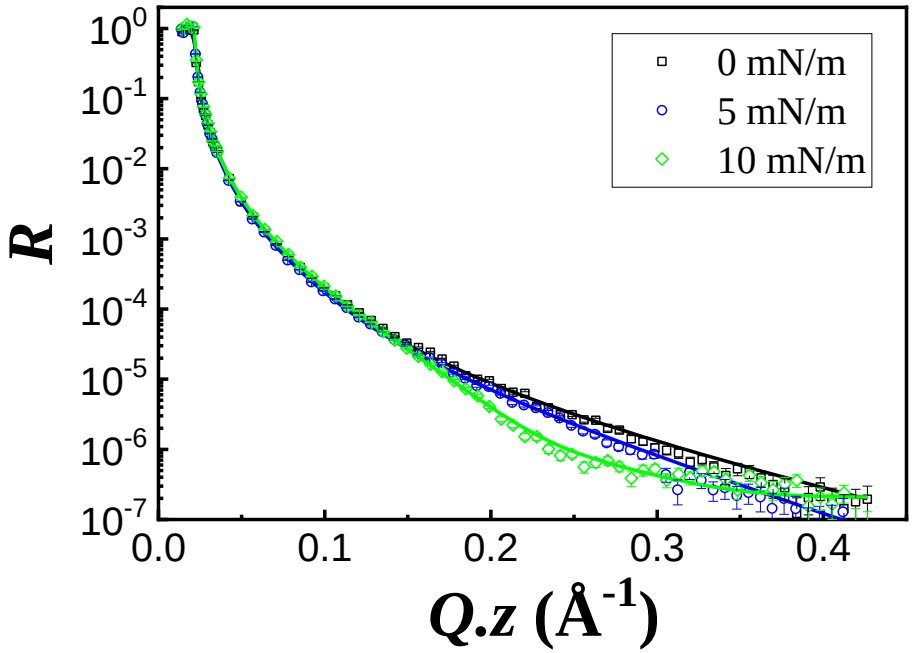


Observation: protein adsorption becomes thicker and denser while being compressed.

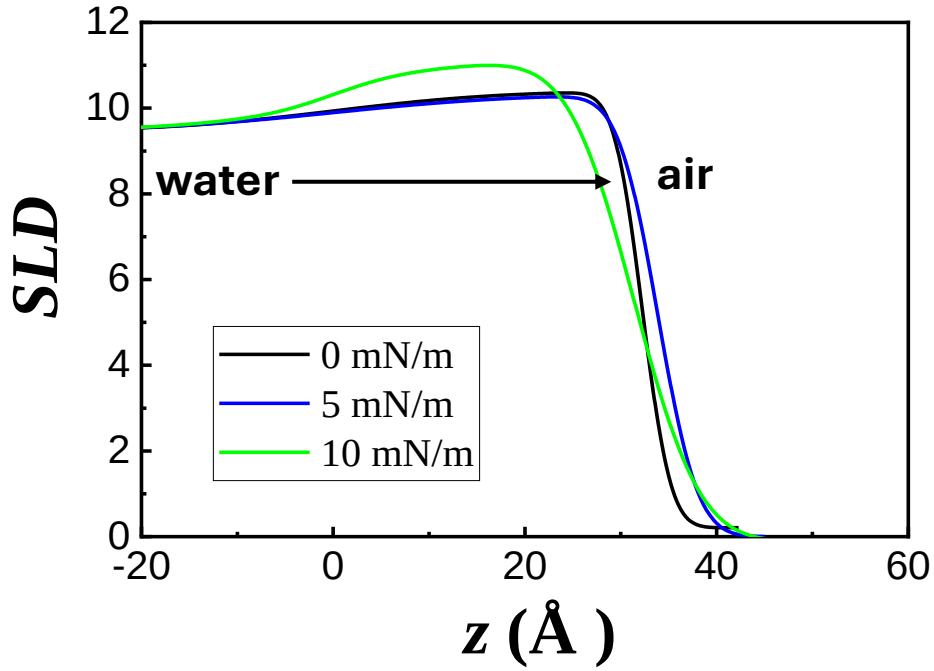
XRR RESULTS

(BSA+PDMS) solution

Reflectivity Profile



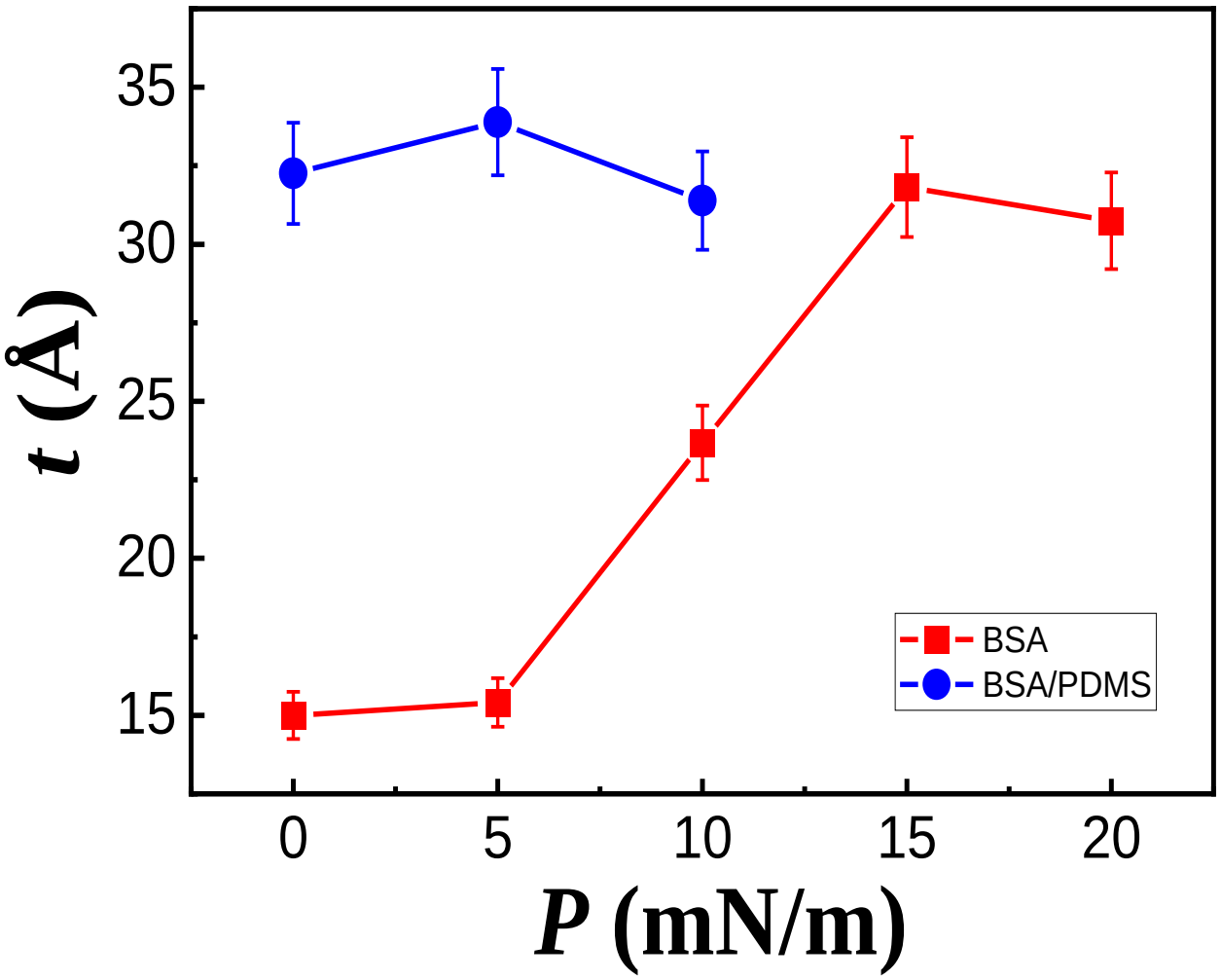
SLD Profile



Observation: Protein adsorption reaches maximum before compressed. Protein layer becomes unstable while being compressed.

XRR RESULTS

Thickness *vs.* Surface pressure



Observation:

In the absence of PDMS, the protein adsorption at the interface is less.

With PDMS, the amount of protein adsorbed at the interface reaches its maximum packing capacity even without compressing.

SUMMARY

- DLS was utilized to examine protein aggregation in bulk solution.
- Different monolayer protein films were prepared utilizing Langmuir Trough.
- XRR was used to characterize films at the air/water interface.
- The results show that silicon oil causes protein aggregation in bulk solution, it also causes more protein adsorption at the air/water interface.
- This research contributes to safer and more effective pharmaceutical packaging by considering protein behavior and its interaction with leachable substances.

ACKNOWLEDGMENTS

- GUANGCUI YUAN
- JOSEPH DURA, DONNA KALTEYER, CHELSEA EDWARDS
- JULIE BORCHERS, SUSANA TEIXEIRA, LELAND HARRIGER, CARA O'MALLEY
- SURF AND CORE INTERNS

'The Center for High Resolution Neutron Scattering (CHRNS) is a national user facility jointly funded by the NIST Center for Neutron Research (NCNR) and the National Science Foundation (NSF) under Agreement No. DMR-2010792.'

PREM
PARTNERSHIPS FOR RESEARCH AND EDUCATION IN MATERIALS

FAYETTEVILLE STATE BRONCOS

NIST CENTER FOR NEUTRON RESEARCH

CHRNS
CENTER FOR HIGH RESOLUTION NEUTRON SCATTERING
NSF
NIST