

Advanced Macromolecular Engineering with Modular Chemical Instruments

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Abstract

More than ever, modern polymer research needs quick and efficient chemical reactions to build intricate macro or supramolecular structures. The current feature article highlights our most recent attempts to create macromolecular synthesis specific modular synthetic platforms. The macromolecular engineering potentials of two “click” reactions, (i) the radical addition of mercaptans onto vinyl double bonds and (ii) the copper catalyzed cycloaddition of azides and terminal alkynes are two examples.

Keywords: Frustrated Lewis pairs; Catalytic hydrogenation; Water tolerance; Reductive amination; Polymer

Introduction

Perhaps more than any other synthetic science, macromolecular chemistry depends on quick, effective and flexible chemical reactions. In fact, despite the significant advancements made in this area of study over the past few decades, synthetic macromolecules are still typically less well understood than biopolymers like proteins or nucleic acids.

Given that contemporary organic synthesis provides workable options for the creation of chemo, regio and stereo controlled low molecular weight molecules, such limitations of polymer chemistry may surprise many non-specialists. The transfer of these chemical tools from the molecular to the macromolecular scale is not always simple, though. For instance, low yield or unfocused chemical processes in ordinary organic synthesis result in the development of different byproducts that can, to a certain extent, be isolated and purified. Similar macromolecular processes result in poorly defined polymer architectures. Consequently, the series of chemical processes frequently utilised for the ability to create or change polymers is, by necessity, constrained to simple tools that have been established. However, what initially seems to as a huge disadvantage could actually be a significant gain. For instance, only a handful of chemical processes and a very modest collection of monomers 20 amino acids are used by nature for creating biopolymers and biological materials with extraordinary structural and functional properties (together with a few sugars and nucleobases).

Description

Perfect functionality nature only chose strong chemical instruments *via* billions of years of optimization, which are perfectly suited to the climatic conditions of earth. Such a selective approach might also be useful in synthetic chemistry and might be a successful method for creating tomorrow's materials. This point is stressed by certain current advances in chemical sciences, such as the “click” chemistry idea put forth by Sharpless and colleagues. The term “click” refers to chemical reactions that are flexible, effective, focused and energetically favoured and have the potential to become commonplace tools in synthetic chemistry. This intriguing idea was originally put forth for the crucial domains of combinatorial research and drug development, as well as for low molecular weight chemical synthesis. However, “click” chemistry has also recently grown to be very well-liked in the polymer and materials sciences. The concept has taken off quickly in macromolecular chemistry as a result. All of this is not very surprising given that polymer research requires universal synthetic tools, as was previously discussed.

This feature article's goal is to explain effective chemical processes, which have recently been demonstrated to be modular tools for polymer synthesis. In particular, two flexible reactions that have received a great deal of attention are the copper catalyzed

1,3-dipolar cycloaddition of azides and alkynes known as “click” chemistry and the free radical addition of u-functional mercaptans on double bonds. The set of chemical processes often utilised to create or alter polymers is, by necessity, constrained to well-established, simple processes. However, what initially seems to be a big disadvantage may actually be a significant advantage. For instance, nature creates biopolymers and biological materials with astounding structural and functional perfection using just a very limited number of chemical processes and a very tiny library of monomers 20 amino acids and a few sugars and nucleobases. Nature only chose sturdy chemical instruments that are well suited to the earth’s climatic circumstances over billions of years of optimization. Such a selective method might also be applicable in synthetic chemistry and might be a successful tactic. Hence calls for universal artificial tools.

Conclusion

This feature article’s goal is to explain effective chemical processes, which have recently been demonstrated to be modular tools for polymer synthesis. In particular, two flexible reactions that have received a great deal of attention are the copper catalyzed 1,3-dipolar cycloaddition of azides and alkynes known as “click chemistry” and the free radical addition of u-functional mercaptans on double bonds. Wide ranging macromolecular engineering opportunities are provided by both processes, including the creation of specified telechelics, functionalized block copolymers and bio hybrid structures.