Reduction of Polysuccinimide

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I continue to be interested in lactams especially pyrrolidone derivatives. This is because of its many important uses such as the ability to form water soluble complexes with many biologically important compounds. It can form hydrogels with appropriate comonomers and can conceivably deliver medicinals to target organs. Therefore, I have many pdf's on my web page concerned with pyrrolidone chemistry. These include various ways to prepare pyrrolidone backbone polymers. Another idea for preparing such polymers crossed my mind when I became interested in polyaspartic acid chemistry.

Aspartic acid + heat affords polysuccinimides

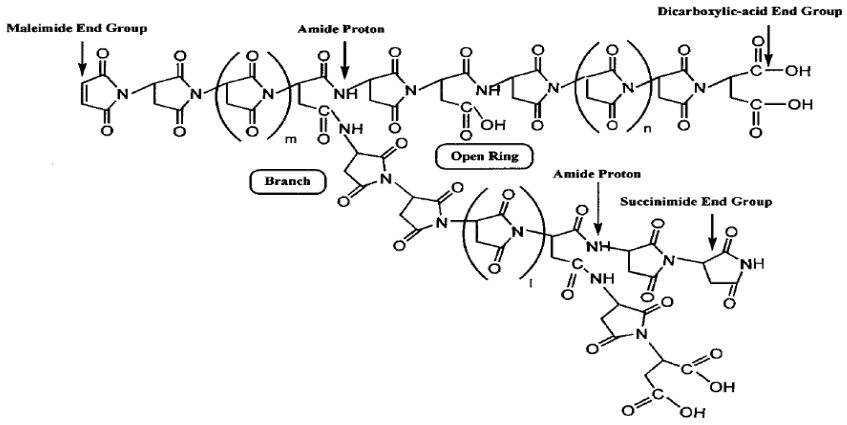


Figure 1. Structural image of polysuccinimide.

Nakato, T., Kusuno, A., & Kakuchi, T. (2000). Synthesis of poly (succinimide) by bulk polycondensation of L-aspartic acid with an acid catalyst. *Journal of Polymer Science Part A: Polymer Chemistry*, *38*(1), 117-122.

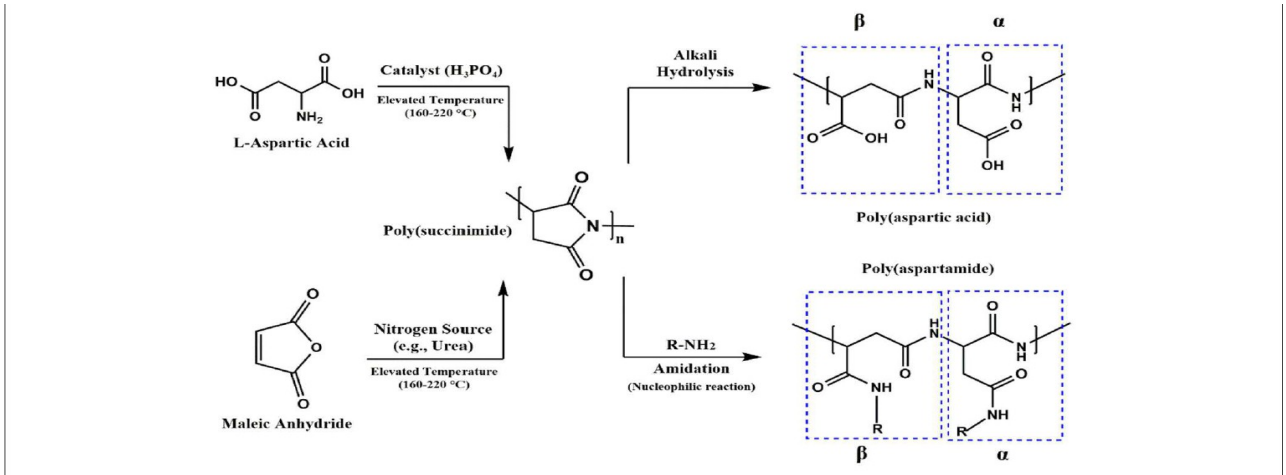


FIGURE 1 | Synthesis procedure of PSI, PASP, and poly(aspartamide). PSI can either be obtained through poly-condensation (usually at elevated temperature >160°C using an acid as the catalyst) of ASP or malic acid (synthesized by maleic anhydride and a nitrogen source such as urea or ammonia). PSI can be hydrolysed under alkali media to yield PASP or reacted with primary amines (without catalyst at room temperature) to yield poly(aspartamide) derivatives. The ring opening of succinimde groups occurs both at α and β sites in amidation and hydrolysis reaction.

Adelnia, H., Blakey, I., Little, P. J., & Ta, H. T. (2019). Hydrogels Based on Poly (aspartic acid): Synthesis and Applications. *Frontiers in chemistry*, *7*, 755.

These authors afford a nice review of the synthesis of polyaspartic acids. The use of maleic anhydride is said to produce low MW polymers; however, the patent literature has several examples of methods to increase the MW to 10K or higher.

Das, P., & Jana, N. R. (2021). Biomedical Applications of Functional Polyaspartamide-Based Materials. *ACS Applied Polymer Materials*.

Adelnia, H., Tran, H. D., Little, P. J., Blakey, I., & Ta, H. T. (2021). Poly (aspartic acid) in Biomedical Applications: From Polymerization, Modification, Properties, Degradation, and Bio-compatibility to Applications. *ACS Biomaterials Science & Engineering*.

I also proposed this type of polymer ...Copolymers Prepared by the In-Situ Synthesis of Maleimide/Maleamic Acid Monomers ...see pdf on my web page for details.

Reduction:

Cohen, H. L., & Minsk, L. M. (1959). Reduction of Polymers Using Complex Metal Hydrides. *The Journal of Organic Chemistry*, *24*(10), 1404-1407.

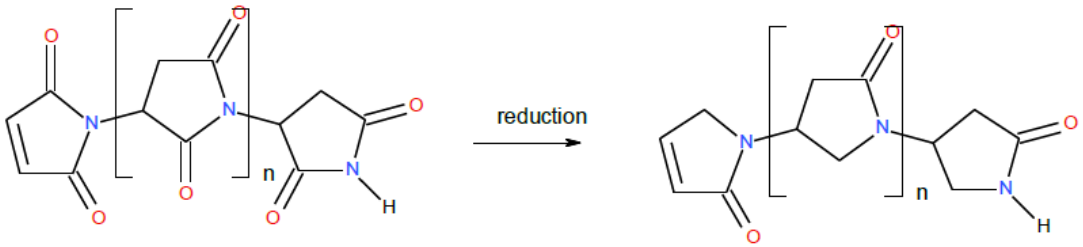
Cohen, H. L., Borden, D. G., & Minsk, L. M. (1961). Reduction of Polymers Using Complex Metal Hydrides. II. *The Journal of Organic Chemistry*, *26*(4), 1274-1278.

Miller, S. A., & Chamberlin, A. R. (1989). Highly selective formation of cis-substituted hydroxylactams via auxiliary-controlled reduction of imides. *The Journal of Organic Chemistry*, *54*(11), 2502-2504.

These are the earliest references I found that illustrate the reduction of an amide or imide. My question is can imides also be reduced to amides? Unfortunately these references show imides being converted to cyclic amines or to hydroxylactams. They also employ inorganic classic reducing agent that are hard to handle and produce difficult to remove after use.

Hargreaves, M. K., Pritchard, J. G., & Dave, H. R. (1970). Cyclic carboxylic monoimides. *Chemical Reviews*, *70*(4), 439-469. This is an outdated but interesting reference.

My proposal then is to suggest ways of converting polysuccinimides to polypyrrolidones.



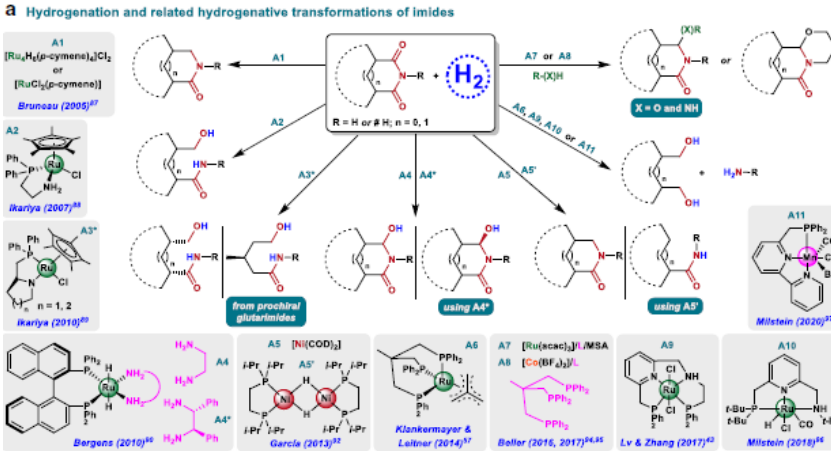
Polysuccinimide Polypyrrolidone

Scheme 1: Obviously the question is how to accomplish this reduction so that usable polypyrrolidones are produced?

I would not expect 100% conversion to the pyrrolidone, but enough to afford

usefulness. What attracts me is that the polysuccinimides can be prepared from the very inexpensive maleic anhydride route.

Recently a review of hydrogenation of amides and imides appeared. The following chart is from that reference:



Cabrero-Antonino, J. R., Adam, R., Papa, V., & Beller, M. (2020). Homogeneous and heterogeneous catalytic reduction of amides and related compounds using molecular hydrogen. *Nature Communications*, *11*(1), 1-18.

Considering this excellent review, experimentation with these or similar catalyst ideas could lead to a very cost effective reduction of polysuccinimides to pyrrolidones with these effective soluble hydrogenation catalysts.

Pyrrolidone backbone polymers can exhibit many worthwhile properties such as delivery of medicinals, blood plasma expanders, iodophor, surfactant(after appropriate derivative), water soluble glue, hydrogel(cross-linked) etc.. Please go to my web page (rloginconsulting.com) and look at my other pyrrolidone backbone ideas.

Pyrrolidone Backbone Polymers

rROP of Lactam Derivatives

3-Methylene-2-Pyrrolidone(3M2P) and Related Monomer Chemistry

Potential "Vinyl" Lactam Monomers.

Epoxylactams

Vinylcyclopropane Pyrrolidone Polymers

Polypyrrolidones and Cyclopolymerization

Lactam Chain Polymers

"Vince Lactam" Polymers

Thank you for reading this proposal!
Dr, Robert B. Login