



# **ArcticExpress RIL Competent Cells and ArcticExpress RP Competent Cells**

## **Instruction Manual**

**Catalog #230193 ArcticExpress (DE3)RIL Competent Cells**

**#230194 ArcticExpress (DE3)RP Competent Cells**

**#230195 ArcticExpress RIL Competent Cells**

**#230196 ArcticExpress RP Competent Cells**

Revision C.0

**For Research Use Only. Not for use in diagnostic procedures.**

230193-12



**Agilent Technologies**

## LIMITED PRODUCT WARRANTY

This warranty limits our liability to replacement of this product. No other warranties of any kind, express or implied, including without limitation, implied warranties of merchantability or fitness for a particular purpose, are provided by Agilent. Agilent shall have no liability for any direct, indirect, consequential, or incidental damages arising out of the use, the results of use, or the inability to use this product.

## ORDERING INFORMATION AND TECHNICAL SERVICES

### Email

techservices@agilent.com

### World Wide Web

www.genomics.agilent.com

### Telephone

Location	Telephone
United States and Canada	800 227 9770
Austria	01 25125 6800
Benelux	02 404 92 22
Denmark	45 70 13 00 30
Finland	010 802 220
France	0810 446 446
Germany	0800 603 1000
Italy	800 012575
Netherlands	020 547 2600
Spain	901 11 68 90
Sweden	08 506 4 8960
Switzerland	0848 8035 60
UK/Ireland	0845 712 5292
All Other Countries	Please visit <a href="http://www.genomics.agilent.com">www.genomics.agilent.com</a> and click <b>Contact Us</b>

# ArcticExpress RIL Competent Cells and ArcticExpress RP Competent Cells

## CONTENTS

<b>Materials Provided</b> .....	<b>1</b>
<b>Storage Conditions</b> .....	<b>1</b>
<b>Additional Material Required</b> .....	<b>1</b>
<b>Notice to Purchaser: Limited License</b> .....	<b>2</b>
<b>Academic and Nonprofit Laboratory Assurance Letter</b> .....	<b>2</b>
<b>Introduction</b> .....	<b>3</b>
Overcoming Protein Misfolding and Insolubility.....	3
Overcoming Codon Bias .....	4
Protein Expression Systems and Induction Methods .....	5
Host Strain Genotype and Features .....	6
<b>Protocols</b> .....	<b>8</b>
Protocol Overview.....	8
Transformation Guidelines .....	9
Transformation Protocol.....	10
Protein Expression Protocol .....	12
<b>Preparation of Media and Reagents</b> .....	<b>15</b>
<b>References</b> .....	<b>16</b>
<b>Endnotes</b> .....	<b>16</b>
<b>MSDS Information</b> .....	<b>16</b>

# ArcticExpress RIL Competent Cells and ArcticExpress RP Competent Cells

## MATERIALS PROVIDED

Catalog number	Materials provided	Quantity	Efficiency (cfu/ $\mu$ g of pUC18 DNA) <sup>a</sup>
#230193	ArcticExpress (DE3)RIL competent cells (yellow tubes)	10 $\times$ 0.1 ml	$\geq 5 \times 10^6$
	pUC18 control plasmid (0.1 ng/ $\mu$ l in TE buffer <sup>b</sup> )	10 $\mu$ l	—
	XL10-Gold $\beta$ -mercaptoethanol mix	50 $\mu$ l	—
#230194	ArcticExpress (DE3)RP competent cells (green tubes)	10 $\times$ 0.1 ml	$\geq 5 \times 10^6$
	pUC18 control plasmid (0.1 ng/ $\mu$ l in TE buffer <sup>b</sup> )	10 $\mu$ l	—
	XL10-Gold $\beta$ -mercaptoethanol mix	50 $\mu$ l	—
#230195	ArcticExpress RIL competent cells (blue tubes)	10 $\times$ 0.1 ml	$\geq 5 \times 10^6$
	pUC18 control plasmid (0.1 ng/ $\mu$ l in TE buffer <sup>b</sup> )	10 $\mu$ l	—
	XL10-Gold $\beta$ -mercaptoethanol mix	50 $\mu$ l	—
#230196	ArcticExpress RP competent cells (clear tubes)	10 $\times$ 0.1 ml	$\geq 5 \times 10^6$
	pUC18 control plasmid (0.1 ng/ $\mu$ l in TE buffer <sup>b</sup> )	10 $\mu$ l	—
	XL10-Gold $\beta$ -mercaptoethanol mix	50 $\mu$ l	—

<sup>a</sup> These competent cell efficiencies are guaranteed when cells are used according to the specifications outlined in this instruction manual.

<sup>b</sup> See *Preparation of Media and Reagents*.

## STORAGE CONDITIONS

**Store cells immediately at  $-80^{\circ}\text{C}$ . Do not place the cells in liquid nitrogen.**

**pUC18 Control Plasmid:  $-80^{\circ}\text{C}$**

**XL10-Gold  $\beta$ -Mercaptoethanol Mix:  $-80^{\circ}\text{C}$**

## ADDITIONAL MATERIAL REQUIRED

Low-temperature ( $10$ – $13^{\circ}\text{C}$ ) incubator with shaker

14-ml BD Falcon polypropylene round-bottom tubes (BD Biosciences Catalog #352059)

Gentamycin sulfate

Isopropyl-1-thio- $\beta$ -D-galactopyranoside (IPTG)

## **NOTICE TO PURCHASER: LIMITED LICENSE**

The purchase price of this product includes limited, nontransferable license under patents owned by Hoffmann-La Roche Inc. and F. Hoffmann-La Roche Ltd ("Roche"), to use this product only as a reagent for research purposes. No other license under these patents to use this product is conveyed expressly or by implication to the purchaser by the purchase of this product. A further license is available from Roche for commercial purposes. Further information on purchasing licenses may be obtained by contacting the Head of Licensing, F. Hoffmann-La Roche Ltd, Grenzacherstrasse 124, 4070 Basel, Switzerland.

## **ACADEMIC AND NONPROFIT LABORATORY ASSURANCE LETTER**

The T7 expression system is based on technology developed at Brookhaven National Laboratory under contract with the U.S. Department of Energy and is protected by U.S. patents assigned to Brookhaven Science Associates (BSA). BSA will grant a nonexclusive license for use of this technology, including the enclosed materials, based on the following assurances:

1. These materials are to be used for noncommercial research purposes only. A separate license is required for any commercial use, including the use of these materials for research purposes or production purposes by any commercial entity. Information about commercial licenses may be obtained from the Office of Intellectual Property and Industrial Partnerships, Brookhaven National Laboratory, Bldg. 475D, Upton, New York, 11973 [telephone (631) 344-7134].

2. No materials that contain the cloned copy of T7 gene 1, the gene for T7 RNA polymerase, may be distributed further to third parties outside of your laboratory, unless the recipient receives a copy of this license and agrees to be bound by its terms. This limitation applies to strains ArcticExpress RIL, ArcticExpress RP, ArcticExpress (DE3)RIL, and ArcticExpress (DE3)RP, included in this kit and any derivatives you may make of them.

You may refuse this license by returning the enclosed materials unused. By keeping or using the enclosed materials, you agree to be bound by the terms of this license.

### **Commercial Entities Outside of the US**

The T7 expression system is based on technology developed at Brookhaven National Laboratory under contract with the U.S. Department of Energy and is protected by U.S. Patents assigned to Brookhaven Science Associates (BSA). To protect its patent properties BSA requires commercial entities doing business in the United States, its Territories or Possessions to obtain a license to practice the technology. This applies for in-house research use of the T7 system as well as commercial manufacturing using the system. Commercial entities outside the U.S. that are doing business in the U.S., must also obtain a license in advance of purchasing T7 products. Commercial entities outside the U.S. that are using the T7 system solely for in-house research need not obtain a license if they do no business in the United States. However all customers, whether in the U.S. or outside the U.S. must agree to the terms and conditions in the Assurance Letter which accompanies the T7 products. Specifically, no materials that contain the cloned copy of T7 gene 1, the gene for T7 RNA polymerase, may be distributed further to third parties outside of your laboratory, unless the recipient receives a copy of the assurance letter and agrees to be bound by its terms. This limitation applies to strains ArcticExpress RIL, ArcticExpress RP, ArcticExpress (DE3)RIL, and ArcticExpress (DE3)RP, included in this kit and any derivatives you may make of them.

To obtain information about licensing, please contact the Office of Intellectual Property and Industrial Partnerships, Brookhaven National Laboratory, Building 475D, Upton, NY 11973 [telephone: 631-344-7134; Fax: 631-344-3729].

## INTRODUCTION

---

ArcticExpress RIL and RP Competent Cells, featuring CodonPlus technology,<sup>1</sup> are engineered to simultaneously address two common bacterial gene expression hurdles: protein insolubility and codon bias. These cells are derived from Agilent's high-performance BL21-Gold competent cell line, enabling efficient high-level expression of heterologous proteins in *Escherichia coli*.<sup>2</sup>

### Overcoming Protein Misfolding and Insolubility

Forced high-level expression of a heterologous protein in *E. coli* can result in the production of large amounts of incorrectly folded protein, generating aggregates of inactive protein known as inclusion bodies. While the aggregated protein may be easy to purify, obtaining active protein from inclusion bodies typically requires protein-specific and labor-intensive *in vitro* re-folding steps, with no guarantee of obtaining biologically active product. The ArcticExpress series of competent cells provides an *in vivo* approach to increasing the yield of soluble protein produced in *E. coli*.

The mesophilic host *E. coli* is suitable for expression of a wide range of heterologous proteins. At standard cultivation temperatures, however, high-level expression of a heterologous protein can impair the cell's ability to properly process the recombinant protein. Low-temperature cultivation represents one strategy for increasing the recovery of soluble protein.<sup>3</sup> An obstacle to using this approach, however, is that *E. coli* chaperonins, which facilitate proper protein folding by binding to and stabilizing unfolded or partially folded proteins, lose activity at reduced temperatures. Specifically, it has been shown that the activity of the *E. coli* chaperonin complex GroEL/ES retains only about 30% refolding activity at 12°C, compared to its activity at the temperature optimum of 30°C.<sup>4</sup> To overcome this obstacle, ArcticExpress competent cells have been engineered for improved protein processing at low temperatures. These cells co-express the cold-adapted chaperonins Cpn10 and Cpn60 from the psychrophilic bacterium, *Oleispira antarctica*. The Cpn10 and Cpn60 chaperonins from *O. antarctica* have 74% and 54% amino acid identity to the *E. coli* GroEL and GroES chaperonins, respectively, and show high protein refolding activities at temperatures of 4–12°C.<sup>4</sup> When expressed in ArcticExpress cells, these chaperonins confer improved protein processing at lower temperatures, potentially increasing the yield of active, soluble recombinant protein.

## Overcoming Codon Bias

Efficient production of heterologous proteins in *E. coli* is frequently limited by the rarity of certain tRNAs that are abundant in the organisms from which the heterologous proteins are derived.<sup>||</sup> High-level expression of heterologous proteins can deplete the pool of rare tRNAs and stall translation. ArcticExpress RIL and RP strains are engineered to contain extra copies of genes that encode the tRNAs that most frequently limit translation of heterologous proteins in *E. coli*. Availability of these limiting tRNAs allows high-level expression of many heterologous recombinant genes that are poorly expressed in conventional BL21 strains.

### ArcticExpress RIL Strains

ArcticExpress RIL and ArcticExpress (DE3)RIL cells contain extra copies of the *argU*, *ileY*, and *leuW* tRNA genes. These genes encode tRNAs that recognize the arginine codons AGA and AGG, the isoleucine codon AUA, and the leucine codon CUA, respectively (Table I). The ArcticExpress RIL strains have available the tRNAs that most frequently restrict translation of heterologous proteins from organisms that have AT-rich genomes.

### ArcticExpress RP Strains

ArcticExpress RP and ArcticExpress (DE3)RP cells contain extra copies of the *argU* and *proL* genes. These genes encode tRNAs that recognize the arginine codons AGA and AGG and the proline codon CCC, respectively. The ArcticExpress RP strains have available the tRNAs that most frequently restrict translation of heterologous proteins of organisms that have GC-rich genomes.

**TABLE I**

**Extra Copies of tRNA Genes in ArcticExpress RIL and RP Strains**

Host strain	tRNA genes (codon recognition of gene product)
ArcticExpress RIL strain	<i>argU</i> (AGA, AGG), <i>ileY</i> (AUA), <i>leuW</i> (CUA)
ArcticExpress (DE3)RIL strain	<i>argU</i> (AGA, AGG), <i>ileY</i> (AUA), <i>leuW</i> (CUA)
ArcticExpress RP strain	<i>argU</i> (AGA, AGG), <i>proL</i> (CCC)
ArcticExpress (DE3)RP strain	<i>argU</i> (AGA, AGG), <i>proL</i> (CCC)

<sup>||</sup> A complete compilation of codon usage of the sequences in the GenBank® database is available at <http://www.kazusa.or.jp/codon/>

## Protein Expression Systems and Induction Methods

The ArcticExpress strains are designed for expression of recombinant proteins either from the T7 promoter using the DE3 lysogen strains, or from IPTG-inducible, non-T7 promoters using the non-DE3 lysogen strains (See Table II).

### Expression from the T7 Promoter

For recombinant proteins expressed from vectors driven by the T7 promoter, such as the pCAL vectors and the pET vectors, use the DE3 lysogen ArcticExpress (DE3)RIL and ArcticExpress (DE3)RP host strains. These host strains contain a chromosomally integrated cassette in which the T7 RNA polymerase is expressed from the *lacUV5* promoter. Induction of T7 RNA polymerase expression with IPTG results in expression of the T7 promoter-driven recombinant protein.

### Expression from Other IPTG-Inducible Promoters

For recombinant proteins expressed from IPTG-inducible promoters other than the T7 promoter, such as the *tac* or *trc* promoter, use the non-DE3 lysogen ArcticExpress RIL and ArcticExpress RP host strains.

**Table II**

Expression Strain	Compatible Expression Vectors	Induction Method
ArcticExpress (DE3)RIL competent cells	T7 promoter-driven expression vectors (e.g. pCAL and pET vectors)	Isopropyl-1-thio- $\beta$ -D-galactopyranoside (IPTG) induction of T7 RNA polymerase from <i>lacUV5</i> promoter
ArcticExpress (DE3)RP competent cells		
ArcticExpress RIL competent cells	<i>lac</i> , <i>tac</i> , and <i>trc</i> promoter-driven expression vectors	Isopropyl-1-thio- $\beta$ -D-galactopyranoside (IPTG) induction of the promoter driving recombinant gene expression ( e.g. <i>lac</i> , <i>tac</i> , or <i>trc</i> promoter)
ArcticExpress RP competent cells		



## Host Strain Genotype and Features

Derived from *E. coli* B, the ArcticExpress RIL and RP expression strains naturally lack the Lon protease, which can degrade recombinant proteins. In addition, these strains are engineered to be deficient for a second protease, the OmpT protein. These strains also feature the Hte phenotype\* present in Agilent's highest efficiency competent cell strain, XL10-Gold.<sup>5</sup> The presence of the Hte phenotype increases the transformation efficiency of the cells. In addition, the gene that encodes endonuclease I (*endA*), an enzyme that rapidly degrades plasmid DNA isolated by most miniprep procedures, has been inactivated in these cells. These two features enable direct cloning of many protein expression constructs. The *Oleispira antarctica* chaperonins Cpn10 and Cpn60 are constitutively expressed in these strains from a ColE1-compatible, pACYC-based plasmid that contains a gentamycin-resistance gene. See Table III for complete genotype information.

**Note** When analyzing a cell extract by gel electrophoresis, the Cpn60 chaperonin will be observed at ~ 56,900 Da.

**Table III: Host Strain Genotypes**

Host strain <sup>o</sup>	Genotype
ArcticExpress RIL strain	<i>E. coli</i> B F <sup>-</sup> <i>ompT</i> <i>hsdS</i> (r <sub>B</sub> <sup>-</sup> m <sub>B</sub> <sup>-</sup> ) <i>dcm</i> <sup>+</sup> Tet <sup>r</sup> <i>gal</i> <i>endA</i> Hte [ <i>cpn10</i> <i>cpn60</i> Gent <sup>r</sup> ] [ <i>argU</i> <i>ileY</i> <i>leuW</i> Str <sup>r</sup> ]
ArcticExpress (DE3)RIL strain	<i>E. coli</i> B F <sup>-</sup> <i>ompT</i> <i>hsdS</i> (r <sub>B</sub> <sup>-</sup> m <sub>B</sub> <sup>-</sup> ) <i>dcm</i> <sup>+</sup> Tet <sup>r</sup> <i>gal</i> λ(DE3) <i>endA</i> Hte [ <i>cpn10</i> <i>cpn60</i> Gent <sup>r</sup> ] [ <i>argU</i> <i>ileY</i> <i>leuW</i> Str <sup>r</sup> ]
ArcticExpress RP strain	<i>E. coli</i> B F <sup>-</sup> <i>ompT</i> <i>hsdS</i> (r <sub>B</sub> <sup>-</sup> m <sub>B</sub> <sup>-</sup> ) <i>dcm</i> <sup>+</sup> Tet <sup>r</sup> <i>gal</i> <i>endA</i> Hte [ <i>cpn10</i> <i>cpn60</i> Gent <sup>r</sup> ] [ <i>argU</i> <i>proL</i> Str <sup>r</sup> ]
ArcticExpress (DE3)RP strain	<i>E. coli</i> B F <sup>-</sup> <i>ompT</i> <i>hsdS</i> (r <sub>B</sub> <sup>-</sup> m <sub>B</sub> <sup>-</sup> ) <i>dcm</i> <sup>+</sup> Tet <sup>r</sup> <i>gal</i> λ(DE3) <i>endA</i> Hte [ <i>cpn10</i> <i>cpn60</i> Gent <sup>r</sup> ] [ <i>argU</i> <i>proL</i> Str <sup>r</sup> ]

<sup>o</sup> These strains, derivatives of *E. coli* B, are general protein expression strains that lack both the Lon protease and the OmpT protease, which can degrade proteins during purification.<sup>6</sup> Dcm methylase, naturally lacking in *E. coli* B, is inserted into the genomes.

## tRNA Expression Plasmids

- ♦ ArcticExpress RIL and ArcticExpress (DE3)RIL cells contain a ColE1-compatible, pSC101-based plasmid, which contains extra copies of the *argU*, *ileY*, and *leuW* tRNA genes. This plasmid also contains a streptomycin resistance gene.
- ♦ ArcticExpress RP and ArcticExpress (DE3)RP cells contain a ColE1-compatible, pSC101-based plasmid, which contains extra copies of the *argU* and *proL* tRNA genes. This plasmid also contains a streptomycin resistance gene.

\*U. S. Patent No. 6,706,525.

### **Optional Confirmation of the Presence of the tRNA-Encoding Plasmid Before Induction**

The presence of the pSC101-based plasmid that encodes the supplementary tRNA genes can be confirmed by verifying the streptomycin- or spectinomycin-resistance phenotype. If phenotypic verification is desired, we recommend using LB-agar medium supplemented with 75 µg/ml streptomycin. It is **not**, however, necessary to add streptomycin to the growth medium prior to induction in order to maintain the pSC101-based plasmid. The plasmid contains a functional partitioning locus that ensures proper plasmid segregation, preventing plasmid loss even in the absence of a selective agent. When analyzing cell extracts by gel electrophoresis followed by Coomassie® staining, the protein that confers streptomycin resistance is **not** typically detected.

### **Selection for the Chaperonin-Encoding Plasmid Before Induction**

Selection for the *cpn10/cpn60* chaperonin expression plasmid prior to induction is recommended. Gentamycin should be added to the overnight LB broth culture at a final concentration 20 µg/ml. (See the *Protein Expression Protocol* in the *Protocols* section.) When analyzing cell extracts by gel electrophoresis followed by Coomassie® staining, the protein that confers gentamycin resistance is **not** typically detected.

### **Composition of Miniprep DNA Prepared from Transformed Cells**

Miniprep DNA obtained following transformation of the competent cells with the expression plasmid of choice will be a mixture containing the expression plasmid, the *cpn10/cpn60*-encoding pACYC-based plasmid (~5.5 kb), and the tRNA-encoding pSC101-based plasmid (~4.7 kb). The pACYC-based plasmid is typically observed during gel analysis of miniprep DNA. The pSC101-based plasmid is maintained at relatively low copy number and may or may not be observed.

## PROTOCOLS

---

### Protocol Overview

- ◆ Transform the appropriate host strain with the protein expression plasmid, using a 37°C cultivation temperature.
- ◆ Pick several transformants and grow overnight cultures in medium containing gentamycin and antibiotic for selection of the expression plasmid at 37°C.
- ◆ Grow the cells without antibiotic selection for 3 hours at 30°C.
- ◆ Induce expression of the recombinant protein with IPTG at 10–13°C, and continue growth after induction at 10–13°C for 24 hours.
- ◆ Analyze protein expression in induced cultures and non-induced controls by SDS-PAGE.

## Transformation Guidelines

**Important** For optimal transformation efficiency, please read the guidelines outlined in this section before proceeding with the Transformation Protocol.

### Storage Conditions

The competent cells are very sensitive to slight variations in temperature. In order to prevent a loss of transformation efficiency, store the competent cells at the bottom of a  $-80^{\circ}\text{C}$  freezer directly from the dry ice shipping container. Transferring tubes from one freezer to another may result in a loss of efficiency. The transformation efficiency of the competent cells is guaranteed when the competent cells are used according to the specifications outlined in this instruction manual.

### Use of 14-ml BD Falcon Polypropylene Round-Bottom Tubes

It is important to use 14-ml BD Falcon polypropylene round-bottom tubes (BD Biosciences Catalog #352059) for the *Transformation Protocol* because the heat pulse duration, which is critical for obtaining the highest efficiencies, is optimized specifically for the thickness and shape of these tubes.

### Aliquoting Cells

Store the competent cells on ice at all times while aliquoting. It is essential to place the 14-ml polypropylene tubes on ice before the competent cells are thawed and to transfer the competent cells directly into the prechilled 14-ml polypropylene tubes. It is also important to use 100  $\mu\text{l}$  of competent cells/transformation. Using an inadequate volume of competent cells results in lower transformation efficiencies.

### Quantity of DNA

Greatest transformation efficiencies (i.e., transformants/microgram of DNA) are observed when each 100- $\mu\text{l}$  aliquot of competent cells is transformed with 1  $\mu\text{l}$  of DNA at a concentration of 0.1 ng/ $\mu\text{l}$ . Although the overall transformation efficiency may be lower, a greater number of colonies will be obtained when the cells are transformed with up to 50 ng of DNA.

### Use of $\beta$ -Mercaptoethanol

$\beta$ -Mercaptoethanol has been shown to increase transformation efficiency. For optimal efficiency, use 2.0  $\mu\text{l}$  of a 1:10 dilution of the XL10-Gold  $\beta$ -mercaptoethanol mix provided in this kit. (Using an alternative source of  $\beta$ -ME may reduce transformation efficiency.)

### Length of the Heat Pulse

Optimal transformation efficiencies are observed when transformation reactions are heat-pulsed for 20–25 seconds. Transformation efficiencies decrease sharply when the duration of the heat pulse is  $<20$  seconds or  $>25$  seconds.

## Transformation Protocol

1. Thaw the competent cells on ice.

**Note** *Store the competent cells on ice at all times while aliquoting. It is essential that 14-ml BD Falcon polypropylene round-bottom tubes are placed on ice before the competent cells are thawed and that 100  $\mu$ l of competent cells are transferred directly into each **prechilled** polypropylene tube.*

2. Gently mix the competent cells. For each expression plasmid transformation, transfer 100  $\mu$ l of competent cells into a prechilled 14-ml BD Falcon polypropylene round-bottom tube. Prepare an additional 100- $\mu$ l aliquot of cells for use as a transformation control.
3. Dilute XL10-Gold  $\beta$ -mercaptoethanol mix provided with this kit 1:10 with dH<sub>2</sub>O. Each 100- $\mu$ l aliquot of cells requires 2  $\mu$ l of diluted  $\beta$ -mercaptoethanol.
4. Add 2.0  $\mu$ l of the 1:10 dilution of  $\beta$ -mercaptoethanol to each of the 100- $\mu$ l aliquots of competent cells. (Using an alternative source of  $\beta$ -ME may reduce transformation efficiency.)
5. Swirl the contents of the tubes gently. Incubate the cells on ice for 10 minutes, swirling gently every 2 minutes.
6. Add 1–50 ng of expression plasmid DNA, containing the gene of interest, to each tube of cells and swirl gently. For the control transformation reaction, add 1  $\mu$ l of the pUC18 control plasmid to a separate 100- $\mu$ l aliquot of competent cells and swirl gently.
7. Incubate the reactions on ice for 30 minutes.
8. Preheat SOC medium (see *Preparation of Media and Reagents*) in a 42°C water bath for use in step 11.
9. Heat-pulse each transformation reaction in a 42°C water bath for 20 seconds. **The duration of the heat pulse is critical for optimal transformation efficiencies.**
10. Incubate the reactions on ice for 2 minutes.
11. Add 0.9 ml of preheated (42°C) SOC medium to each transformation reaction and incubate the reactions at 37°C for 1 hour with shaking at 225–250 rpm.

12. Using a sterile spreader, spread  $\leq 200$   $\mu\text{l}$  of the cells transformed with the experimental DNA onto LB agar<sup>§</sup> plates that contain the appropriate antibiotic for selection of the expression plasmid.

For the pUC18 control plasmid, plate 100  $\mu\text{l}$  on an LB–ampicillin agar plate.<sup>§</sup>

**Notes** *It is **not** necessary to add streptomycin or gentamycin to the transformation plates.*

*The cells may be concentrated by centrifuging at  $200 \times g$  for 3–5 minutes at  $4^\circ\text{C}$  if desired. Resuspend the pellet in 200  $\mu\text{l}$  of SOC broth.*

*If plating  $\leq 100$   $\mu\text{l}$  of the transformation reaction, first place a 100- $\mu\text{l}$  pool of SOC medium onto the plate. Pipet the cells from the transformation reaction into the pool of SOC and then spread the mixture. If plating  $> 100$   $\mu\text{l}$ , spread the cell suspension onto the plates directly.*

13. Transformants will appear as colonies following overnight incubation at  $37^\circ\text{C}$ . For the pUC18 control transformation,  $\geq 50$  cfu are expected, indicating a transformation efficiency  $\geq 5 \times 10^6$  cfu/ $\mu\text{g}$  pUC18 DNA.

<sup>§</sup> See *Preparation of Media and Reagents*.

## Protein Expression Protocol

**Note** *The induction phase of this protocol requires incubation of cell cultures at 10–13°C. This may be achieved using a low-temperature incubator equipped with a shaker or by placing a water bath, equipped with a shaker, in a cold room and adjusting the water bath to 10–13°C.*

The following induction protocol is a general guide for expression of genes under the control of IPTG-inducible promoters on an analytical scale (3 ml of induced culture). Optimization of induction conditions (IPTG concentration and duration of growth periods preceding and following induction) may improve active protein yield for some recombinant proteins.

### Preparation of Liquid Cultures Prior to Induction

1. Inoculate 1 ml aliquots of LB broth (containing 20 µg/ml gentamycin and the appropriate antibiotic for selection of the expression plasmid) with single colonies from the transformation plates. Incubate these cultures at 37°C with shaking at 220–250 rpm overnight.

**Note** *It is prudent to test more than one colony as colony-to-colony variations in protein expression are possible.*

2. The next morning, subculture the cells in 50-ml culture tubes by pipetting 60 µl of each culture into 3-ml of LB broth containing no selection antibiotics. Incubate these cultures at 30°C with shaking at 220–250 rpm for 3 hours.

### Induction of Target Protein Using IPTG

3. Pipet 100 µl of each culture into a clean microcentrifuge tube and place the tubes on ice until needed for gel analysis. These will serve as the non-induced control samples.
4. Transfer the culture tubes to 10–13°C and incubate with shaking at 220–250 rpm for ~10 minutes. After the culture has equilibrated to 10–13°C, add IPTG to each tube to a final concentration of 1 mM. Incubate at 10–13°C, with shaking at 220–250 rpm, for 24 hours.

**Note** *These values for IPTG concentration and induction time are starting values only and may require optimization depending on the gene expressed.*

5. After the end of the induction period, place the cultures on ice.

## Analysis of Protein Expression by SDS-PAGE

6. Pipet 20  $\mu$ l of each of the induced cultures into clean microcentrifuge tubes. Add 20  $\mu$ l of 2 $\times$  SDS gel sample buffer (see *Preparation of Media and Reagents*) to each microcentrifuge tube.
7. Mix the non-induced samples held on ice to resuspend the cells. Pipet 20  $\mu$ l from each tube into a clean microcentrifuge tube. Add 20  $\mu$ l of 2 $\times$  SDS gel sample buffer to each of the 20- $\mu$ l aliquots of cells.
8. Heat all tubes to 95°C for 5 minutes. Load the associated non-induced and induced samples in adjacent lanes for analysis by SDS-PAGE. Stain the protein gel with Coomassie Brilliant Blue stain.

**Note** *When analyzing a cell extract by SDS-PAGE, the Cpn60 protein will be observed at ~57 kDa, and the Cpn10 protein may be observed at ~10 kDa.*



## TROUBLESHOOTING

Observations	Suggestions
Plasmid instability	An insert that contains a repeated sequence or secondary structures may undergo rearrangement (the competent cells are <i>recA</i> <sup>+</sup> ). Establish the insert in a recombination-deficient host strain, such as SURE competent cells ( <i>recB</i> <sup>-</sup> and <i>recJ</i> <sup>-</sup> ) or XL1-Blue competent cells ( <i>recA</i> <sup>-</sup> ), prior to expression in ArcticExpress competent cells.
Gel analysis of miniprep restriction digestion results in multiple bands	The pACYC-based chaperonin expression plasmid (5.5 kb) and the pSC101-based tRNA expression plasmid (4.7 kb) harbored in the ArcticExpress RIL and RP strains may be detected in miniprep DNA. Insert cloning and verification should be performed in a general cloning strain (e. g., XL1-Blue competent cells) prior to expression in the ArcticExpress strains.
Gel analysis of cell extract results in an extra protein band at ~57 kDa	The Cpn60 protein (~57 kDa), which is constitutively expressed from the pACYC-based plasmid, is typically detected in protein gel analysis of ArcticExpress cell lysates. An additional band, corresponding to Cpn10 (~10 kDa) may also be observed.
No increase in expression of the recombinant protein after induction	Optimize the induction conditions, including IPTG concentration, length of the 30°C-incubation period prior to induction, and length of the 10–13°C-incubation period after induction.
	If induction of recombinant protein expression cannot be verified by Coomassie staining, analyze protein levels by Western blot, when possible, for greater sensitivity and reduced background.
	Verify that the expression strain chosen is compatible with the promoter driving expression of the recombinant protein [e.g. pET vectors are compatible only with the ArcticExpress (DE3)RIL competent cells and the ArcticExpress (DE3)RP competent cells].
	Verify the integrity of the expression plasmid to ensure that the plasmid contained in the expression strain does not include a mutation that impairs expression of functional protein, such as a premature stop codon. If non-functional clones are obtained from multiple independent cloning attempts, functional clones may be under negative selection due to toxicity.
	Some DNA sequences may adopt strong secondary structures (e.g. hairpin structures) at low temperatures that impede transcription of the gene of interest.
Protein is produced in insoluble form	Some recombinant proteins are not substrates for the Cpn60/Cpn10 chaperonins. Consider alternative approaches to increasing the solubility of the recombinant protein, such as the Agilent VariFlex bacterial protein expression system, which allows the convenient addition of solubility-enhancement and purification tags to the protein of interest.

## PREPARATION OF MEDIA AND REAGENTS

<p><b>LB Broth (per Liter)</b>            10 g of NaCl            10 g of tryptone            5 g of yeast extract            Add dH<sub>2</sub>O to a final volume of 1 liter            Adjust pH to 7.0 with 5 N NaOH            Autoclave            Pour into petri dishes (~25 ml/100-mm plate)</p>	<p><b>LB Agar (per Liter)</b>            10 g of NaCl            10 g of tryptone            5 g of yeast extract            20 g of agar            Add deionized H<sub>2</sub>O to a final volume of 1 liter            Adjust pH to 7.0 with 5 N NaOH            Autoclave            Cool to 55°C, and then add antibiotic, if required            Pour into petri dishes (~25 ml/100-mm plate)</p>
<p><b>LB–Ampicillin Agar (per Liter)</b>            1 liter of LB agar, autoclaved            Cool to 55°C            Add 10 ml of 10-mg/ml filter-sterilized ampicillin            Pour into petri dishes (~25 ml/100-mm plate)</p>	<p><b>SOC Medium (per 100 ml)</b>  <b>Note</b> <i>This medium should be prepared immediately before use</i>            1 ml of a 2 M filter-sterilized glucose solution  <b>or</b> 2 ml of 20% (w/v) glucose            SOB medium to a final volume of 100 ml            Filter sterilize</p>
<p><b>SOB Medium (per Liter)</b>            20.0 g of tryptone            5.0 g of yeast extract            0.5 g of NaCl            Add deionized H<sub>2</sub>O to a final volume of 1 liter            Autoclave            Add 10 ml of filter-sterilized 1 M MgCl<sub>2</sub> and 10 ml of filter-sterilized 1 M MgSO<sub>4</sub> prior to use</p>	<p><b>2× SDS gel sample buffer</b>            100 mM Tris-HCl (pH 6.5)            4% SDS (electrophoresis grade)            0.2% bromophenol blue            20% glycerol   <b>Note</b> <i>Add dithiothreitol to a final concentration in the 2× buffer of 200 mM prior to use. This sample buffer is useful for denaturing, discontinuous acrylamide gel systems only.</i></p>
<p><b>TE Buffer</b>            10 mM Tris-HCl (pH 7.5)            1 mM EDTA</p>	

## REFERENCES

---

1. Carstens, C.-P., Bonnardel, J., Allen, R. and Waesche, A. (2001) *Strategies* 14:50.
2. Jerpseth, M., Jerpseth, B., Briester, L. and Greener, A. (1998) *Strategies* 11(1):3-4.
3. Schein, C. H. (1989) *Biotechnology* 7:1141-8.
4. Ferrer, M., Chernikova, T. N., Yakimov, M. M., Golyshin, P. N. and Timmis, K. N. (2003) *Nat Biotechnol.* 21(11):1266-7.
5. Jerpseth, B., Callahan, M. and Greener, A. (1997) *Strategies* 10(2):37-38.
6. Grodberg, J. and Dunn, J. J. (1988) *J Bacteriol* 170(3):1245-53.

## ENDNOTES

---

GenBank® is registered trademark of the U.S Department of Health and Human Services.  
Coomassie® is a registered trademark of Imperial Chemical Industries.

## MSDS INFORMATION

---

Material Safety Data Sheets (MSDSs) are provided online at <http://www.genomics.agilent.com>. MSDS documents are not included with product shipments.