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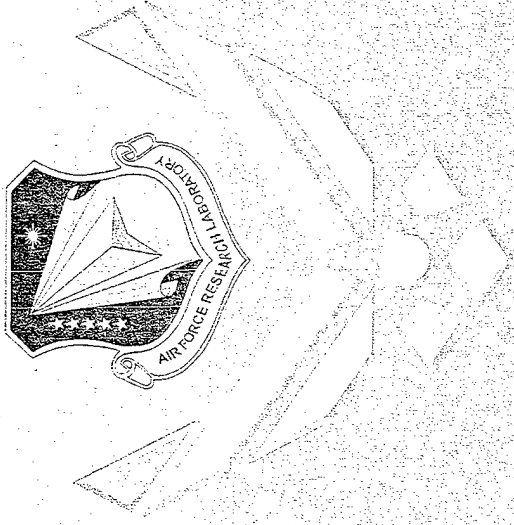
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The Specific Refractive Index Increments for POSS Polymers in Solution.

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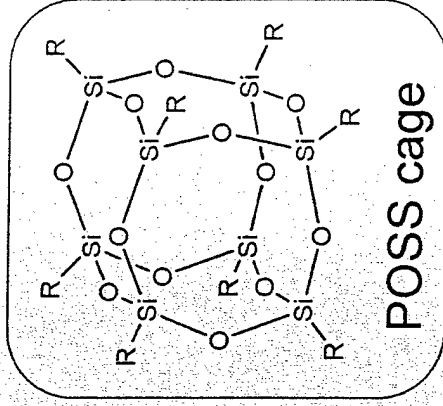
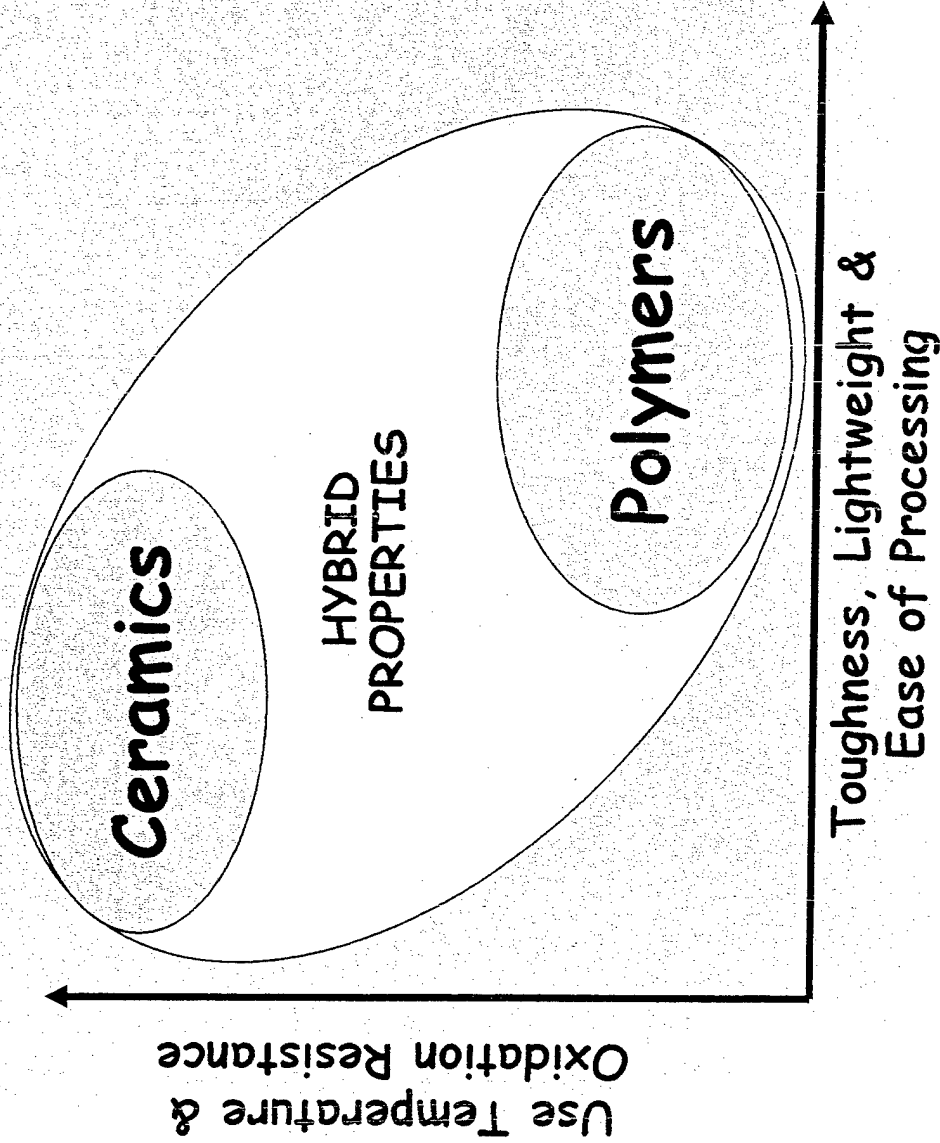
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Hybrid Inorganic/Organic Polymers

Goal: Develop High Performance Polymers that REDEFINE material properties

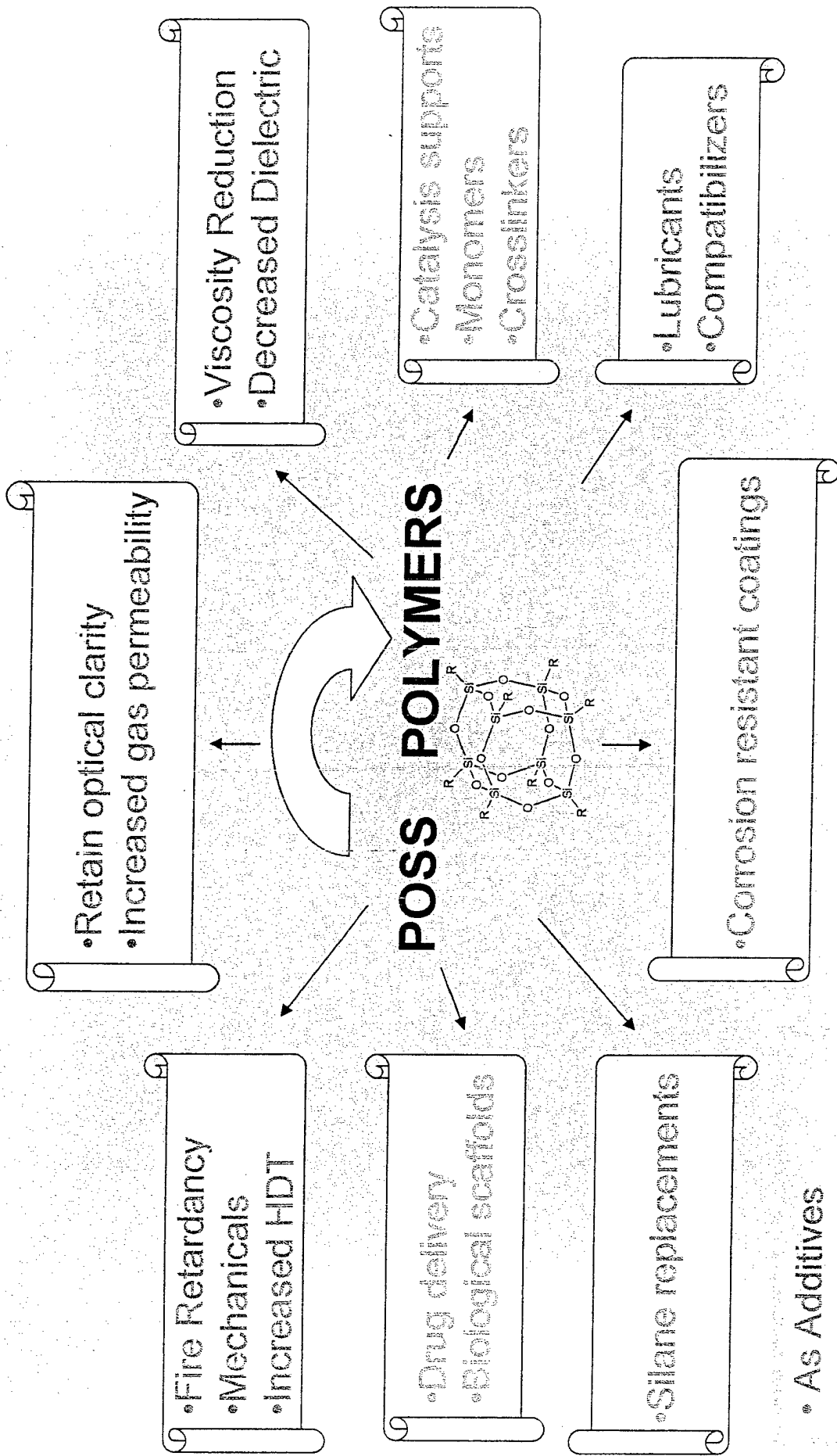
POSS – Polyhedral Oligomeric Silsesquioxanes



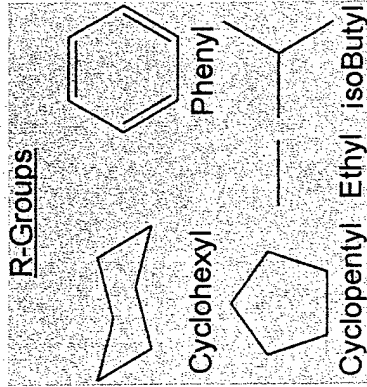
• Hybrid Plastics bridge the differences between ceramics and polymers

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Introduction to POSS

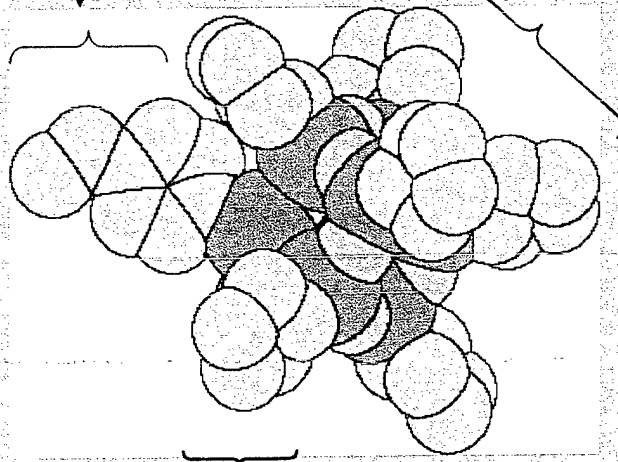


Anatomy of a POSS Nanostructure



Nonreactive organic (R) groups for solubilization and compatibilization.

Nanosopic in size with an Si-Si distance of 0.5 nm and a R-R distance of 1.5 nm.

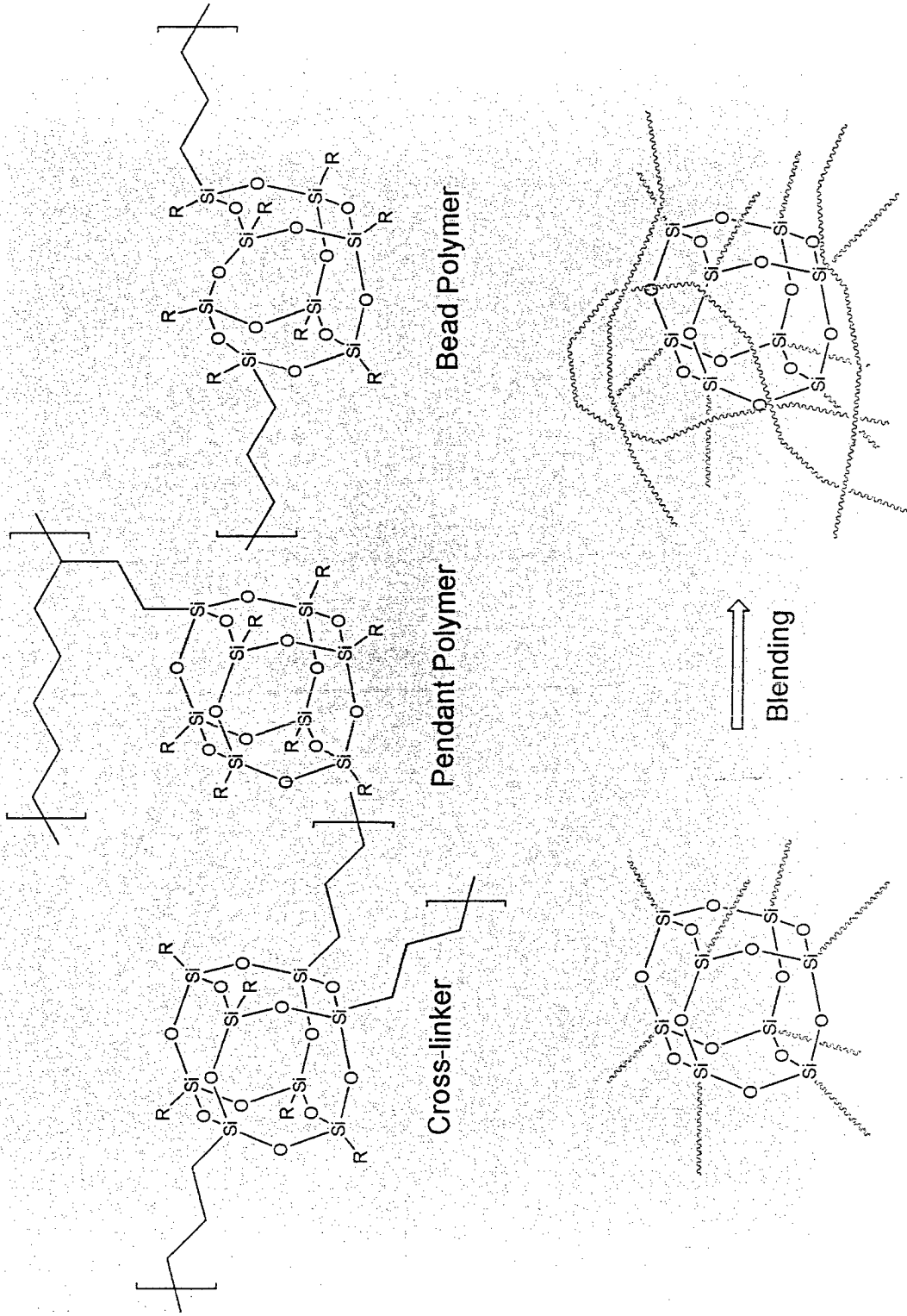


May possess one or more Functional groups suitable for Polymerization or grafting.

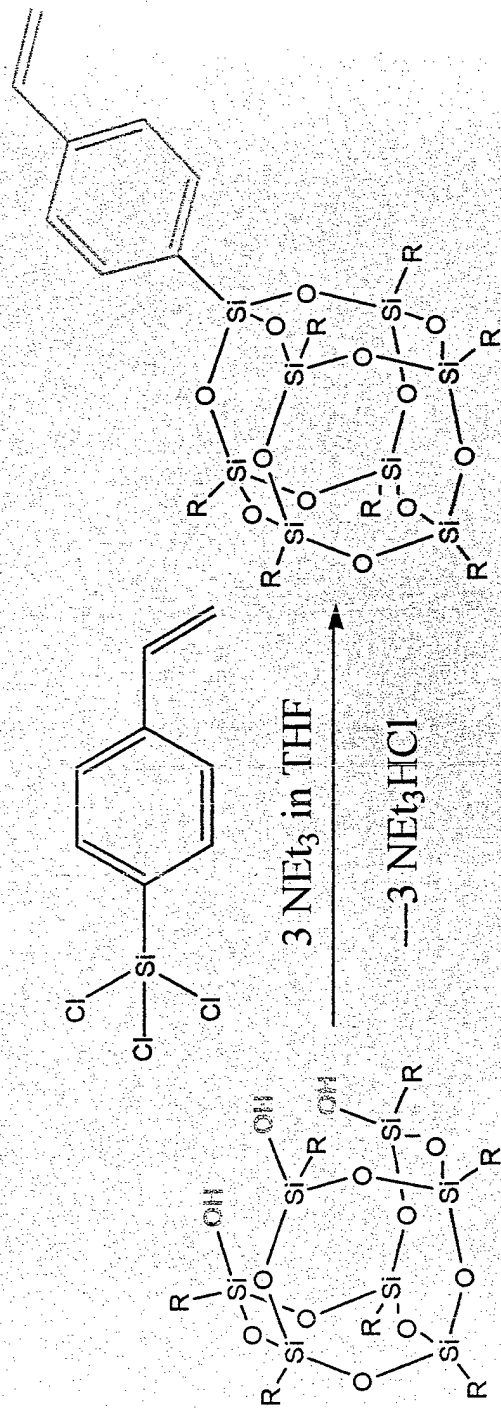
Thermally and chemically robust hybrid (organic-inorganic) framework.

Precise three-dimensional structure for molecular level reinforcement of polymer segments and coils.

POSS Polymer Incorporation

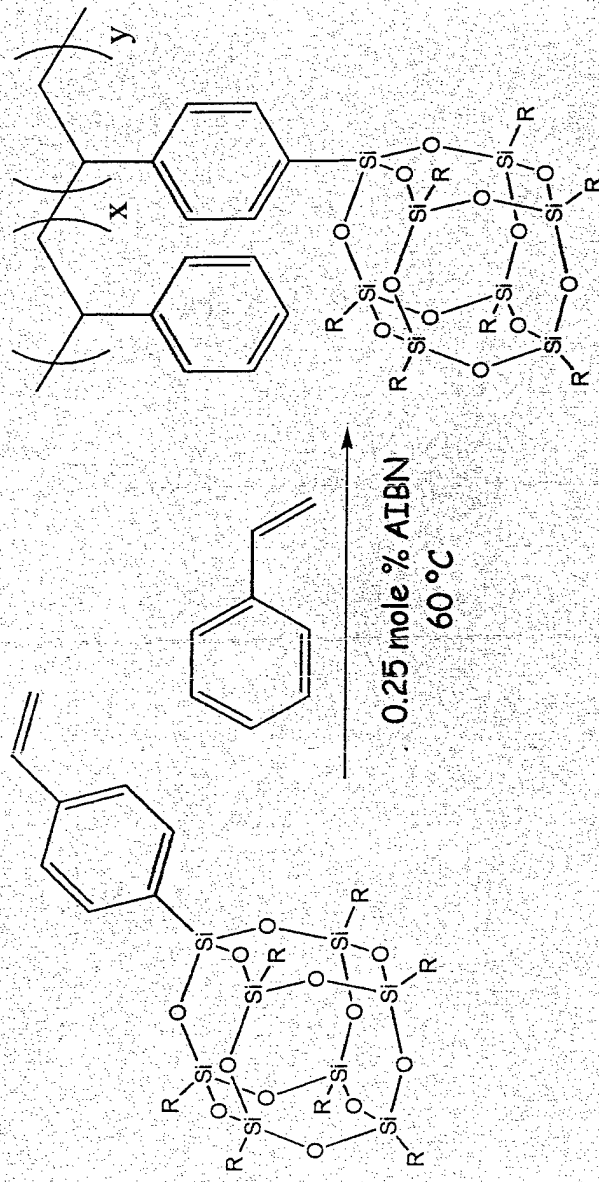


POSS Styrene Monomer Synthesis



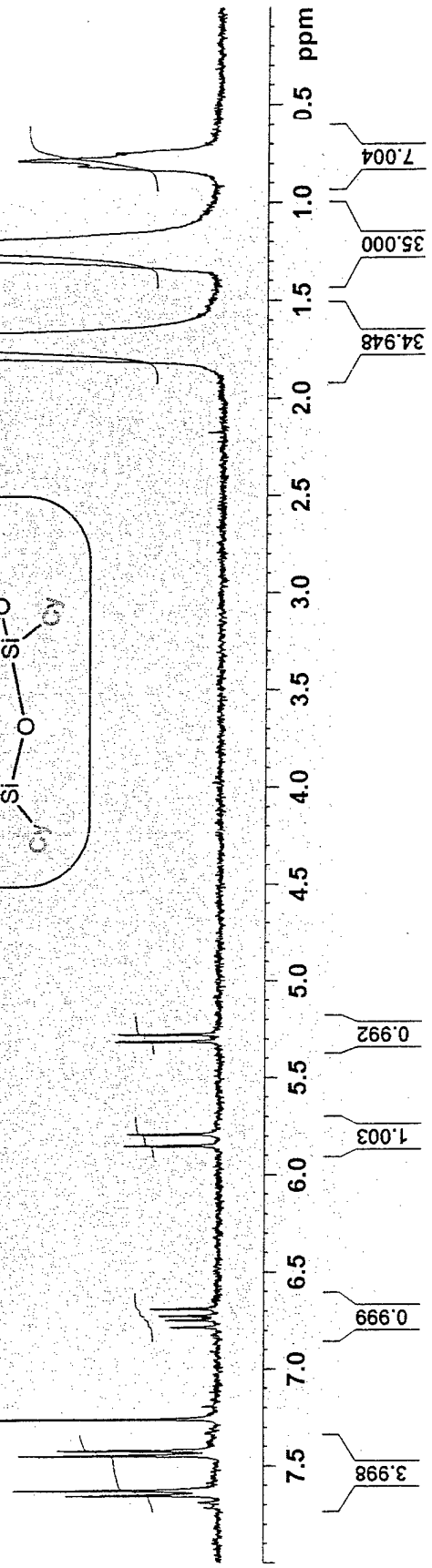
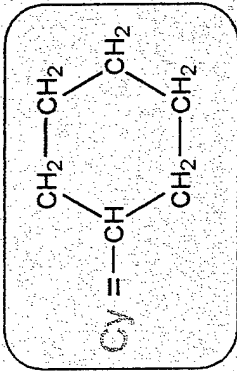
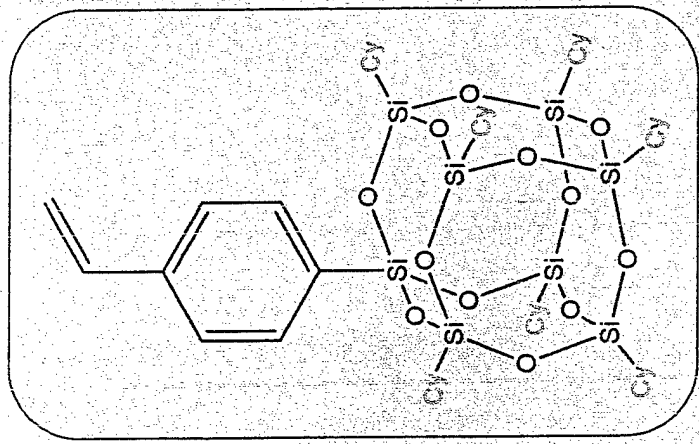
- High-yield syntheses
- Phenyl derivative requires inverse addition
- J. Inorg. Organomet. Polym., Vol 11, 2002, p. 155

POSS/ styrene Copolymer Synthesis



- Solution polymerization in toluene or bulk polymerization possible
- Polymerization is limited by solubility of the POSS-macromer
- Isobutyl-POSS is the most soluble, Phenyl-POSS the least soluble
- Macromolecules Vol. 29, 1996 p. 7302

¹H NMR Cyclohexyl POSS monomer



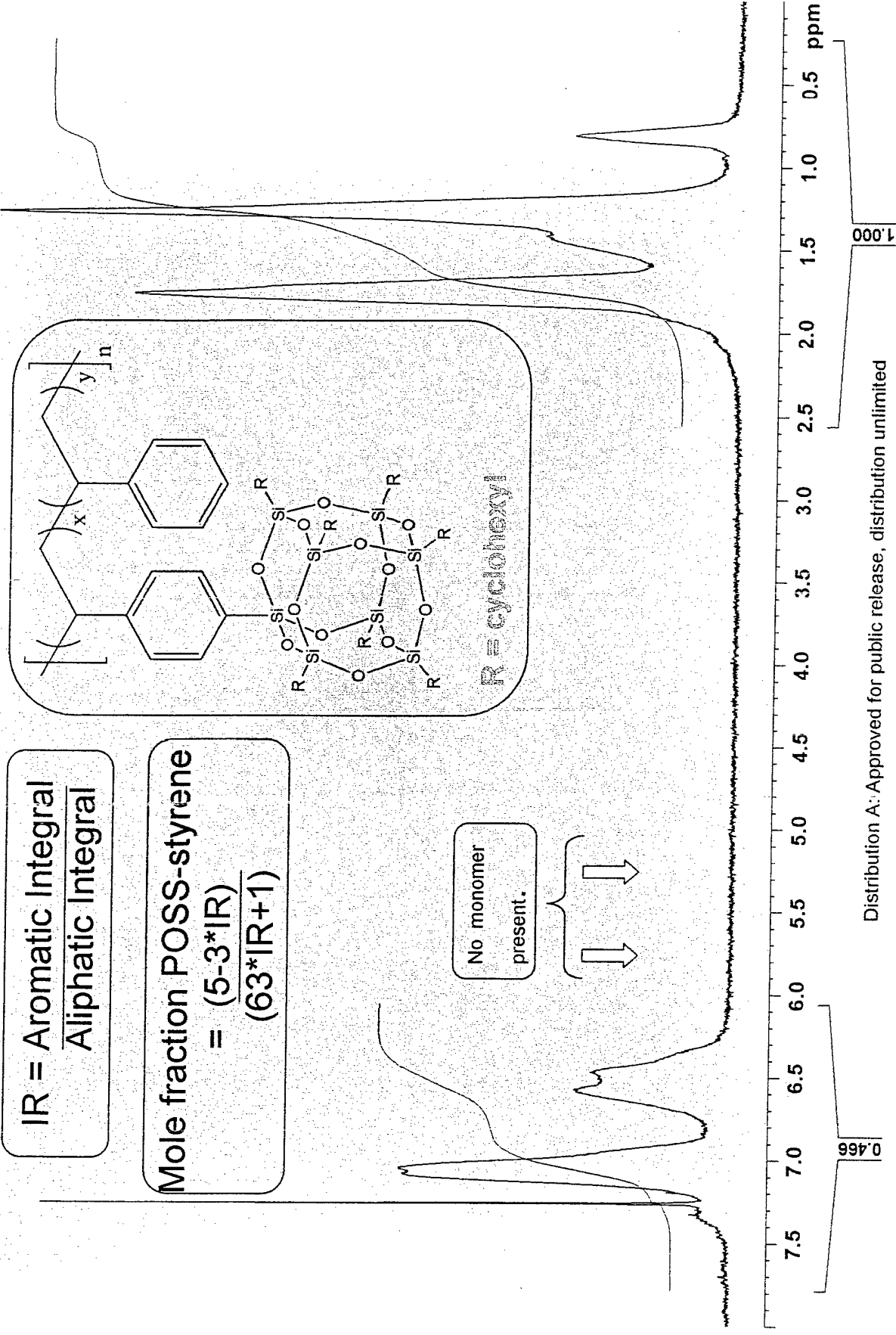
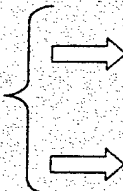
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¹H NMR 50 wt% POSS-PS copolymer

$$IR = \frac{\text{Aromatic Integral}}{\text{Aliphatic Integral}}$$

$$\text{Mole fraction POSS-styrene} = \frac{(5-3*IR)}{(63*IR+1)}$$

No monomer present.



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The Specific Refractive Index Increment and POSS Polymer

- The Specific Refractive Index Increment, $dn/dc = (n - n_0)/c$, is the change in RI with change in concentration.
- It is a constant value for a dilute polymer in solution at constant temperature, pressure and wavelength.
- It is useful for determining the M_w of a polymer by light scattering (GPC).
- For copolymers composed of two monomers, the dn/dc is an additive function of the individual weight fractions.

WAYFIND THE CH/DC VALUES

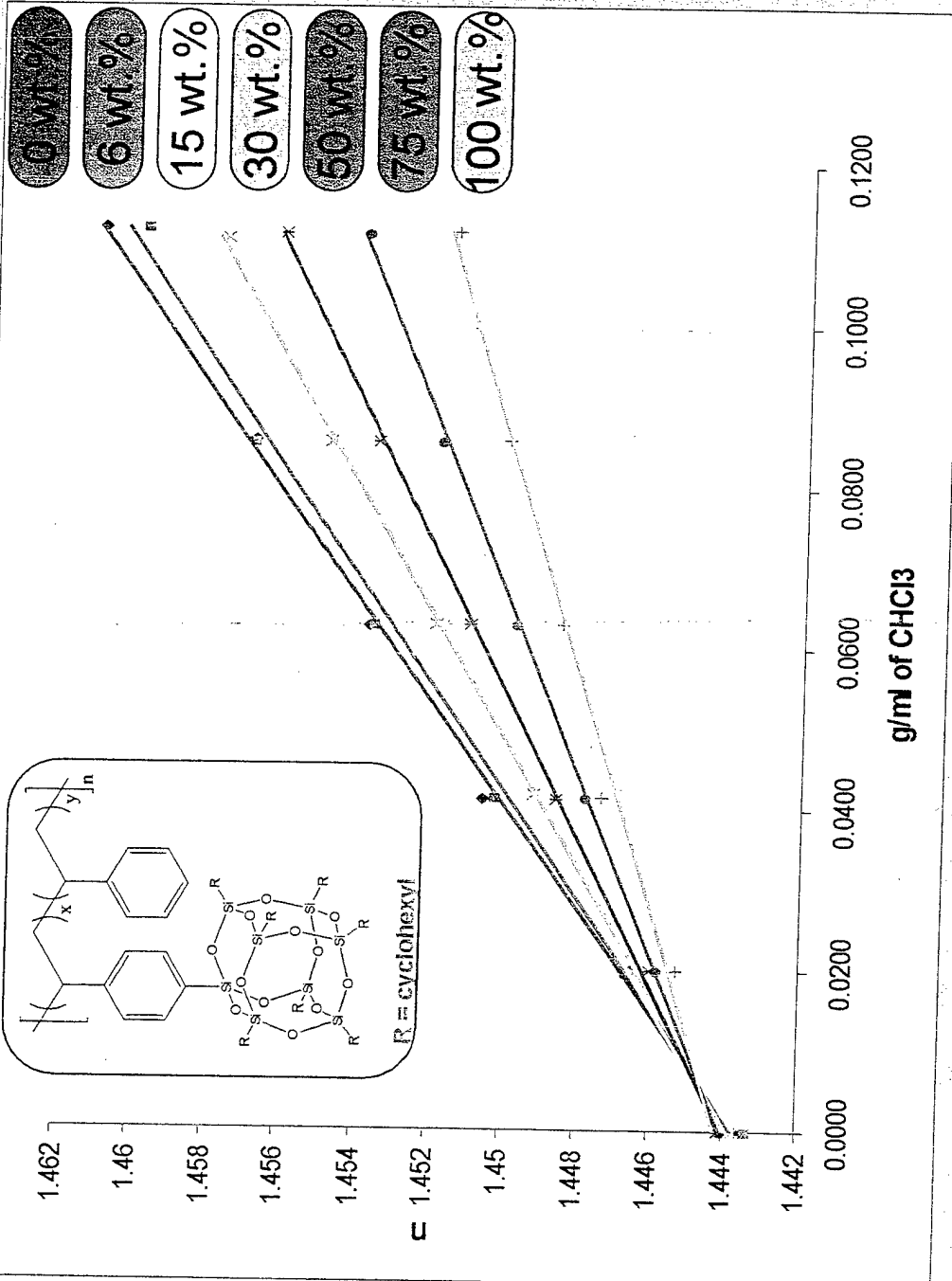
- To accurately determine the weight average molecular weights of various POSS-polymers.
- To generically parameterize each POSS type (R = cyclohexyl, isobutyl, phenyl etc.) in order to predict POSS-polymer dn/dc values.
- To provide a quick and accurate method to determine POSS % incorporation in any polymer system.

RI vs. Concentration of CyPOSS-PS copolymer

wt.% POSS-Styrene

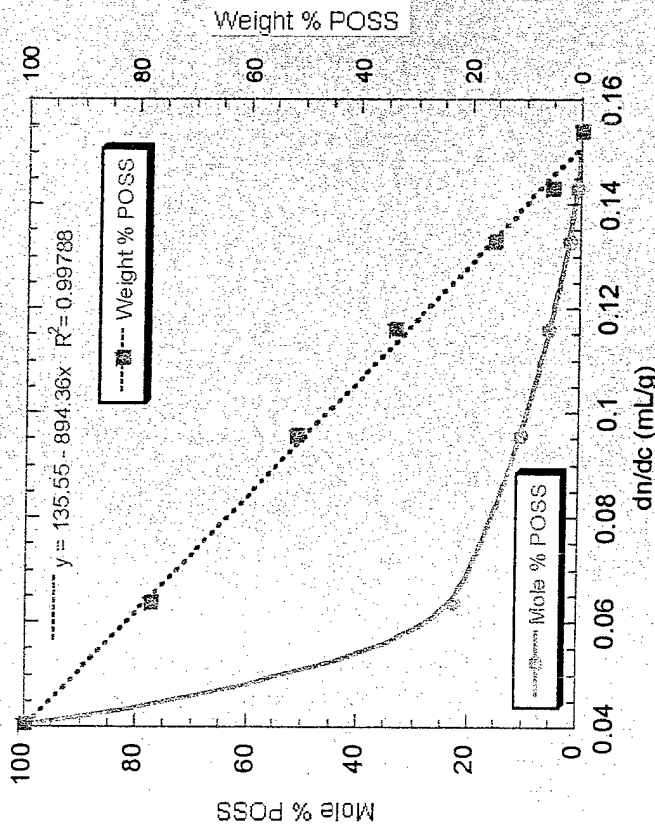
Slope = dn/dc

Y=0.1253x+1.4437 R ² =0.9975	Y=0.1488x+1.4437 R ² =0.9949	Y=0.1352x+1.4439 R ² =0.9985	Y=0.1270x+1.4438 R ² =0.9995	Y=0.1000x+1.4442 R ² =0.9985	Y=0.0894x+1.4444 R ² =0.9998	Y=0.0676x+1.4442 R ² =0.9959
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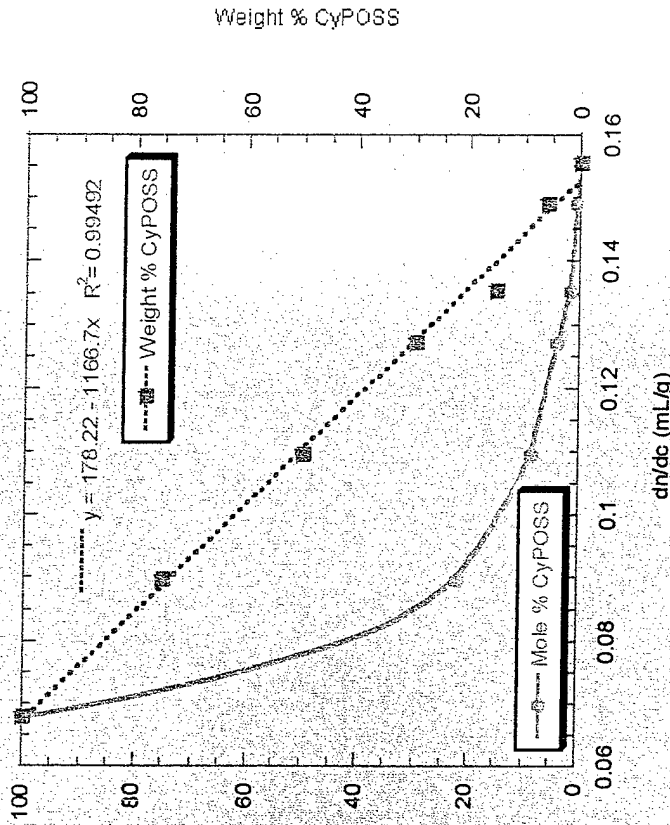


dn/dc vs wt% and mole%

iBuPOSS-PS copolymer



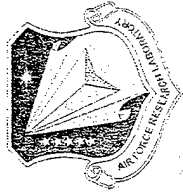
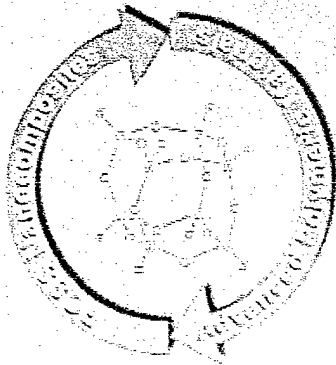
CyPOSS-PS copolymer



- Clearly, dn/dc is linear with respect to weight % POSS not mole % POSS; changes in refractive index are proportional to the volume occupied by the polymeric components. A typical POSS monomer is about 10X more massive than a typical organic monomer.
- Note that the dn/dc value decreases with increasing POSS incorporation.

Summary & Future Work

- There is a linear relationship between weight % POSS and the dn/dc of a styrene copolymer.
- To graph a dn/dc / weight % POSS relationship for any new POSS polymer it is reasonable to just measure the dn/dc values of the 0 and 100 % POSS polymer.
- We intend to prove this concept for other glassy (Acrylics) and rubbery (Norbornenes) POSS copolymers.



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