Escherichia coli Gyrase Supercoiling Inhibition Assay

Introduction
DNA gyrase is a type II topoisomerase that can introduce negative supercoils into DNA at the expense of ATP hydrolysis. It is essential in all bacteria but absent from higher eukaryotes. In this assay, the substrate is relaxed pBR322 which is supercoiled by the gyrase. The two forms of the plasmid can be separated by agarose gel electrophoresis. It can be used to determine the activity of compounds as inhibitors of gyrase.

Materials

**E. coli Gyrase Assay Buffer:** 35 mM Tris-HCl (pH 7.5), 24 mM KCl, 4 mM MgCl₂, 2 mM DTT, 1.8 mM spermidine, 1 mM ATP, 6.5 % (w/v) glycerol, and 0.1 mg/ml albumin (supplied as 5X). Store at -20°C or below.

**Dilution Buffer:** 50 mM Tris-HCl (pH 7.5), 100 mM KCl, 2 mM DTT, 1 mM EDTA, and 50% (w/v) glycerol (supplied as 1X). Store at -20°C or below.

**Enzyme:** *E. coli* gyrase (see data sheet for concentration). Store at -80°C. (NOTE 1)

**Plasmid:** Relaxed pBR322 (supplied at 1 μg/μL). Store at -20°C or below.

Other materials not included in the kit

**STEB:** 40 % (w/v) sucrose, 100 mM Tris-HCl pH8, 10 mM EDTA, 0.5 mg/ml Bromophenol Blue.

Method
(Note: This is an example method and the volume of water can be increased or decreased to allow for the addition of inhibitors although the final volume will be 30 μL)

On ice, set up a MIX of (per assay): Assay Buffer (6 μL of 5x buffer) (NOTE 2), relaxed pBR322 (0.5 μL) and water (17.5 μL). 24 μL of MIX are required per assay.

Set up the appropriate number of 1.5 ml tubes and aliquot 24 μL of MIX into each tube.

Add 3 μL of the appropriate solvent (e.g. water, DMSO) to tubes 1 and 2 (NOTE 3).

Add 3 μL of the test compounds to the other tubes as appropriate.

Mix briefly (gentle vortexing or pipetting).

Add 3 μL of dilution buffer (NOTE 4) to tube 1.

Dilute the enzyme in dilution buffer then add 3 μL of this to the remaining tubes (see NOTE 1).

Mix by gentle vortexing and incubate 30 minutes at 37°C.

Stop reaction by adding 30 μL of STEB and 30 μL of chloroform/isoamyl alcohol (v:v, 24:1) (NOTE 5).

Vortex briefly ~5 secs and centrifuge for 1 minute.

Load 20 μL of aqueous (upper blue) phase onto a 1% (w/v) agarose gel (NOTE 6).

Run at 85V for approximately 2 hours (or 15 V overnight).

Stain with 1 μg/mL ethidium bromide in water (15 mins), destain (5-10 mins) in water (NOTE 7) and visualise with a transilluminator or gel documentation system.
Example Results

1. Determination of enzyme activity.

The gel below shows the results for a gel-based supercoiling experiment with relaxed pBR322, set up as follows: a MIX was prepared of 84 µL of Assay Buffer (5X), 7 µL relaxed pBR322, 287 µL of water. 27 µL of this MIX was added to each tube.

Serial dilutions of the enzyme were made in dilution buffer. Then 3.0 µL added to the reactions.

<table>
<thead>
<tr>
<th>Reaction#</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dilution</td>
<td>DB</td>
<td>1/600</td>
<td>1/300</td>
<td>1/200</td>
<td>1/150</td>
<td>1/120</td>
<td>1/100</td>
<td>1/60</td>
<td>1/30</td>
<td>1/20</td>
<td>1/15</td>
<td>1/12</td>
<td>1/10</td>
<td>1/6</td>
</tr>
</tbody>
</table>

The gel shows the results of the supercoiling reaction with the equivalent amount of neat enzyme added (e.g. reaction 2 contains 3 µL of a 1/600 dilution equivalent to 0.005 µL of neat enzyme)

Gyrase titration (volume neat enzyme added)

In this case approximately 0.1 µL of the neat enzyme is required to give full supercoiling. It is not recommended to store the diluted enzyme as it can lose activity.

2. Determination of the inhibitory activity of a compound

The assay was set up as follows: a MIX was made consisting of 84 µL of Assay Buffer (5X), 7 µL relaxed pBR322, 245 µL of water. 24 µL of the MIX was added to each tube then 3 µL DMSO/inhibitor and finally the dilution buffer/enceyme (using a dilution determined as in example 1 above).

<table>
<thead>
<tr>
<th>Sample</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIX (µL)</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td>Initial [Cpd] µM</td>
<td>DMSO</td>
<td>DMSO</td>
<td>0.01</td>
<td>0.05</td>
<td>0.1</td>
<td>0.5</td>
<td>1</td>
<td>5</td>
<td>10</td>
<td>50</td>
<td>100</td>
<td>250</td>
<td>500</td>
<td>1000</td>
</tr>
<tr>
<td>Final [Cpd] µM</td>
<td>0</td>
<td>0</td>
<td>0.001</td>
<td>0.005</td>
<td>0.01</td>
<td>0.05</td>
<td>0.1</td>
<td>0.5</td>
<td>1</td>
<td>5</td>
<td>10</td>
<td>25</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Dil. Buffer (µL)</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Enzyme (µL)</td>
<td>OC</td>
<td>R</td>
<td>SC</td>
<td>OC</td>
<td>R</td>
<td>SC</td>
<td>OC</td>
<td>R</td>
<td>SC</td>
<td>OC</td>
<td>R</td>
<td>SC</td>
<td>OC</td>
<td>R</td>
</tr>
</tbody>
</table>

Gyrase + (Inhibitor) (µM)

OC= nicked, open circular
R=relaxed topoisomers
SC= supercoiled topoisomers
Notes

1) Enzyme is supplied at a minimum number of U/µL (see data sheet and certificate of analysis), where 1U is the amount of DNA gyrase required to just supercoil 0.5 µg of relaxed pBR322, but it can be significantly more. Thus if you require a known amount of supercoiling (e.g. 90% supercoiling or just full supercoiling) then it is recommended to run an enzyme dilution series first, where the enzyme is titrated into the assay. The quoted activity (e.g. 5U/µL) is in the absence of solvents so an enzyme titration must be done in the actual assay conditions before assaying inhibitors.

2) The final concentration of assay buffer should be 1X.

3) DMSO has an inhibitory effect on the enzyme, thus no more than 5-10% (v/v) DMSO (final concentration) should be used (to check the effect of DMSO on the reaction, tubes +/- DMSO can be included. Also see NOTE 1 above. More enzyme will need to be added in the presence of DMSO to allow for its inhibitory effect. For example, if the enzyme has only 50% activity in the presence of 5% DMSO then twice as much (i.e. 2U) will need to be added to get full supercoiling. In this case more inhibitor will probably need to be added to get 50% inhibition.

4) The dilution buffer contains a high concentration of glycerol therefore the total dilution buffer added should not exceed 10% of the final volume.

5) Compounds can be removed from the reactions by extracting with water-saturated butanol before this step (the STEB/chloroform step) if necessary. The upper (butanol) phase is then removed and discarded and the STEB/chloroform added as normal. Usually however, the chloroform extraction is sufficient to remove the compounds as well as the DNA gyrase.

6) The agarose gels shown in the results are run in Tris-acetate-EDTA buffer (40 mM Tris-acetate, 1 mM EDTA) but TPE (36mM Tris, 30mM sodium phosphate, 1mM EDTA pH7.8) or TBE (89mM Tris, 89mM borate, 2mM EDTA pH7.6) buffers can also be used. Gels should be run at about 4 V/cm. Gels are usually run until the bromophenol blue dye has run at least 6-7cm. This will resolve the relaxed and supercoiled bands. Longer runs will give greater separation.

7) Gel tanks, gel formers and combs should be free of intercalators such as ethidium bromide and chloroquine which will affect the mobility of the various forms of the plasmid (relaxed, supercoiled etc.). If the apparatus has been used with intercalators then they should be thoroughly cleaned before use. This can be done by soaking for several hours or preferable overnight in a detergent solution (e.g. washing up liquid) and then thoroughly rinsing with water before rinsing with distilled water.

8) Once the reactions have been stopped with the STEB and mixed, it is possible to store them overnight at 4°C although it is preferable to load them on a gel as soon as possible.