Microenviromental Effects: Loading, Stereoselectivity and Reaction rates Involving Polymeric Reagents

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Microenvironmental Effects

Normally observed using crosslinked polymers

the semi-rigid nature of crosslinked polymers provides a rather unique chemical environment.

May be due to the polymer chain, functional groups on the chain, or combination of both

Higher Localized Rate Constants

Alters Reactivities (Attractions or Repulsions) and Selectivities

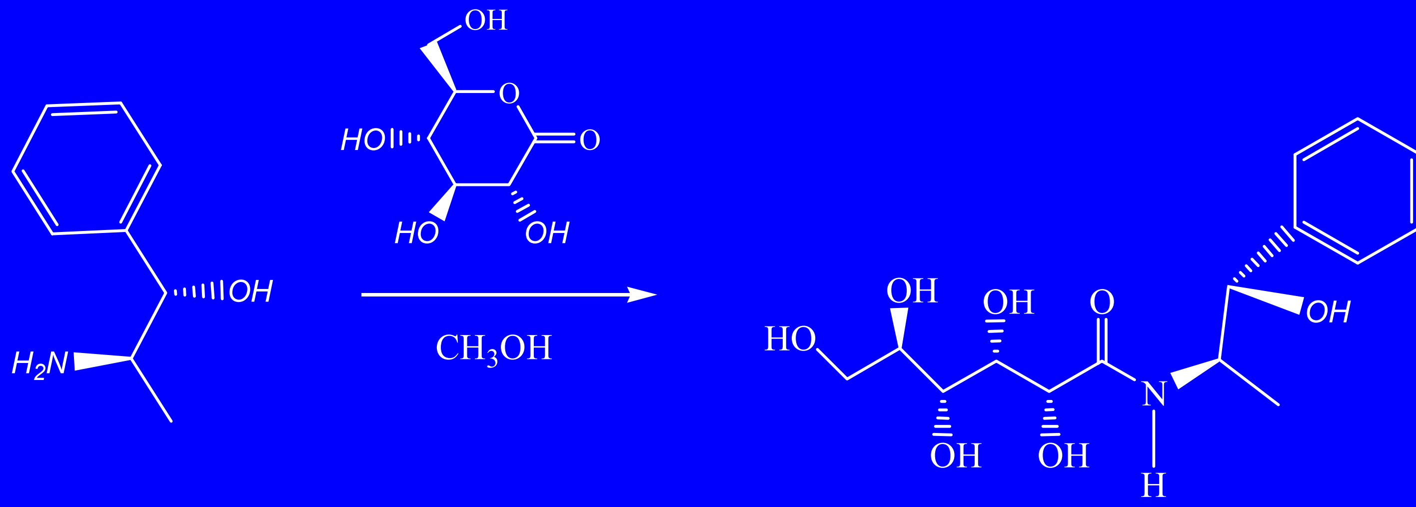
Background

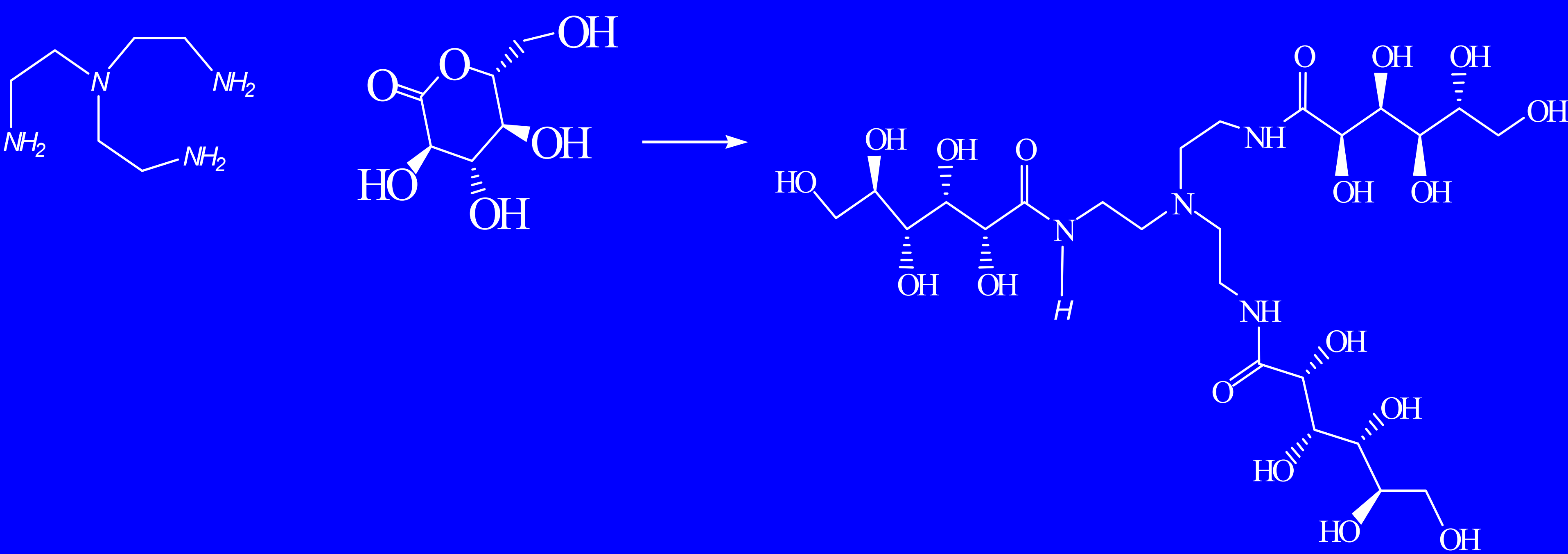
- Reaction Rates – relative to polar/nonpolar environments, utilized crosslinked polymers (Alexandrotos and Miller, 2000/Krishnakumar and Mathew, 2002)
- Asymmetric Induction – critical concentration of groups are needed, used dendrimers (Schmitzer, et al., 2001)
- Microenvironmental effects can be altered to improve the stereoselectivity of reactions using crosslinked polymers (Blanton, 2004)

Project Focus

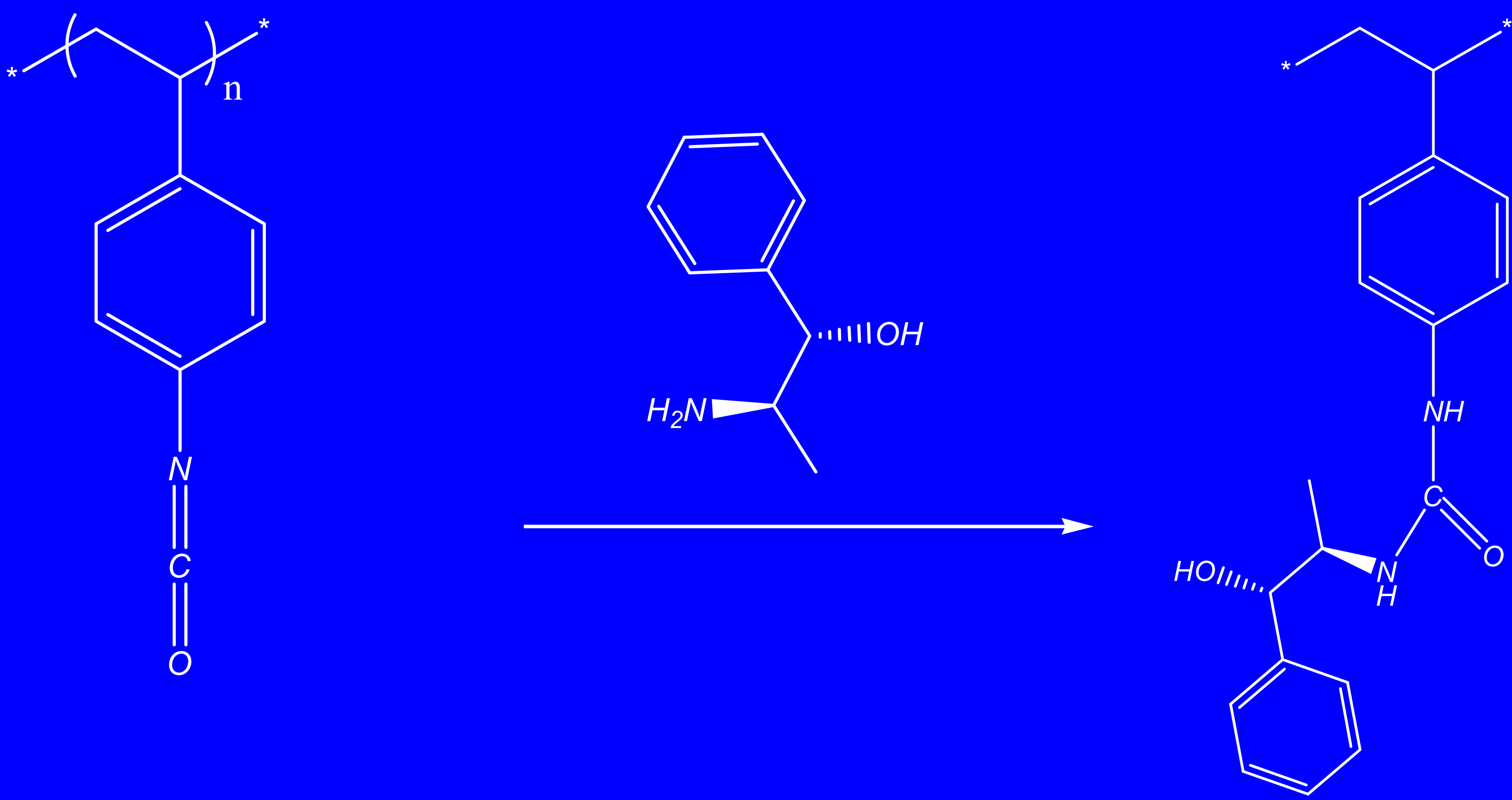
- Chiral Polyols were attached to polymer backbones via carbamate (urethane) or urea links
- Substrates with increasing numbers of alcohol groups were used to increase the group density within the polymer matrix
- Loading, asymmetric induction, and reaction rate was ascertained for each polymer

Amide Preparation



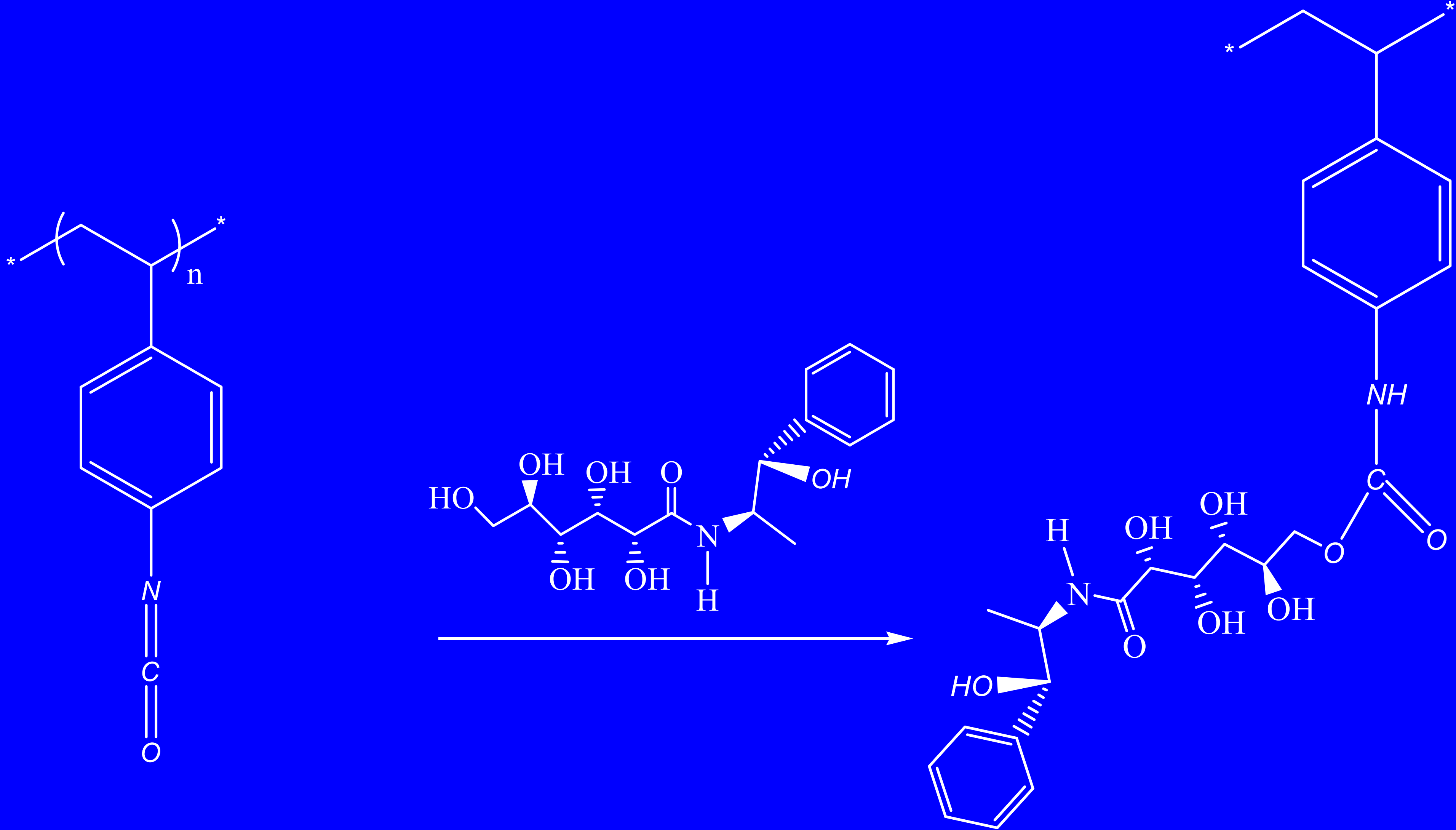


Preparation of Polymer 1



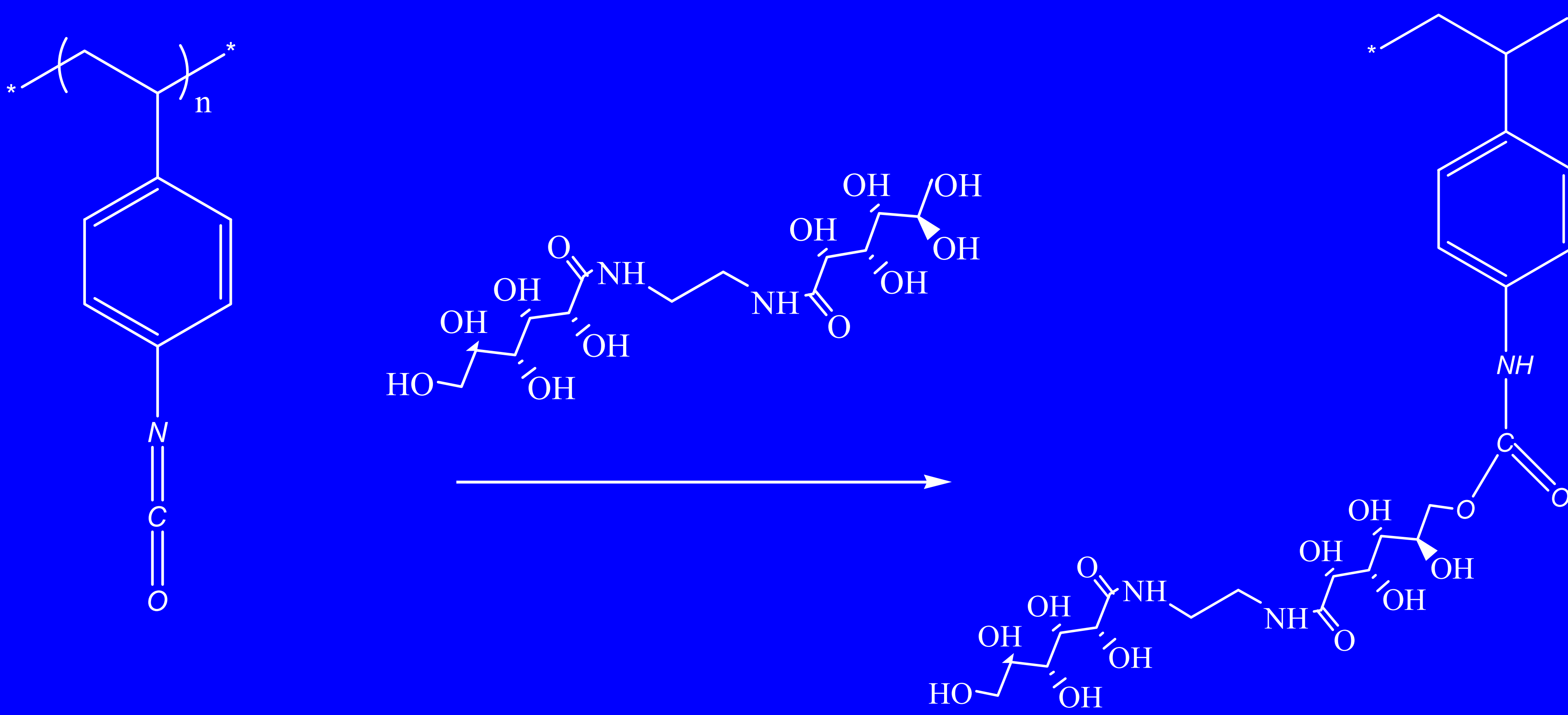
1

Preparation of Polymer 2



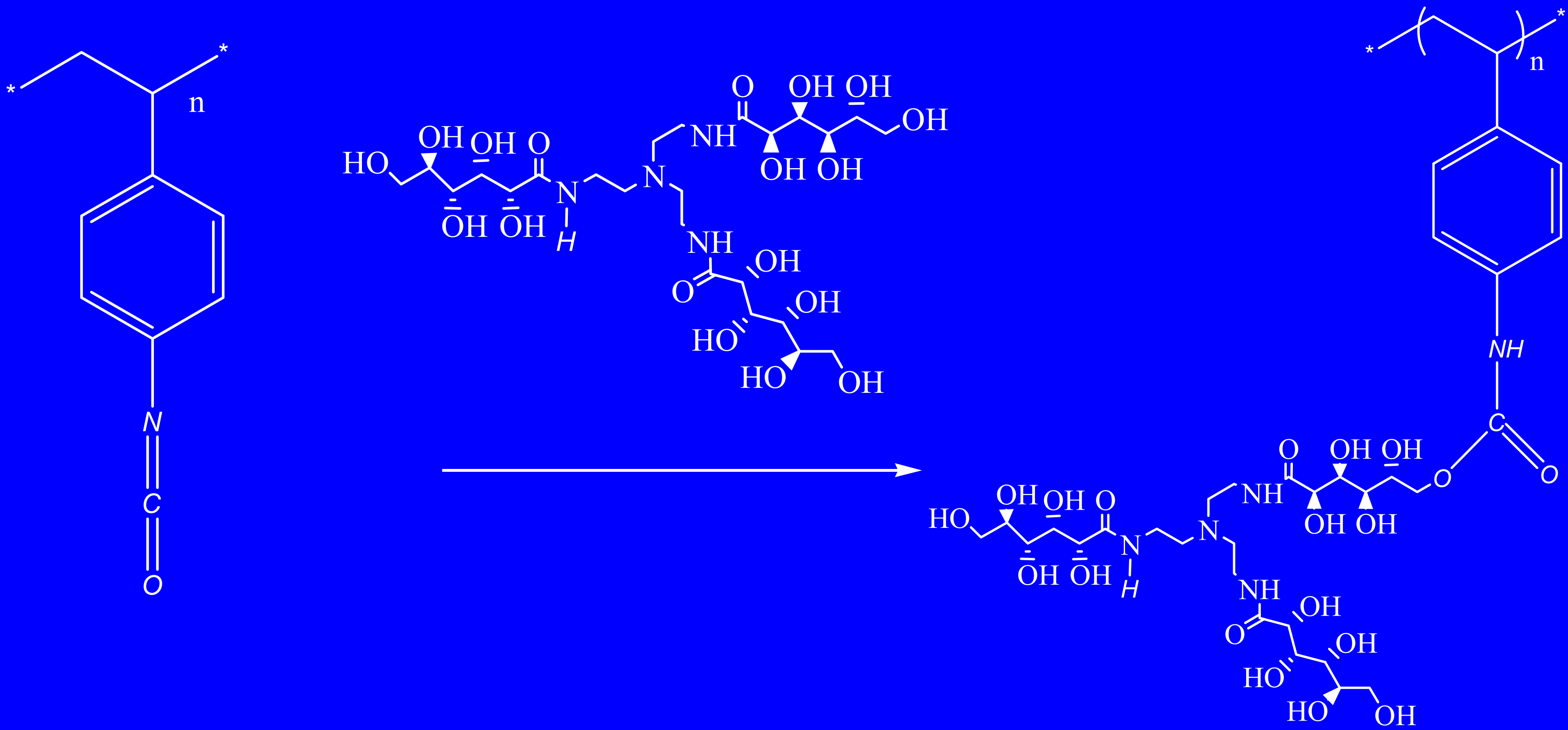
2

Preparation of Polymer 3



3

Preparation of Polymer 4



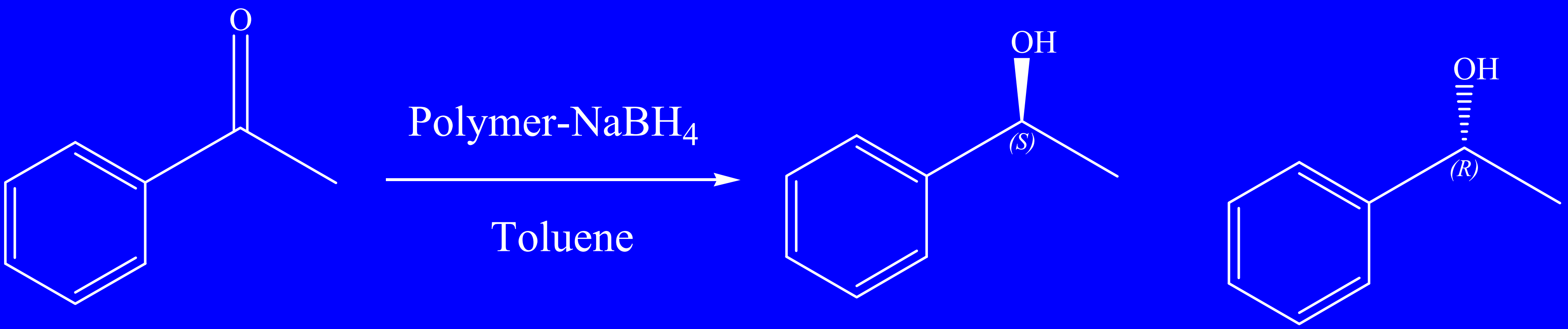
4

Polymer Functionalization

Polymer-Bound $NaBH_4$

$$\text{Polymer-OH} \xrightarrow[\text{Diglyme, } 70^{o}]{NaBH_4} \text{Polymer-}NaBH_4$$

Reduction Reaction



Data Acquisition

Analysis: Capillary GC using a β-cyclodextrin stationary phase to separate the stereoisomers using a known amount of dodecane as an internal reference

Loadings: the polymers were washed to remove excess $NaBH_4$. A 5-fold excess of ketone was used to insure complete reaction of the bound borohydride. The meq of product formed/g of polymer used.

Rate Studies were conducted by determining the average pseudo-first-order rate constant after 300 s and normalizing it with respect to the meq of H^- present.

Data Table

Polymer	Load (meq H^-/g)		%ee	Rate (10^4k/meq H^-)s^{-1}
1	2.6 ± 0.3	(3)	10.4 ± 1.4 (R)	8.0 ± 0.8
2	4.8 ± 0.3	(15)	6.8 ± 1.1 (S)	7.3 ± 0.7
3	4.3 ± 0.5	(27)	22.0 ± 1.5 (S)	9.7 ± 0.2
4	4.1 ± 0.3	(42)	34.2 ± 3.0 (S)	14.7 ± 1.8

All uncertainties are the standard deviations for each set of experiments

Numbers in parentheses represent the potential loading

Conclusions

- Loading
  - Relatively Constant (2.6 to 4.8) meq H^-/g polymer
  - Increase in polymer weight was considerably less than predicted
  - Indicates that multiple reactions occurred between the substrate and the flexible polymer chain.
  - Diffusion of the polar substrate into the nonpolar polymer may have been slow relative to the reaction with the isocyanate group

- Asymmetric Induction
  - significant increases occurred when the concentration of chiral groups increased
  - The degree exceeded those reported for larger dendrimers (1st and 2nd generation)
  - Because the loadings of the polymers didn’t increase appreciably, the change in the microenvironment must be the influence
  - Would expect further increases with larger substrates

- Activity
  - Normalized rate constants increased as the microenvironment became more polar
  - While the magnitude wasn’t as impressive as those in different studies, they were significant

Acknowledgements

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