^{1}H NMR relaxation study of poly-vinyl pyrrolidone adsorption in zinc oxide colloidal dispersions

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Nanoparticle Carriers for Drug Delivery

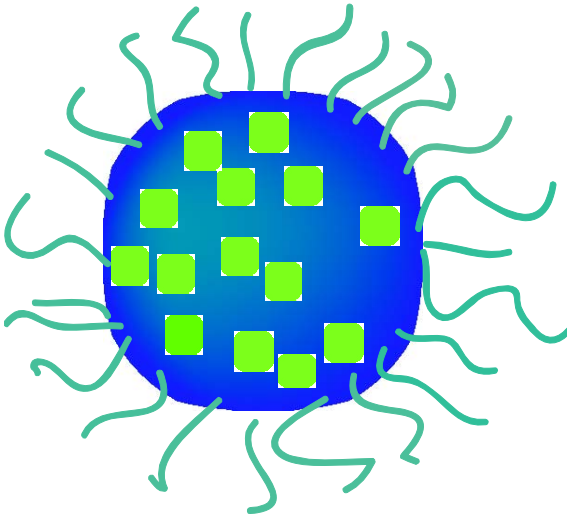
Size
- Circulation Time
- Biodistrubution
- Endocytosis
- Renal Clearance
- Target Accumulation

Shape
- Circulation time
- Vascular adherence
- Endocytosis
- Intracellular trafficking
- Phagosytosis

Drug Carriers

Surface Chemistry
- Circulation Time
- Endocytosis
- Target Accumulation
- Endosomal Escape
- Toxicity

Mechanical Properties
- Circulation Time
- Biodistribution
- Phagosytosis

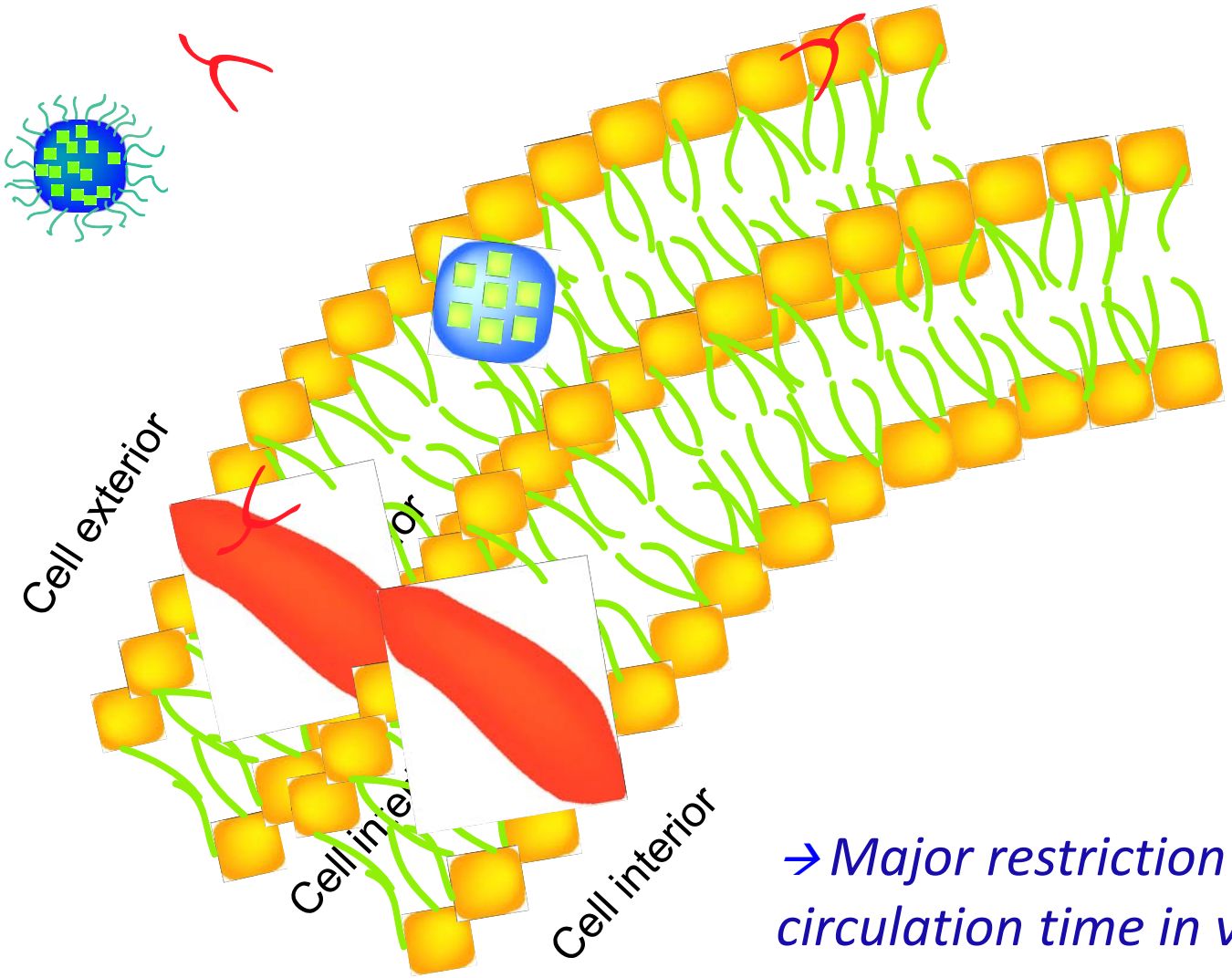


Pharmaceutical agent

→ ability to target specific cells

→ to control the drug release

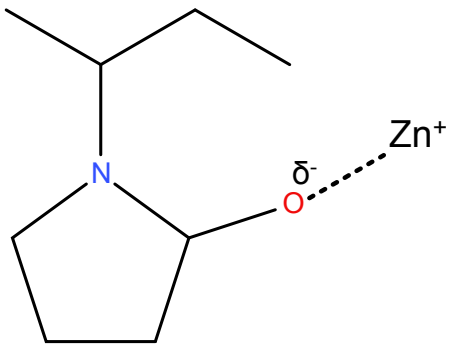
Nanoparticles on Drug Delivery

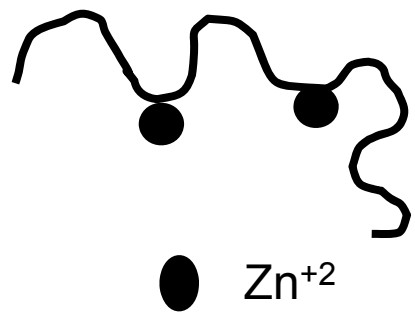


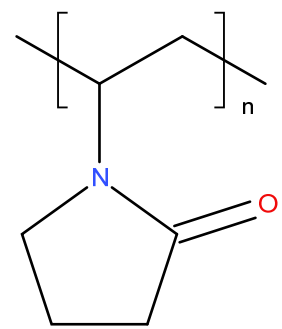
→ *Major restriction is their short circulation time in vivo*

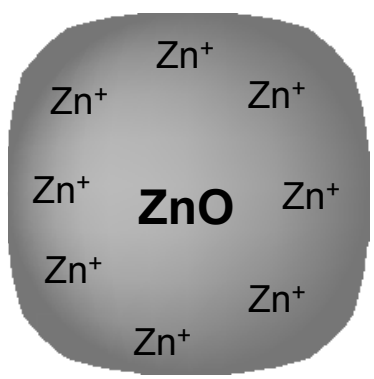
ZnO Nanoparticles as a Model System

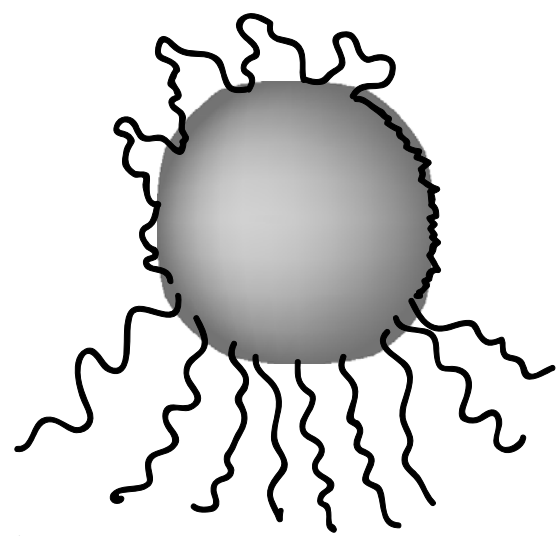
$$Zn(CH_3COO)_2 \cdot 2H_2O + 2NaOH \longrightarrow Zn_2{+}(OH^-)_2 + 2Na(CH3COO)_2 + H_2O$$



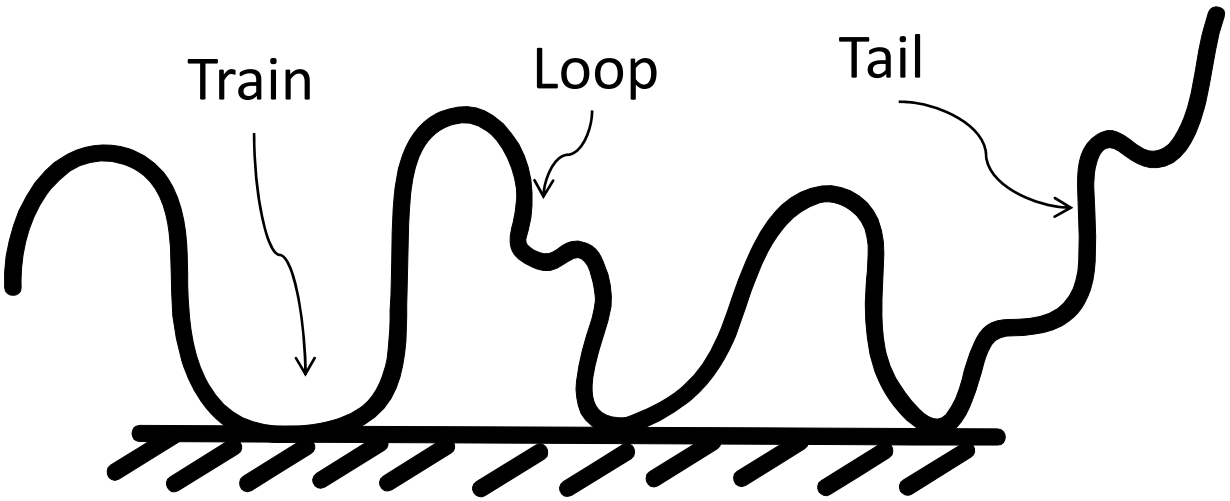






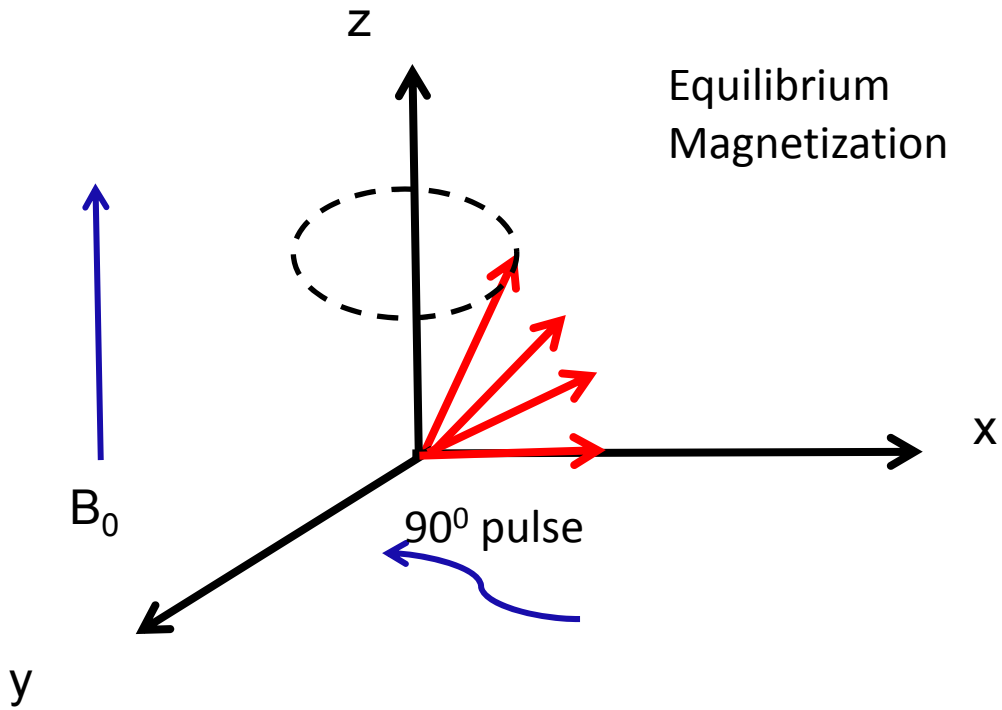


Objective: Understand how PVP is attached to the surface of ZnO



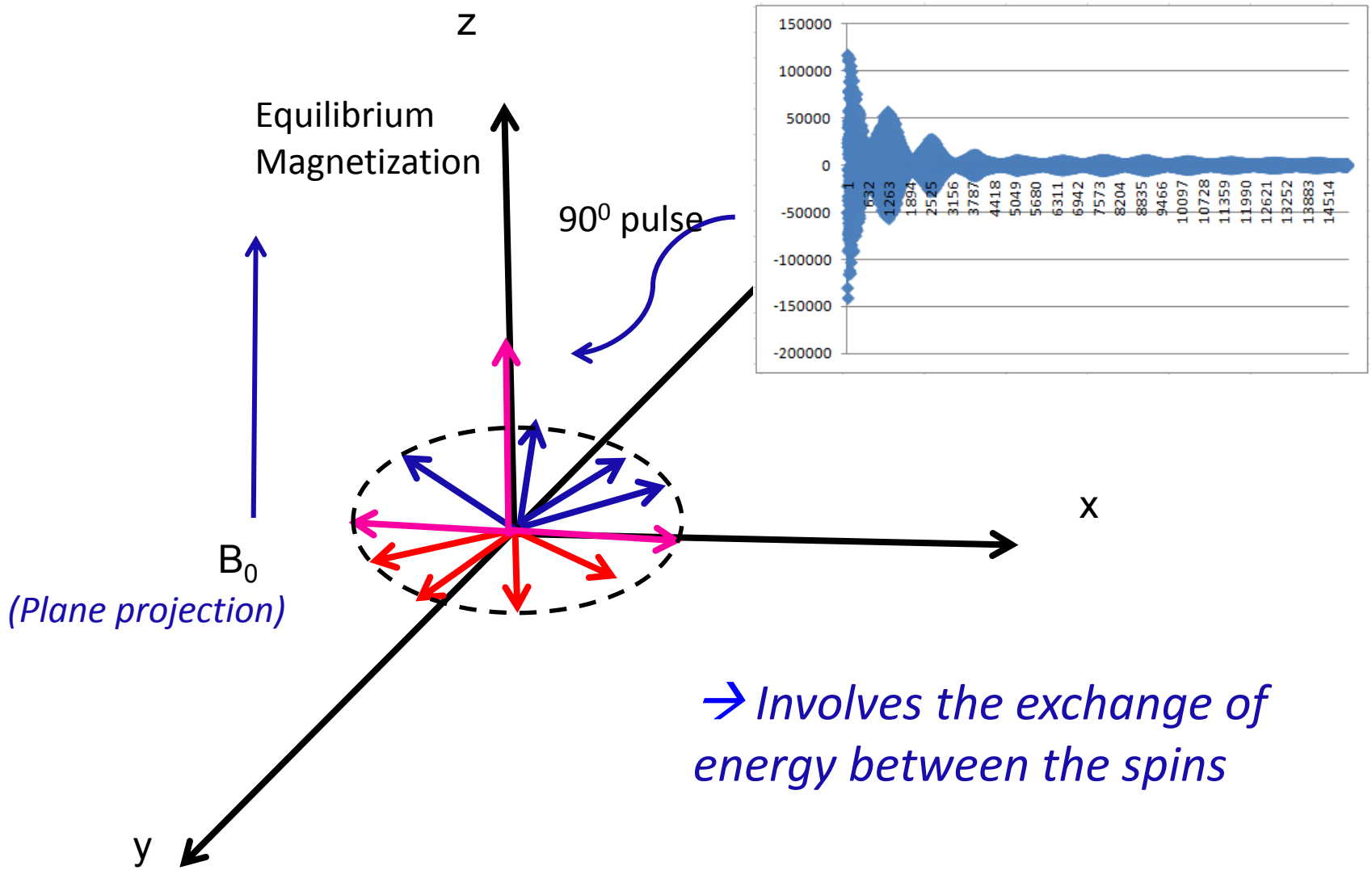
Our Hypothesis: Dynamic NMR methods can be used to elucidate how nanoparticles form in a polymeric solution

Relaxation Time: Spin-Lattice or Longitudinal Relaxation T_1



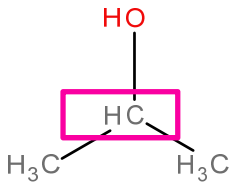
→ *Atomic nuclei decay by precessing back to thermal equilibrium*

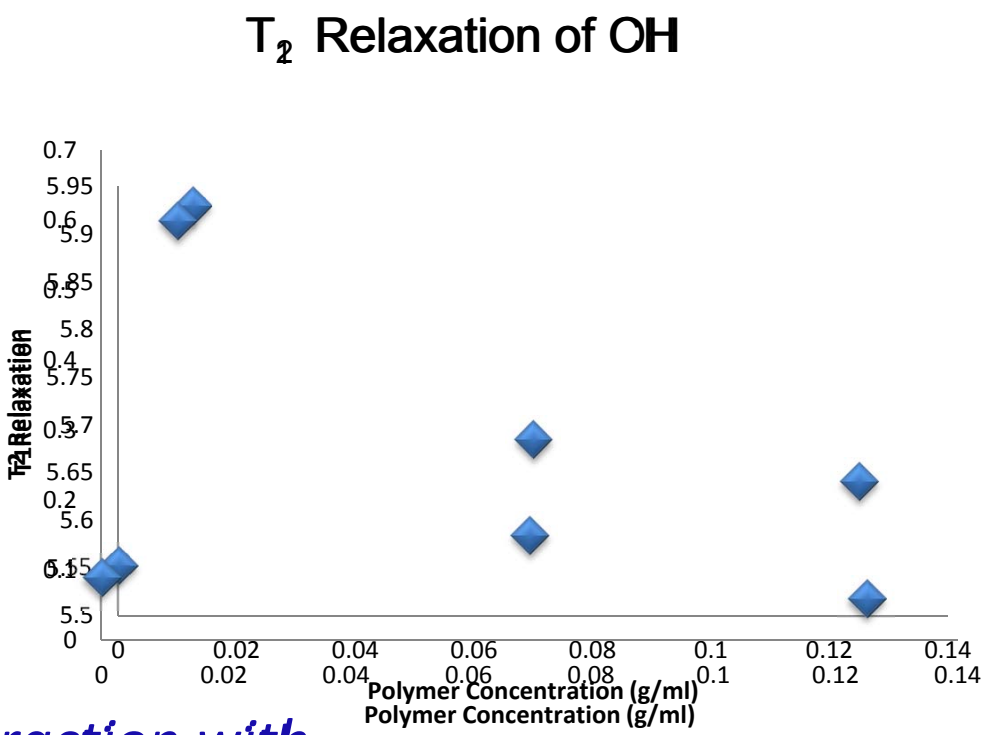
Relaxation Time: Spin-Spin or Transverse Relaxation T_2

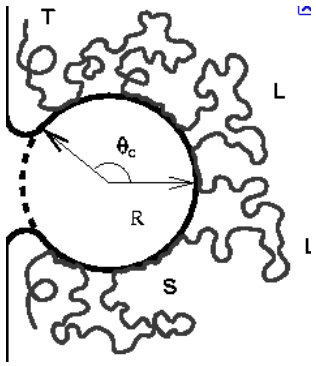


→ *Involves the exchange of energy between the spins*

Solvent Relaxation: H_2O & IPA







http://iopscience.iop.org/0295-5075/47/3/292/fulltext/47303.html

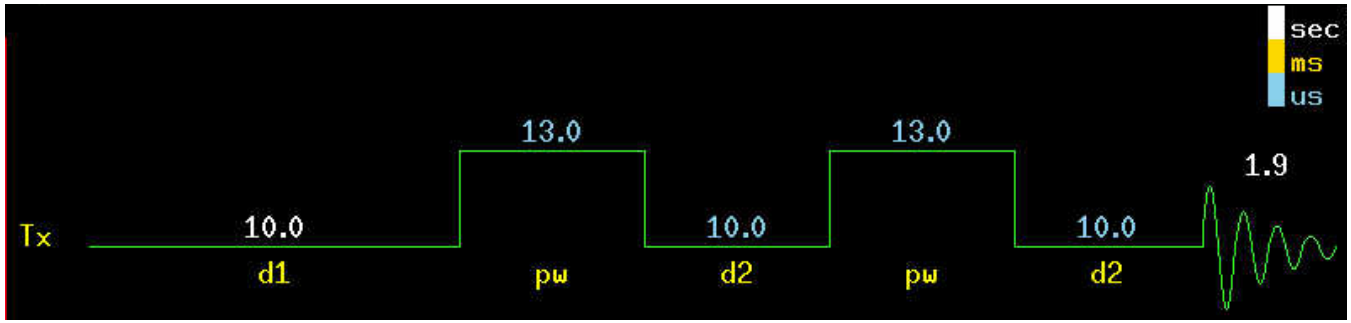
Stronger H_2O interaction with lower polymer concentration

G. P. van der Beer, *et al.*, J. Mag. Reson. (1981)

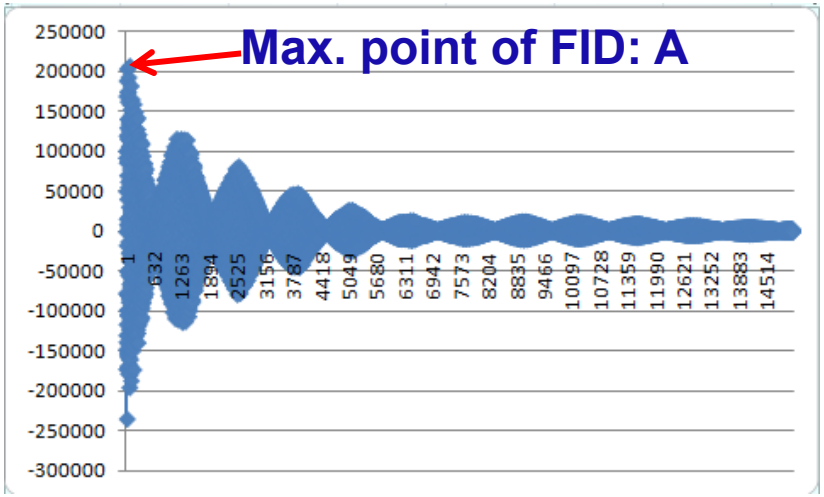
Estimation of Bound Fraction of Polymer onto Nanoparticle

Bound fraction: **<p> = 1- B/A**

- Bound and non-bound polymer: **$90^0_x - \tau - 90^0_y - 2\tau$**



τ=10 μs

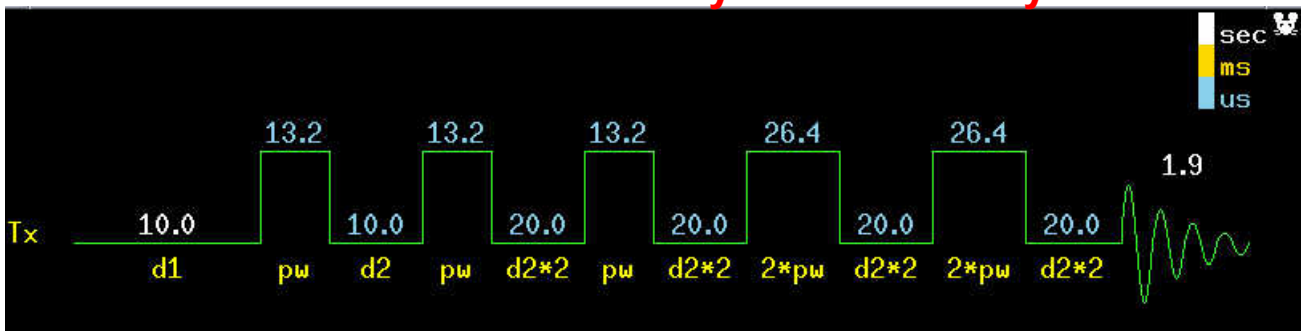


K. G. Barnel, *et.al*, Macromolecules, (1981).

Estimation of Bound Fraction of Polymer onto Nanoparticle

Bound fraction: **<p> = 1- B/A**

- Non- bound polymer: **90^0_y –2τ- 180^0_y- 2τ- 180^0_y- 2τ**



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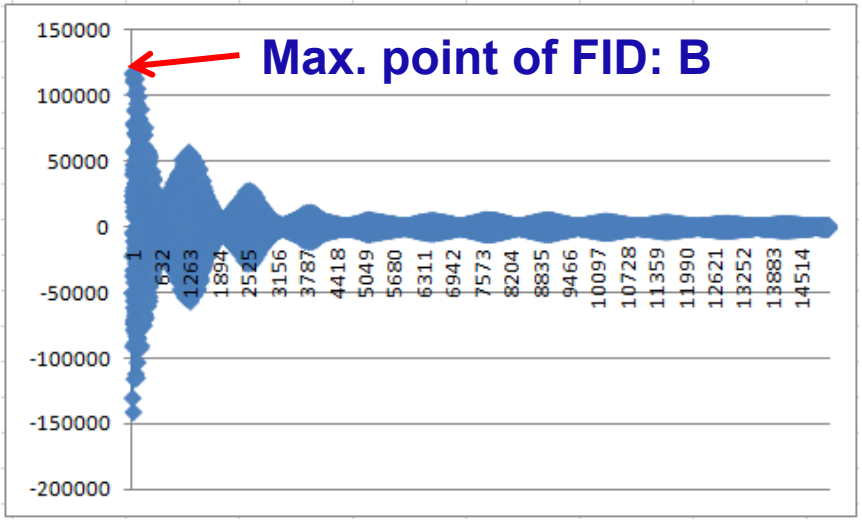

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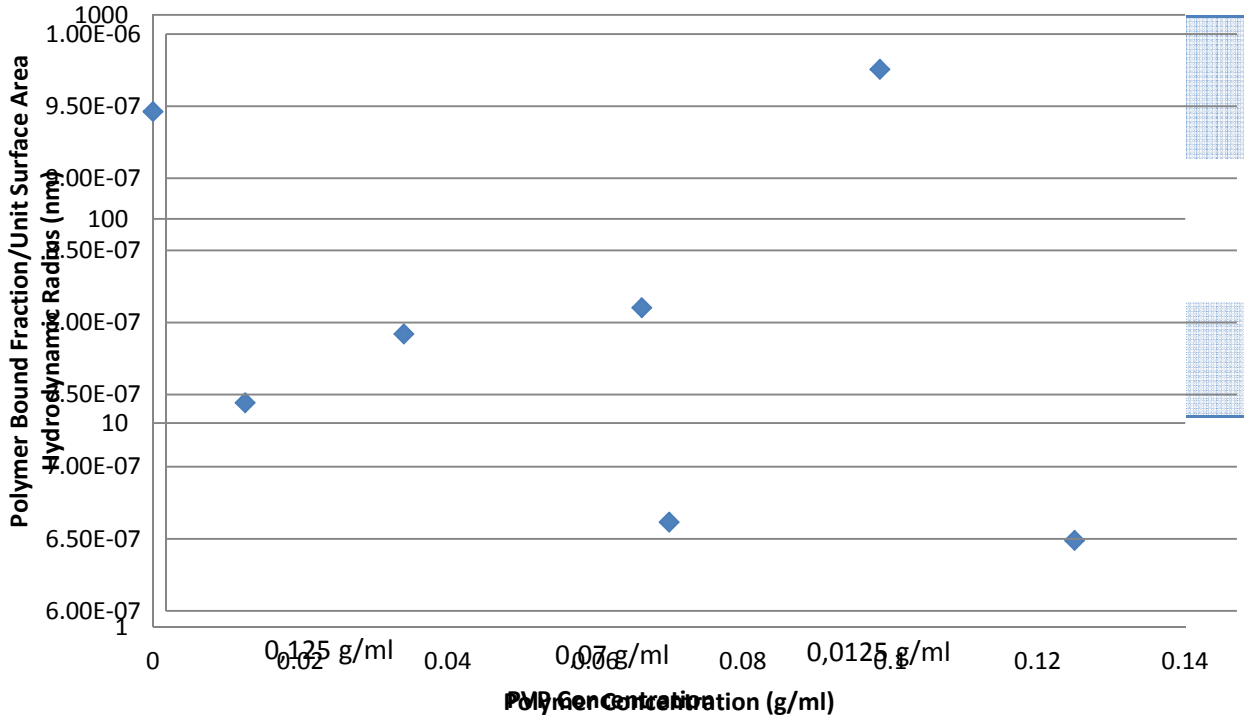
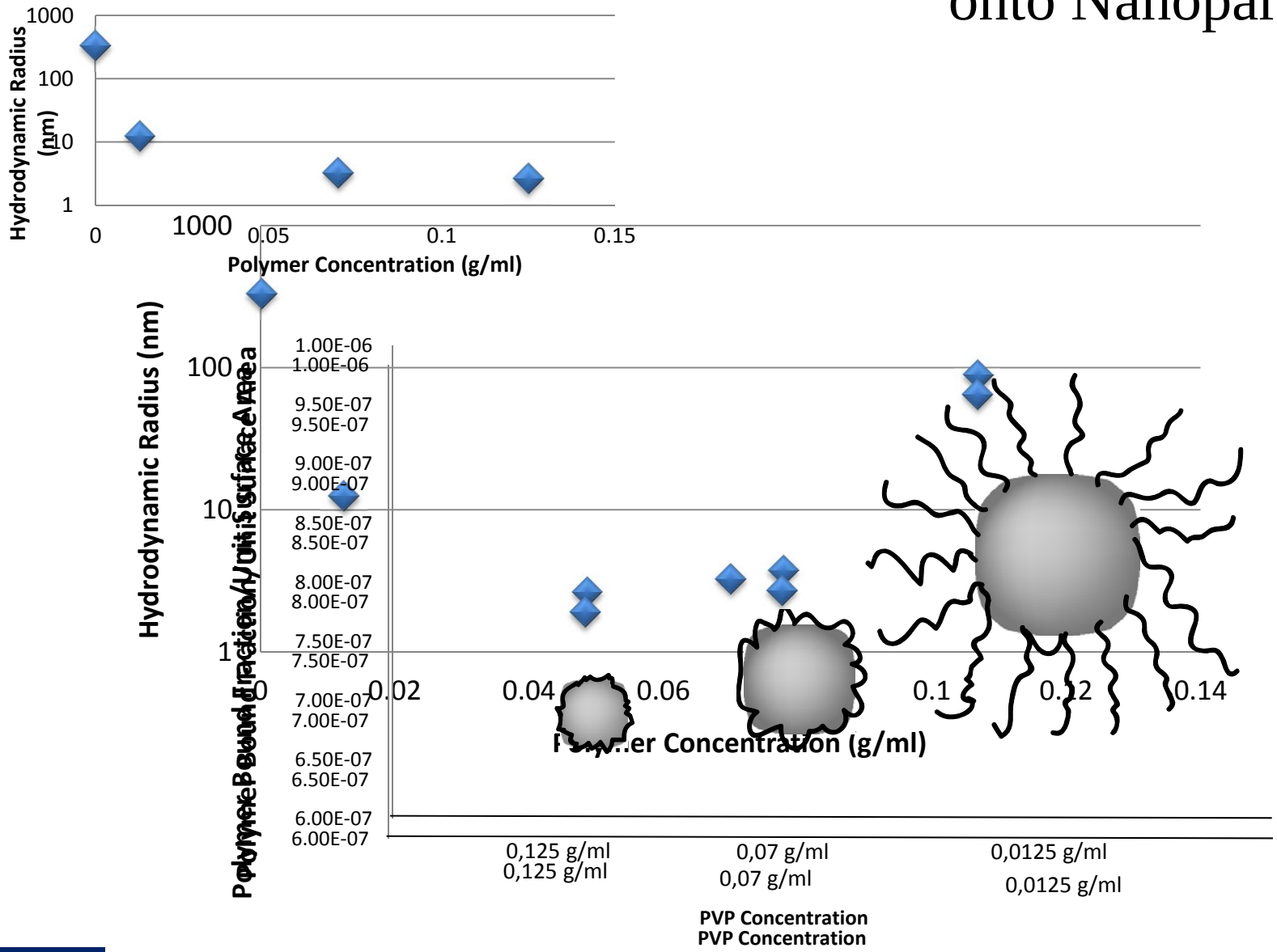


Polymer Concentration	Bound Fraction
0.125 g/ml	0,43
0.07 g/ml	0,38
0.0125 g/ml	0,42

Estimation of Bound Fraction of Polymer onto Nanoparticle



Conclusions

- Two possible scenarios, for polymer participation in the colloidal NP nucleation and growth
  - the polymeric functionalizing molecules may be templating the nanoparticle precipitation
  - the polymer may simply be increasing viscosity to slow the growth
- Dynamic NMR is useful for elucidating how PVP functionalizing molecules direct colloidal ZnO NP formation
- These techniques can be applied to the engineering of nanoparticles for drug delivery

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Hydrodynamic vs Absorption Spectroscopy Radius