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2008 : July 2008 - New Hot Papers : Wolfgang H. Binder

NEW HOT PAPERS - 2008

July 2008



Wolfgang H. Binder talks with *ScienceWatch.com* and answers a few questions about this month's New Hot Paper in the field of Chemistry. The author has also sent along images of their work.



Article Title: **'Click' chemistry in polymer and materials science**

Authors: Binder, WH; Sachsenhofer, R

Journal: MACROMOL RAPID COMMUN

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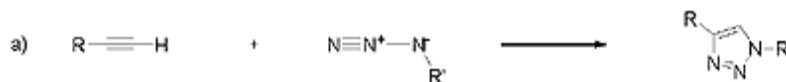
Year: JAN 5 2007

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SW: Why do you think your paper is highly cited?

The paper on "click"-chemistry in polymer and materials-science¹ provides an overview on the use of a newly discovered reaction for application in polymer and material science. The reaction basically is an old one (i.e.: a Huisgen-type 1,3-dipolar cycloaddition reaction), but was re-discovered as a catalytic-high-yielding reaction in 2001-2002 by Meldal *et al.*^{2, 3} and Sharpless *et al.*⁴ by using Cu(I)-salts as catalysts.



Scheme 1 Basic reaction of the azide/alkyne-"click"-reaction.

As the reaction is highly ubiquitous (i.e.: yield of product often more than 99%, substrate and solvent independent reaction progress) it represents a landmark in **polymer**, material, and supramolecular science, where reactions with such completeness and effectiveness are difficult to conduct. The method brings polymer science to a standard of organic chemistry in terms of impurities and completeness, most of all in the synthesis of highly defined polymer-molecules and materials.

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

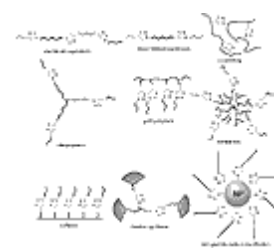
"Click"-chemistry is a valuable tool in polymer science for the efficient linkage of functional entities, oligomers, or polymers, yielding access to functional homo-, block-, star-, graft-polymers as well as higher polymeric architectures (dendrimers, hyperbranched polymers, supramolecular polymers, gels, polymer brushes).

Besides other efficient-"click"-reactions, the copper(I)-catalyzed 1,3-dipolar-azide/alkyne-cycloaddition reaction has emerged as the method of choice for this and related purposes. The main advantage in relation to conventional linking reactions are (a) quantitative yields (b) mild reaction conditions (c) solvent and substrate insensitivity (d) high-yielding reactions under both homogeneous and heterogeneous reaction conditions.

Shortly after 2001, the azide/alkyne-"click"-reaction was discovered as a metal-catalyzed (Cu(I))-1,3-dipolar cycloaddition reaction (Huisgen-reaction), revealing many applications in bioorganic and organic chemistry. This reaction proved superior over others since (a) the two reactants (terminal azide, reacting with a terminal alkyne) are of individual low reactivity and (b) as only a catalytic quantity of a metal salt (Cu(I)) was required to accelerate the reaction. The reaction showed all features of a "click"-reaction including substrate insensitivity, ease, wide scope, solvent-insensitivity, and quantitative nature. Subsequently, the first published applications of this reaction in polymer science were published around 2004,5-10 quickly demonstrating the high efficiency of this process, coupled with a high functional group tolerance and solvent insensitivity (the reaction is also highly active in water), working equally well under homogeneous and heterogeneous conditions.

Thus the azide/alkyne-"click"-reaction emerged as a solution to many of the types of problems encountered in polymer science for a long time, such as: (a) a poor degree of functionalization with many conventional methods, especially when involving multiple functional groups (i.e.: at graft-, star-, block copolymers; dendrimers as well as on densely packed surfaces and interfaces) (see Figure 1); (b) purification problems associated with the often emerging partially functionalized mixtures; (c) incomplete reaction on surfaces and interfaces; and (d) harsh reaction conditions of conventional methods, often leading to the break-up of associates and assemblates, in particular in the newly emerging supramolecular sciences. Therefore, the Cu(I)-catalyzed azide/alkyne-"click"-reaction is a highly valuable tool for any quantitative polymeric postmodification reaction.

Figure 2: [+ details](#)



SW: Would you summarize the significance of your paper in layman's terms?

A unified chemical reaction, which efficiently links molecules under complete and quantitative reaction, irrespective of the solvent and the substrate (molecule) even at room-temperature. Copper(I)-salts are required as catalysts to accelerate the reaction. In contrast to many previous chemical reactions, this one can be used at any time without great effort.

SW: How did you become involved in this research, and were there any problems along the way?

I had heard a talk from one of the inventors of this reaction (**Prof. K. Barry Sharpless** of The Scripps Research Institute), who entirely focused on the use of this reaction in organic synthesis (Vienna, 2003). As this reaction seemed a solution to many problems encountered by us in previous years, we immediately probed the reaction and found it extremely useful for application in polymer science. From thereon we successfully applied this reaction^{1, 9, 11-24} and have gained fast approach to polymers for supramolecular science,^{12-14, 16, 18, 24, 25} surfaces,^{16, 18, 24} bioencapsulation,^{12, 23} nanoparticles,^{22, 26} and nanotechnology.^{16, 27} A new review¹¹ covers the topic in a special issue.

SW: Where do you see your research leading in the future?

Future research will deal with applications of this reaction for biomedical polymers, in particular, materials located at the interface of biological-, microelectronic-, and chemical polymers. Thus, new materials for solar cells or biomembranes are currently investigated in our laboratory, which are prepared via the "click"-chemistry method.

SW: Do you foresee any social or political implications for your research?

The reaction leads to a faster growth of polymer science due to the ease of generating defined polymeric molecules with specific function. Therefore, modern areas at the borderline between medicine, polymer science, and material science will have a faster development due to better synthetic methodologies. As an example, the highly complex interface between structural biology and synthetic polymer chemistry can be investigated much better. In particular, fields of superglues/superstrong adhesives, biomedical polymers, and microelectronics will benefit from this discovery.

Prof. Dr. Wolfgang Binder
Professor of Macromolecular Chemistry

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Halle-Wittenberg, Saxony-Anhalt, Germany**

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Keywords: click chemistry, Cu(I)-catalyzed azide/alkyne-click-reaction, polymer and materials-science, supramolecular science, Huisgen-type 1,3-dipolar cycloaddition reaction, polymer-molecules, higher polymeric architectures, dendrimers, hyperbranched polymers, supramolecular polymers, gels, polymer brushes, nanoparticles, nanotechnology, bioencapsulation.



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July 2008


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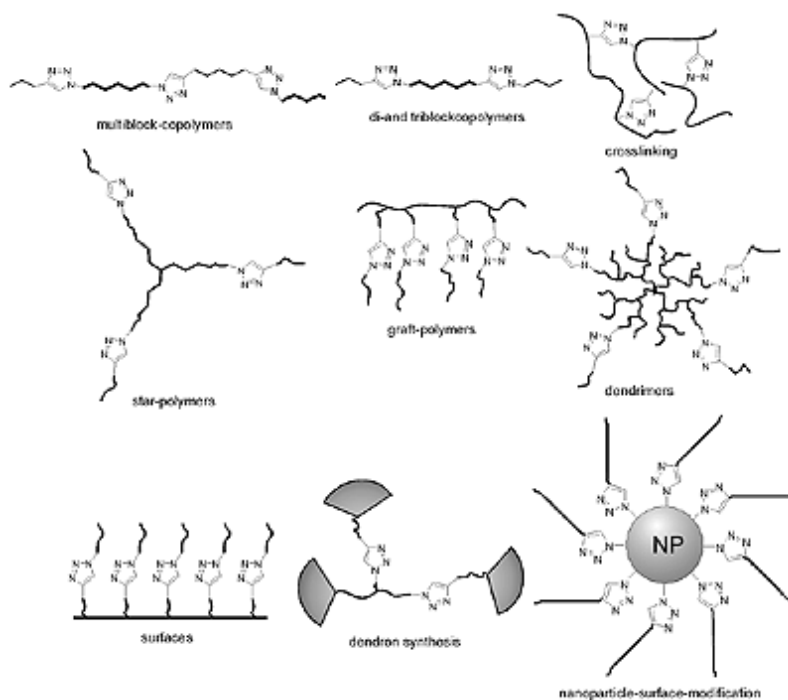


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Authors: Binder, WH;Sachsenhofer, R

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Figure 1:



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