

点击化学 Click Chemistry

Introduction

Classic Click Chemistry uses copper, Cu(I), to catalyze the 1,3-dipolar cycloaddition of an alkyne with an azide to form a 1,2,3-triazole.^{1,2} Sources of Cu(I) include copper(I) iodide, copper(I) bromide, copper turnings, or copper(II) sulfate (CuSO₄) and a reducing agent.¹ However, the thermodynamic instability of Cu(I), which readily oxidizes to inactive Cu(II) usually requires the copper catalyst to be prepared with an appropriate chelating ligand.

An improvement in Click Chemistry uses the in situ preparation of Cu(I) from the reduction of CuSO₄ with sodium ascorbate and a Cu(I) stabilizing ligand, tris-(benzyltriazolylmethyl)amine (TBTA).³ This leads to a more reliable click reaction by avoiding the oxidation of catalytic Cu(I) by dissolved oxygen. In a typical reaction, copper sulfate is pre-complexed with TBTA. This complexed catalyst is mixed with an alkyne and an azide, followed by the addition of sodium ascorbate to initiate the click reaction.

TBTA covers some of the practical applications for Click Chemistry except for aqueous conjugation reactions. The water-soluble tris(3-hydroxypropyltriazolylmethyl)amine (THPTA) click ligand further simplifies Click Chemistry by allowing the entire reaction to be run in water, affording biological compatibility for Click reactions.⁴ The THPTA ligand binds Cu(I), blocking the bioavailability of Cu(I) and ameliorating the potential toxic effects while maintaining the catalytic effectiveness in click conjugations. The THPTA ligand was effectively used to label live cells with high efficiency while maintaining cell viability.

In our hands, we have found THPTA to be a highly efficient ligand for click chemistry, in partially in completely aqueous reactions. Labeling is complete in as little as 15–30 minutes at room temperature. The ligand CuSO₄ complex exhibits no loss of activity when frozen for at least a month.

Example Protocols:

This section contains some general protocols for click reactions. These protocols may be used as a starting point for optimization of your particular click chemistry procedures.

Labeling of Oligonucleotides and DNA

1. Prepare the following stock solutions:
 - 200 mM THPTA ligand in water
 - 100 mM CuSO₄ in water
 - alkyne labeled oligo in water
 - 100 mM sodium ascorbate in water
 - 10 mM azide in DMSO/tBuOH or water.
2. Incubate CuSO₄ with THPTA ligand in a 1:2 ratio several minutes before the reaction. This solution is stable for several weeks when frozen.
3. To the oligo/DNA solution, add an excess of azide (4-50 eq).
4. Add 25 equivalents of THPTA/CuSO₄.
5. Add 40 equivalents of sodium ascorbate.
6. Let the reaction stand at room temperature for 30-60 minutes.
7. Ethanol-precipitate the oligo or purify.

Labeling of Cell Lysate

1. Prepare the following click solutions:
 - 100 mM THPTA ligand in aqueous buffer or water
 - 20 mM CuSO₄ in water
 - 300 mM sodium ascorbate in water
 - 2.5 mM alkyne or azide labeling reagent in water or DMSO
2. For each azide or alkyne- modified protein lysate sample, add the following to a 1.5 mL microfuge tube, then vortex briefly to mix.
 - 50 μ L protein lysate (1-5 mg/mL) in protein extraction buffer
 - 90 μ L PBS buffer
 - 20 μ L of 2.5 mM corresponding azide (or alkyne) detection reagent in DMSO or water
3. Add 10 μ L of 100 mM THPTA solution, vortex briefly to mix.
4. Add 10 μ L of 20 mM CuSO₄ solution, vortex briefly to mix.
5. Add 10 μ L of 300 mM sodium ascorbate solution to initiate click reaction, vortex briefly to mix.
6. Protect reaction from light and allow click reaction to incubate for 30 minutes at room temperature.
7. Proteins in lysate are now click labeled and ready for downstream processing and/or analysis.

References

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